Using Electronic Voting Systems in Lectures

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Summary

This report is a review of research into the use of electronic voting systems to support lectures. This review, which was undertaken through funding from the Sub-Committee on Innovations in Learning, Teaching and Assessment, provides an overview of the potential of such systems; it also identifies issues associated with their use.

Based on this review, it has been concluded that:

- Voting systems are best understood as a tool rather than a teaching approach. They do not 'cause' good learning – in fact, if poorly prepared or used for their own sake, students were extremely critical of them. However, when lecturers used these tools as part of a wider effort to support active engagement with learning there is evidence that they can support increased motivation and attainment, at least in part as a result of their ability to provide rapid feedback on the learning process.

- Such systems represent an opportunity to improve lecturing. The requirement to emphasise engagement and interaction with students prompts lecturers to reflect on qualities believed to characterise good teaching.

- Such systems build on work already undertaken in college, in areas such as technology and lecturing, confidence assessment and objective testing.

- The introduction of such a system has resource implications. The direct costs of such a system are in the region of £10,000-£60,000 for a lecture theatre for 250 students. In addition, there are indirect costs in terms of lecturers' time (to learn how to use the system and reflect on how it will change their teaching), support staff time (including Media Resources and Information Services) and for staff time to provide pedagogic support (e.g. involvement in a SCILTA project or a secondment to Education & Professional Development).

- In addition, practical issues such as the installation and mobility of the resource would need to be addressed.

In summary, voting systems do appear to have the potential to enhance learning and motivation, as well as providing variety and engagement within lectures. Based on this review, it is recommended that:

- Provided adequate resources can be made available (for the initial purchase and for supporting use) such a would be an asset to learning at teaching at UCL; and

- If purchased, the system should be installed in a single location, with a priority system in the room bookings process to allow the optimum use of this resource.

It is also important to note that a system of this type is already in use at UCL. The *Discourse* system has been used within lectures at the Royal Free campus for several years; it offers the full functionality of most other systems but is also able to support bi-directional free text exchanges. The system has been installed in nine classrooms on the Royal Free site, is available in a browser-supported format suitable for use in cluster rooms and a site licence has been purchased that also covers the Whittington and Bloomsbury campuses (Van Den Bergh, 2002). It is currently being developed so that it can be used *via* wireless network enabled laptops or Personal Digital Assistants (PDAs), removing the need for specialist handsets to be purchased. Students' access to suitable laptops could be provided under the Student Notebook Initiative currently being considered by the Academic Systems Steering Group, if wireless networking for selected lecture rooms was considered viable by EISD. For these reasons, it is recommended that *Discourse* be considered as a first choice for a system of this type, although it is recognised that such a purchase may need to be delayed until an appropriate wireless infrastructure is in place within college.

Using Electronic Voting Systems in Lectures

1. Introduction

> *Much attention has been on the use of computer technology for delivering education on the desktop, but not much attention is paid to its use in the lecture.*
>
> *(Jones, 1999)*

Under the first round of the Teaching Quality Enhancement Fund, UCL undertook a study to investigate how the use of large lecturing spaces, many of which are far from ideal in terms of layout or facilities, could be improved (Issroff & Oliver, 2001). During this study, it became apparent that the introduction of technology could have a substantial impact on the lecturing process. When such technology worked well, it helped to focus students' attention and structure the lecturing process. However, when problems arose, the interruption could be severe.

One particularly relevant development has been the recent growth in the development and use of electronic voting systems within the context of lectures. Whilst pioneering work has already been undertaken at UCL using systems of this type (e.g. Epstein *et al*, 2000), interest has been growing across college. In response to this, the Sub-Committee on Innovations in Learning, Teaching and Assessment at UCL commissioned a review to investigate this technology and make recommendations about its possible adoption.

This report reviews the literature on the use of electronic voting systems within the context of lectures and identifies examples of good practice. The foci of this review are:

- the assumptions, advantages and disadvantages associated with this approach;
- identification of the kinds of systems available;
- provision of examples that illustrate how such systems might be used; and
- a summary of the potential costs and benefits associated with this approach.

The report is divided into the following sections:

1. Introduction
2. General description
3. Variety of uses in lecture theatre teaching
4. Improved lecturing and potential benefits
5. Student opinion and perceptions of voting systems
6. Impact on staff skills and current teaching practice
7. Considerations for successful adoption and integration
8. Conclusions and recommendations
9. Bibliography
10. Appendix: System specifications and costs

Methodology

Because voting systems are used globally, it was necessary to identify and review literature on an international basis. However, this process was complicated by the fact that the terminology used to describe such systems varies considerably.

The search that was undertaken involved using a range of indexes and search engines, including the Web of Science (Arts & Humanities Citation Index and Social Sciences Citation Index), BIDS (ERIC, British Education Index and International Bibliography of Social Sciences), Zetoc (British Library resources), Educati*on-line,* EdResearch Online and Google. These searches were iterative, in that the databases used were regularly re-searched as new descriptors became apparent. The final search terms used identified voting systems from various perspectives:

- Technological (e.g. 'key-pad', 'hand-set')
- Pedagogical (e.g. 'interactive')
- Physical action (e.g. 'group response', 'audience response', 'personal response', 'electronic voting')
- Brand name (e.g. 'Varitronix')

These searches identified around 30 potentially relevant papers. The abstracts of these were inspected to select those papers that were relevant to teaching and learning, focusing in particular on the use and role of these systems in lectures. As a result, a total of 15 were classified as being of direct relevance to this work. These formed the basis of this review.

2. General description

This section will outline the basic process involved in using a voting system, and illustrate the common features of voting systems as considered in this study.

The basic process

During the lecture, the lecturer poses a question. This can be done verbally, or could be displayed using presentation technology on a computer, overhead transparencies (OHTs) or from within the voting software. Each student has a **handset** that allows him or her to select the preferred option for the answer. The handsets transmit this information to a **receiver**, which in turn transmits it to the **voting software** on a **computer** in the theatre. After the allotted time, the software produces a histogram or bar-chart of the results, which is displayed to the students using a **data projector** connected to the computer. The lecturer then chooses a course of action to respond to the results.

Equipment features and functionality

Each voting system has its own specific set of features and functionality and some of the major products are reviewed individually in section 10 (Appendix: System

specifications and costs). However, the common features of the major systems currently in use are summarised below.

Handset

Usually one handset is used by one student, but it is feasible for each to be used by a group working together.

Handsets can have one or multiple buttons (which are usually marked numerically). The single button handset is best used to answer simple binary question, for example by pressing to indicate a 'yes' response to question. There are advantages in this simplicity: "it requires little effort to understand the system, there is no possibility of the wrong button being pressed, and it causes minimal disruption and distraction when used" (Poulis *et al*, 1998). However, if the one-button system is used for multiple choice questions, it requires each response option to be offered in sequence rather than in parallel, thus lengthening the time for response. Most handsets allow multiple choice responses (and sometimes multiple selections), with up to ten answers available.

As well as transmitting the preferred option, with some systems (e.g. PRS) the handsets have buttons where the student can record low, medium or high confidence in the accuracy of their answer. This is helpful in analysing whether correct answers were chosen through luck or based on knowledge. (The ability to assess confidence about multiple choice assessment is another interest of staff at UCL – see, for example, Gardner-Medwin, 1995, and the recent successful FDTL bid on this topic: Gardner-Medwin, 2002.)

The handsets can be used anonymously so that only the number of the handset is known, not the individual students' name. However, the handsets have an ID number that can be mapped to a student's name. This allows the lecturer to see an individual's answer, either within the lecture or when reviewing responses at a later stage.

Draper (2002a) also identifies other desirable developments that may become available in future systems, including:

- The use of Personal Digital Assistants (PDAs) rather than handsets;
- The ability to enter multi-digit numbers;
- The ability to enter a sequence of digits rather than exactly one as an answer; and
- Free text entry.

Free text entry would allow the extension of feedback from the group:

> *We can at last address a fundamental problem of discussion groups (such as research seminars) where many people want to ask a question: which is the best question to take for the group as a whole? Using only voice, we cannot know what the set of candidate questions is without having them asked. With textual group responses, everyone's questions could appear in*

front of the speaker and/or facilitator, and could then be grouped, sequenced, and sorted by priority.

(Draper et al, 2002a).

The ability to use free text is available in the Discourse system. Using this system in the lecture theatre (it can also be used in a computer laboratory with PCs), the student has a wireless portable terminal (known as a Studycom) and not a handset with buttons. Importantly, however, this dedicated terminal is now being phased out in favour of PDAs or laptops that have been configured to transmit information to the lecturers' computer over a wireless local network. Discourse allows bi-directional free text: students can respond to the lecturer's question in their own words and the lecturer can share a response with the whole class by sending it to each student's computer, or to send a message to just one student. This environment has been used mainly in primary and secondary schools in the USA. However, in January 1999, a Discourse interactive electronic classroom was established in the department of medicine at the Royal Free Hospital and subsequently, others have been set up (Epstein, 2000).

Free text is also possible to a limited extent using the Series 8 system. Each handset has a small LCD panel that can display automated information (e.g. count down of time left for response). Text can also be sent to all, some, or individual handsets but the system does not allow the student to send a free-text message to the lecturer.

Voting software

Information from the handsets is sent to a local computer, where it is processed using a dedicated application. This software can display the number of the question being asked, the time allowed in which to answer and the number of attempts allowed. It can also be used to display the questions in a plain text format, thus obviating the need for additional presentation software if required.

Once the timer is started, students can then register their response. Acknowledgement of each response can be done in several ways. For example, using the PRS system, a series of cells are displayed on the data projector which then change colour as each answer is registered. If the students have been assigned a handset, it can also display their name; if used anonymously, it will just display the handset number. Responses can be revealed as they are made, or else hidden until all or a majority of students have responded. With the Reply system, acknowledgement is via the handset: a light comes on when the response is made and switched off when the response is received. With all systems, the software can then display a summary of the responses in a variety of ways such as bar-charts, histograms or a simple percentage.

The different software available provides additional functionality in a variety of ways. For example, the PRS software can record information, including the number of attempts made, the time taken to register an answer and the confidence levels. These results can be saved and used later, using standard software such as Microsoft Office to view the results. If the handsets have been used in named mode, then an individual's performance can be recorded, but in anonymous mode, only a summary is recorded. The differences in functionality would need to be considered when selecting a voting system.

Receiver and communications

The handsets transmit to the receiver using wireless (e.g. radio and infrared) technologies, depending on the particular system used. Radio is becoming more widely used than infrared since radio tends to be faster in operation and more accurate in receiving signals. It also operates over a greater range and does not need to be in direct line with the receiver, as is required for infrared. The radio frequency used is 433, which is licence exempt and standard across Europe.

The increased communication ability of radio is reflected in the hardware requirements. The Reply system, which uses radio, needs only one receiver for up to 650 handsets. The PRS system, which uses infrared, needs one primary receiver for the first 50 students and a secondary receiver for every additional 35 students. Thus a 250-seat lecture theatre would require seven receivers if using the infrared system.

3. Variety of uses in lecture theatre teaching

As with any technology, the design of the voting systems does not entirely predetermine its use. As has been noted in the reviewed literature, the effective use of such systems lies in how each lecturer uses it, not in the equipment or software itself.

> *Our initial impression is thus that the handsets do indeed support learning gains in the ways discussed in Draper et al. (2001), but that benefits depend, not directly on the mere technology, but on how well the particular way they are used on each occasion elicits thought and reflection in the learners.*
>
> *(Draper et al., 2002b)*

As a result the identified uses, as described below, need to be supported by effective lecturing skills suitable for using the medium to ensure their effective use. (This issue is explored further in Section 6: impact on staff skills and current teaching practice.)

This technology has been used in diverse ways in the studies reported in the literature, with students at all levels of study and from a range of subjects. For example, Poulis's study (1998) involved students from the faculties of industrial engineering and management science, electrical engineering, chemical engineering & chemistry, and applied physics, and the software was used both as an occasional and a regular feature within the lecture series studied. Further variety has arisen in its intended use: although this technology is mainly used for educational purposes, it has also been used for administrative and organisational processes within courses.

It is worth noting that many of the uses identified below can be (and sometimes already are) currently undertaken in lectures using non-technological methods. Thus these systems are not necessarily introducing new practices – instead, they allow existing practice to be enhanced. However, their presence in lecture theatres may serve to raise awareness about a range of pedagogic approaches that could be used in these settings. Examples of the kinds of approach that these systems support are presented in this section. The *advantages and benefits* of these possible uses over existing methods – and therefore the rationale for introducing a voting system – are discussed in the next section.

The Creation of a community

At the start of a new study group, voting systems can be used to create awareness of the group. This can contribute to the forming of the group identity and support any future teamwork. For example, Draper suggests that:

> *I might ask whether each student is straight from school or not, their gender, which faculty they belong to, whether they signed up for the course because it is their main interest, a side interest, or are just making up the number of courses they do.*
>
> *(Draper et al, 2002a)*

As well as engendering a group identity, this process allows the individual to place themselves within the context of the wider group.

Assessing understanding

Before the lecturer begins teaching, the voting system can be used to assess the level of understanding of a particular topic, ensuring that areas that are already well understood are not covered and highlighting areas in need of particular attention. As Herr comments,

> *I would lecture without fully appreciating how many were unprepared, what deficiencies some had in their math and science backgrounds and what misconceptions some might be holding.*
>
> *(Herr, 1994)*

The lecturer can then use the system to ask questions that "reveal the formative nature of misconceptions" (Poulis *et al*, 1998) making it easier for the lecturer to address those misunderstandings.

Initiating discussion

One of the main uses of the systems is to stimulate interest and initiate discussion. Draper (2002a) gives an example where the lecturer displays an multiple choice question (MCQ) and the learners register an answer that commits them to forming and recording an opinion. The lecturer then asks the class to discuss their answers with each other, and only afterwards reveals the correct answer.

Other variations include asking students to rework a question through discussion (Poulis *et al*, 1998), sometimes requiring a small group to achieve consensus on a single response (Burnstein *et al*, 2001).

Verification of comprehension

"Once a topic has been covered, the system can be used to assess understanding of the material covered" (Elliott, 2002). Use of a short test based on the material covered can allow a lecturer to ensure that the majority of the students have understood the material before moving to the next topic, or else to highlight topics that have not been sufficiently understood.

Experiments using human responses

Draper (2002a) gives several examples where a range of experiments can be directly demonstrated using the audience as participants and asking them to record their responses.

> *For instance visual illusions may be displayed and the equipment used to show what degree of uniformity of response is found. ... The performance of witnesses to a crime (including the effects of some well known biases) can be explored by showing a short film, followed by various questions about what was shown.*
>
> *(Draper et al, 2002a).*

It should be noted that Draper's use of the system is in the context of psychology teaching. However, comparable uses might be possible in subjects where it is important to demonstrate consensus or uniformity of opinion, for example when highlighting divergent understandings of a text in English or History.

Assessment and revision

The systems can be used for both formative assessment and in revision classes as practice for summative assessment. In these circumstances, the MCQs "are meant to test content knowledge, and perhaps are drawn from a bank used for formal assessment on the course" (Draper et al, 2002a).

Most studies show the systems being used for formative assessment. However, in one example (Burnstein *et al*, 2001), the answers given during the lectures using the handsets counted towards a substantial part (15-25%) of the final grade. (This clearly requires the system to be used in named mode.) However, Burnstein comments that this was only introduced once the system had been in use for a year, so both staff and students were familiar with the process.

Peer assessment

If a student has given a presentation, the systems can be used to get others students to mark their performance on various criteria. "The teacher can display (say) each of 10 criteria in turn, and get the other students to enter their mark for this anonymously but on the spot, with the totals displayed." (Draper et al, 2002a).

Focus and direction

Within a lecture, the students could be asked to use the system to indicate their preferences for topics to be covered within the class. Thus question items at the start of a class could be used to select a topic for detailed coverage allowing the lecturer to modify the lecture accordingly.

Student feedback on lecturer/lecture

The systems can be used for audit purposes in a similar way to the questionnaires already used for soliciting student feedback. Their advantage lies in the fact that they

can also be used more frequently as a quick poll to gain feedback on the pace and interest of an individual lecture.

Testing pre-class preparation

If the students are asked to prepare for a lecture, the system can be used to check that they have done the preparation to a satisfactory level (Burnstein *et al*, 2001).

Organisation

The voting systems can also be used for simple organisation, such as checking that all the students are ready for the lecturer to continue, or establishing preferences such as the timing of the next class.

Attendance

Keypads can be used in anonymous mode, but if used in named mode, the system can also be used to monitor attendance, which one lecturer felt to be an increasing issue (Draper *et al*, 2002b).

4. Improving lecturing: the potential benefits of voting systems

As identified in the previous section, whilst voting systems can support teaching and learning within lectures, any benefits will depend on how effectively they are used on each occasion. In order to judge whether the system does, indeed, enhance the lecture format, it is first necessary to identify the assumptions that are made about what counts as 'good' learning. From the reviewed literature, and the sources they draw from, three key principles have been identified:

- *Content transmission is not the most effective way of learning*. Jones (1999), for example, cites Dearn, who rejects the view that "teaching consists of organising and transmitting content, and that learning is the accurate recall of factual information to one of promoting active learning."

- *Students' active engagement with ideas and applications supports learning.* This view is most clearly advocated by Laurillard (2002), whose conversational framework is drawn upon as a rationale by many researchers in this area, but is clear in the majority of studies reviewed (e.g. Cooper *et al*, 1997). The principle underlying this framework is that learning results in the process of ongoing and adaptive dialogue between teacher and learner, supplemented by activities that provide an opportunity to apply ideas or practice skills.

- *Quality feedback should be provided to students*. Cue (1998) argues that "timely feedback and reinforcement are vital to the synthesis and integration processes" of learning. Jones (1999) adds that this feedback should be both timely and in the optimum setting for learning.

Traditionally, lectures have been seen as the teaching activity where there is the greatest tendency to emphasise content transmission over student engagement (see, e.g., Laurillard, 2002; Bligh, 1998). However, it is important to recognise that there is

a tendency to over-simplify this issue: there is a distinction between student *activity* and student *cognitive experiences*.

> *It is possible that interactive teaching will not automatically result in active cognitive experiences. A student may, for example, choose not to think deeply about the questions the lecturer asks. Similarly, traditional lecturing behaviour will not automatically result in passive students who are accepting the information without thinking critically about it. [… However,] even though it is possible for students to be mentally active during lectures while listening to a teacher's exposition, the chances are that more students will be mentally engaged when involved in learning activities like reading, writing, discussion and problem-solving*
>
> *(Van Dijk et al, 2001)*

Thus although interactive teaching does not *guarantee* an active learner, it is more likely to *encourage* active learning and positively influence student motivation.

It is possible to use more interactive teaching techniques within a lecture with or without using technology. This can be done explicitly, for example by introducing problem solving or pair discussions. It can also be done more subtly: "a traditional lecturing style, where the lecturer tries to activate students in a more implicit way, using e.g. humour and non-verbal behaviour, may also result in student involvement" (Van Dijk et al, 2001).

However, use of technology and the structure the system offers can make it easier to introduce interactivity. This ease may be particularly important for less confident lecturers who are seeking to extend their teaching repertoire. The system also has benefits over and above non-technological methods.

> *In a review of a number of applications (Draper, 1998), I argued that most applications showed no significant improvements over what they replaced, but that the few striking positive exceptions were characterised by "niche-based design": by a good fit between a particular learning situation and a specific technical solution. They were projects that had been inspired by identifying a specific weakness in current delivery, and had focussed technology on solving that problem rather than on replacing what had been adequately done before. Can the use of the classroom equipment described above meet the implied standard of justification?*
>
> *(Draper et al, 2002a)*

McCabe *et al* (2001a) observe that voting systems are different from other uses of Computer Aided Assessment (CAA) in that they are used to promote interaction between student and lecturer with the computer as the intermediary, whilst earlier forms of CAA tend be based on interaction between the student and the computer, with the lecturer preparing questions.

The implication of this is that voting systems should be able to support and promote good lecturing, even if they do not 'cause' it to happen in any simplistic way. There is some research evidence to support this: Poulis *et al* (1998) have also explored the impact of using a voting system on examination results. (He is careful to acknowledge the limitations of examinations but feels that they offer a reasonable indication of

understanding.) The end-of-course examination pass rate for a given course was measured over four years, with either the first 2 years or the last 2 years using a voting system. Measures were taken to ensure that the course covered the same amount of material regardless of using of the voting system, and the examinations were consistent. The results showed that mean pass rate of the lectures using the voting system "is significantly higher than that where conventional methods have been employed. Of equal importance is the reduction in the standard deviation of this average, indicating a more consistent level of comprehension throughout any given class, and year on year" (Poulis *et al*, 1998).

It may be suggested that such improvement is the result of a Hawthorne effect, whereby the novelty of being researched is what led to the observed improvement. However, a separate study by Halloran (1995) suggested that the reverse may in fact be true: that students are initially resistant to the technology (not least because it confounds their expectations of what lectures 'ought' to be like – cf. Van Dijk *et al*, 2001) but that they begin to learn more effectively once the novelty wears off.

The evidence thus far suggests that there are general benefits to be achieved from the use of voting systems within lectures. The remainder of this section will summarise the specific benefits that appear to contribute to this general effect. (These benefits arise from the kinds of uses outlined in Section 3, and are identified in comparison to traditional or more interactive lectures without the use of the system.)

Encouraging participation from each student

The lecture format can be seen as "large and impersonal", engendering a "reluctance to respond." (Burnstein *et al*, 2001). Even when the lecturer does try to use more interactive methods such as posing questions, "not all students can be asked to respond due to time limitations." (Cue, 1998).

The handsets allow the "active involvement of large numbers, not just one or two individuals" (McCabe *et al*, 2001a), requiring "each learner independently to generate an answer whereas otherwise only the handful who put their hands up really do this" (Draper et al, 2002a).

The fact that all students are responding means that the lecturer is receiving the summed responses of all students rather than from a sub-set of the group. This can help to highlight situations where a small group understands a topic whilst those who do not remain silent. Draper (2002b) illustrates this problem:

> *When I asked the students what I thought was a simple question identifying the FCoV carrier cat! …Although most (68%) got it right, an astonishing number chose one of the other cats.*
>
> *(Draper et al, 2002b)*

Supporting feedback about the group's understanding

The voting software produces a summary of responses that are then displayed to all the students. This means that, "regardless of group size, both audience and presenter get to know the distribution of responses (alternatives chosen), and how their own

personal response relates to that distribution, but however without knowing who chose what" (Draper et al, 2002a). This can provide a useful opportunity for learning.

> *People do not feel individually exposed because the replies are anonymous but they do watch the distribution of answers as it appears on the screen. That by itself may be a learning experience as they then consider other possible answers.*
>
> *(Draper et al, 2002b)*

Seeing the summary of group responses may also help encourage a feeling of community. "Seeing whether they all got it right, or that quite a lot had trouble: tells them whether and how to talk to each other about it" (Draper, 2002c).

Providing privacy and freedom to express choice

One of the greatest advantages of handsets is that they offer the opportunity to make the lecture "more interactive without appearing threatening" (Jones, 1999). It is likely that many students hold back from answering or responding through peer pressure or the potential embarrassment of publicly giving the wrong answer. This in turn may mean that only the more confident or able students respond, when they are least in need of lecturer attention.

> *It was great, because the students who got the wrong answer are very likely the same ones who never utter a word in interactive lectures and it gave them a chance to participate anonymously.*
>
> *(Draper et al, 2002b)*

Voting systems offer better privacy that conventional forms of soliciting student response, such as a 'show of hands' poll or the use of coloured cards (where students select a colour to correspond to their 'vote'). However, depending on the way in which information is aggregated and displayed, students may still be able to view each other's responses and may thus be influenced in their choice rather than selecting an answer independently.

The privacy of selection also encourages the individual to choose the answer they incline to "rather than only a choice they feel able to explain and justify to others. These are quite often different both in science learning and in social processes" (Draper *et al*, 2002a).

Privacy can also be helpful in gaining feedback from students who may not wish to mention or express a genuine opinion to the teacher on a face to face basis.

Providing timely feedback

Timely feedback to students about their performance can be greatly assisted by the use of voting systems. Because answers are marked electronically and automatically, feedback on performance and presentation of the right answer(s) can be achieved quickly. Students can then see how their performance compares to that of the rest of the group. When used for peer assessment (for example, in student presentations), students can gain immediate feedback on their work.

The lecturer can also gain feedback in this way. They can, for example, see how well the class has performed and use the information immediately to provide appropriate action such as re-describing a misunderstood item.

> *With the handsets I could see exactly which points I had not conveyed clearly and could rectify it straight away….. The results of their tests gave me some idea of how they had understood the concepts, and if it had been obvious that they were not following what was going on it would have allowed me to reprise the previous section.*
>
> *(Draper et al, 2002b)*

Feedback can also be solicited in the form of student judgements about the course. Questionnaires for overall evaluation tend to be issued at the end of a course or module, which may prove too late to benefit the current cohort. Voting systems can be used to take more regular evaluation allowing modifications to be made during the academic session, rather than afterwards.

Supporting accuracy and detail

Voting systems can provide a more accurate counting of the responses than traditional ways of soliciting student feedback. According to Draper, "most presenters will only estimate shows of hands to about the nearest 20%, unless they have the patience to pursue and count exactly, even with large groups". Draper also suggests that "the accuracy may have a small but not negligible value in making all participants feel their views count, and are not just lost in crudely approximate estimates" (Draper et al, 2002a).

The ability for students to enter their level of confidence in their answer also helps provide more detailed data about student learning.

Summary: Encouraging active learning

Whilst all of the above activities help to create an active and engaging atmosphere, it is important to keep in mind Van Dijk et al's warning (2001) that being active and cognitive engagement are not the same thing. It remains perfectly possible for students to take part in structured activities in a superficial and disengaged way. However, working such activities into teaching will help to create an atmosphere in which true engagement is encouraged and supported (Martin, 1999). Thus the benefits associated with voting systems are likely to result from the changes in teaching practice that accompany their introduction:

> *The biggest learning gains, however, are likely to come from the much better and quicker feedback from learners to teachers, allowing better attunement of the delivery; and from the method of teaching by questions i.e. of discussions in class (whether in small groups, plenaries, or a combination) initiated by well designed questions and by getting each individual to start by committing to an initial position.*
>
> *(Draper et al, 2002a).*

Students are thus actively involved throughout the lecture, from registering a response and therefore maintaining an interest in the answer through to seeing their responses

influence what happens next. Burnstein (2001), for example, reported that as a result, "the students make genuine attempts to prepare for the reading quizzes and remain alert throughout the lecture period." Draper *et al* (2002b) also suggest that "if the students are to answer the questions in a way that will be helpful to them, they have to reflect more on what they have learnt and how they are learning".

5. Student opinion on and perceptions of voting systems

Several of the papers reviewed reported informally on feedback from their students or else conducted more formal evaluation studies of students' perceptions of and views about the systems. This section summarises both the informal and formal feedback that was reported.

General feedback on the systems

Anecdotally, reports from lecturers about the students' reaction seem to be broadly positive:

- "Students are generally, although not universally, enthusiastic about this approach, even over long periods" (Draper *et al*, 2002a).

- "Even in the beginning, student acceptance was surprisingly tolerant and the keypad system always did receive a majority of positive votes" (Burnstein *et al*, 2001).

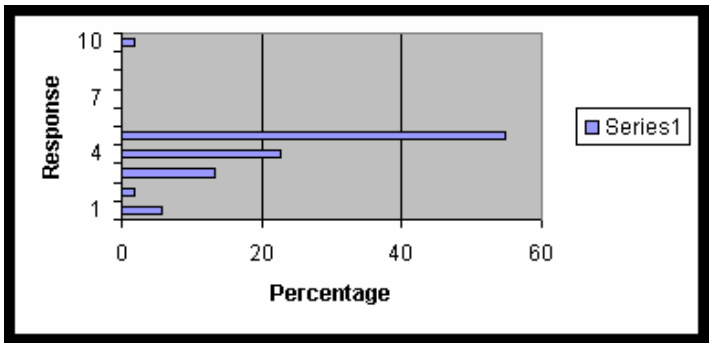
- "The students rapidly accepted the PRS as a standard teaching tool, and did not seem tempted either to take the handsets away or to 'fiddle' with them during lectures" (Elliott, 2002).

More specific evaluation about the usefulness of the voting system also seemed to show a positive student perspective:

- "When asked if they regard the interactive equipment as an advantage or not, classes typically show a spread of opinion such as 70% for it, 20% indifferent, 10% definitely opposed to it" (Draper *et al*, 2002a).

- "61 students reported using handsets in Logic lectures (level 2) and rated their usefulness. The percentage of students who rated them in each category is shown below: [In table format:] Extremely useful, 18.0%; Very useful, 21.3%; Useful, 37.7%; Not very useful, 21.3%; Not at all useful, 0.0%; No rating, 1.6%" (Draper *et al*, 2002b).

- "The final word can be given to students who have been asked a range of questions to evaluate our use of the group response system, by using the system itself. A typical response was in answer to the question: "Does the use of PRS allow more class participation in revision classes?" (1=strongly disagree 5=strongly agree). The responses shown in Figure 11 show the strong level of agreement" (McCabe *et al*, 2001b).



It is possible to conjecture that the positive response could be a result of the novelty of such a system so that students are simply attracted by the novel lecture format. However, Poulis notes that the system has been in place for a considerable time at his institution and that the familiarity of the system should thus mitigate any such effects.

However, it is worth noting that students' perceptions and ratings may be influenced by other factors. Cue (1998) reports on the evaluation of two physics survey courses. When asked to rate the statement, "I attend classes [using the voting system] more regularly than I would the more traditional lecture classes", the distribution is mainly around "Agree Strongly" for the first course (Phys001) but centred nearly at "Neutral" for the second (Phys002). Cue identified the following factors as influencing responses:

(a) PRS was used in almost every class meeting of Phys001 but only at most once a week in the case of Phys002;

(b) The identities of the student respondents were recorded ("known" mode) in Phys001 but not in Phys002 ("anonymous" mode); and

(c) PRS was used occasionally to conduct quizzes (weighted as 10% of the course grade) in Phys-001 but not in Phys002.

Interestingly, although the majority of students appear positive in these examples, there is a significant minority that is either indifferent or negative about the system. However, none of these studies reported any detailed evaluation about the perceptions of this minority.

It is important to note that such value of self-reported perceptions was called into question by the study by Van Dijk *et al* (2001). In this study, the lecturers' attempts to engage the students using techniques such as humour proved to be just as effective at motivating students as using new technology or peer interaction. However, whilst the students were significantly more motivated by the use of voting system software, observation of the lectures suggests that they were actually less active – a claim supported by the *lower* test scores when using voting systems. (Use of the voting system and peer interaction, however, proved at least as effective as traditional but humourous lecturing with good use of non-verbal behaviour.) This emphasises, again, the conclusion that the adoption of technology does not 'cause' good teaching. Similarly, the comparison by Halloran (1995) showed no significant difference between lectures with and without keypads, although observation suggested that a

students' learning improved as the novelty (and thus intrusiveness) of the new technology wore off.

The reasons for students' perceptions of the systems

Some of the studies mentioned above attempted to go beyond a simple judgement about students' likes and dislikes in order to explore the motives that prompted these responses. However, some of these explorations proved more informative than others.

Cue (1998), for example, asked the students to rate statements such as, "I do more thinking in PRS classes than in lecture classes", "Knowing how my classmates respond to questions in class increases my interest in the subject matter" and "PRS helps me learn the subject matter of this course in greater depth". All such statements were rated more highly in the course where the system was used regularly. Although this reinforces the expressed preferences of the students, it does little to explain the motives that prompted these opinions.

Poulis (1998) also compared the responses of students who had used a voting system and those who had not, asking then to respond to the question, "do lectures contribute much/little to a better understanding of the subject?". Using a Likert scale from one to nine (nine indicating a very strong positive), the mean score for students not using a voting system was 5.1 while for students using a voting system it was 6.7. This indicates that there was a preference for the lecture when the voting system is used. Again, however, this study fails to explain the reasons for this preference.

One of the more detailed studies of motivation for preference was conducted by Draper (Draper *et al*, 2002b). The methods used in this study included observation of lectures using handsets, informal discussion with students, written comments from students and questionnaires. This has allowed the study to focus on comments from all student groups, from those who rated the handsets 'extremely useful' to those who rated them as 'not very useful'.

A summary of the perceived benefits and problems are given in Table 1.

Benefits	Problems
Using handsets is fun and breaks up the lecture	Setting up and use of handsets takes up too much time in lectures
Makes lectures more interactive/ interesting and involves the whole class	Can distract from the learning point entirely
I like the ability to contribute opinion to the lecture and it lets me see what others think about it too	Sometimes it is not clear what I am supposed to be voting for
The anonymity allows students to answer without embarrassing themselves	Main focus of lecture seems to be on handset use and not on course content
Gives me an idea of how I am doing in relation to rest of class	The questions sometimes seem to be for the benefit of the lecturer and future students and not us
Checks whether you are understanding it as well as you think you are	Annoying students who persist in pressing their buttons and cause problems for people trying to make an initial vote
Allows problem areas to be identified	Not completely anonymous in some situations
Lecturers can change what they do depending on what students are finding difficult	Some students could vote randomly and mislead the lecturer
Gives a measure of how well the lecturer is putting the ideas across	Sometimes the lecturer seems to be asking questions just for the sake of it

Table 1: Motivations for students' perceptions about voting systems

The benefits identified concur with the uses and advantages identified in the previous sections, largely concerning engagement and stimulation, feedback (allowing the lecturer to adapt their lesson plan), anonymity and the ability to compare oneself with peers. They also echo the findings of Halloran (1995), who found that students valued the way that use of the system made classes more interesting and better organised, and allowed them to focus on areas of weakness without exposing these to the group.

However, it is useful that the perceived disadvantages are also identified; these focus on the intrusiveness of the technology, doubts about how seriously other students take the exercise, concern that technology is used for its own sake and problems with anonymity or the form of questions. These issues will be considered in more detail in the following sections (Sections 5 and 6); however, it is interesting to compare these concerns with the findings of Van Dijk *et al*'s study (2001), which emphasises both that such self-reported data should be interpreted with caution but also that the poorly executed or ill-conceived use of technology can be counter-productive.

6. Impact on staff skills and current teaching practice

The previous sections have focused on how voting systems can be used the potential benefits over and above other teaching activities and students' perceptions of this new form of teaching. However, as has been noted repeatedly, the most crucial factor as to whether this potential is realised is how well the system is used on each occasion to improve learning.

> *Instructional design mostly isn't in the equipment or software, but in how each teacher uses it. That is a lesson which perhaps the rest of the learning technology field should take more to heart if the aim is in fact to improve learning rather than to promote the glamour of machines.*
>
> *(Draper et al, 2002a)*

This section thus focuses on the required skills and approach of lecturing staff.

Rethinking the lecture format to achieve effective integration

Student feedback has identified the problems that "sometimes the lecturer seems to be asking questions just for the sake of it" and that this "can distract from the learning point entirely" (Draper *et al*, 2002b). If use of the system is to be not just an additional tool used 'for the sake of it' but an integral part of the learning and teaching experience, the lecturer needs to be able to make such interactions an integral part of the lecture. This skill can take some time to develop:

> *Our first year's experience was positive in spite of ... inexperience in "weaving" questions into the lecture.*
>
> *(Burnstein et al, 2001)*

Similarly, the questions need to be pitched at an appropriate level. As one lecturer commented, "getting the level of the questions right takes time and experience. My questions were too easy (or else I explain things very well)" (Draper *et al*, 2002b). Fortunately, UCL has staff with expertise in the design and use of objective testing (e.g. Bull & McKenna, 2001).

However, the skill most commonly identified as being of importance was that of altering and adapting the structure and nature of the lecture according to the feedback provided by the answers to questions. Whilst the system has the power to give better, faster and more detailed feedback to the lecturer, the lecturer needs to be prepared to act on that information so as to respond to students' needs.

For example, Poulis *et al* (1998) describes the process involved when a difficulty in comprehension is signalled:

> *When this occurs, the lecturer takes the students through the problem step by step and then asks a supplementary question (often on the blackboard) to check the new level of student understanding. If it becomes obvious that the students are completely comfortable with a topic, for example by questions being answered very rapidly and correctly, the redundant questions are discarded.*
>
> *(Poulis et al, 1998)*

Similarly, Burnstein & Lederman (2001) observe that:

> *As the hardware and software allow the insertion of spontaneous questions into a set of prepared questions. ...we expect that a lecturer experienced with the system can, if appropriate, generate questions 'on the fly'. These are in fact often stimulated by class response to some previous question. [... However,] the ability to weave questions into the*

> *lecture and generate impromptu questions probably takes a semester or so of experience.*
>
> *(Burnstein & Lederman, 2001)*

This ability to respond and adapt also applies to feedback on the lecture (as a process, in contrast to feedback on the content). Draper (2002a) cites as an advantage that **"**on the spot evaluation might be done by asking students what the best and worst issues are in the teaching at present", and that "normally it would take days or weeks: but the whole 2-phase cycle could be done within 10 minutes." However, it may well be that only a confident and adept lecturer would be able to rework their lecture immediately in response to such feedback.

It is important to realise that the traditional lecture format also needs adaptation, as the time required for students to discuss and reflect means that less material can be presented. Clearly the extent of this will depend on the level of use of the system in any one lecture; however, it is obvious that allowances will need to made when introducing a new technique or feature such as this. Poulis *et al* (1998) observe that, in their context, "a lecture consists of around 20 min of [voting system] functions interspersed between 25 min of conventional lecturing." Similarly, Elliott (2002) used only five or so multiple choice questions during any 50 minute lecture, but still felt that less material could be covered. Nonetheless, these authors felt that the sacrifice of breadth was worthwhile to support the increased depth of understanding.

> *I feel that this is more than compensated by my greater awareness concerning the amount of material students understood.*
>
> *(Elliot, 2002)*

Such examples indicate the necessity of rethinking lecturing when introducing new techniques. They also suggest that it may be necessary to place more emphasis on planning in advance. Burnstein *et al* (2001) suggest that although "all keypad questions do not necessarily need to be prepared in advance of the lecture[,] we feel that it is desirable; the result improves as questions are more carefully integrated into the lecture." In Draper *et al*'s evaluation (2002b), one lecturer commented that, "I would need then to decide what do when the students are having difficulties. I would need a plan B which would involve a fuller explanation. So it would affect the way I plan lectures. But why not?"

Developing technical confidence and skills

In incorporating any new technology, the lecturer needs to be able to use the equipment competently. Feedback has shown that the level of technical skills required for lecture voting systems is relatively low (e.g. Draper *et al*, 2002b).

However, whilst basic operation might be simple, it appears to be harder to use the technology whilst also delivering the lecture and carrying out other common activities such as distributing handouts, particularly when doing since it can be "extremely easy to get anxious with hundreds of students watching" (Draper *et al*, 2002b).

It is clear from the studies reviewed that the lecturer must feel comfortable and in control of the technology as well as being able to explain to the students about how the system works so that there is minimal confusion in its subsequent operation (Van

Dijk *et al*, 2001). Then, throughout the session, the lecturer must make judgements and giving clear instructions about what action is required when.

> *When a … problem is presented the lecturer pauses and asks the students to press their buttons when they feel they have an answer … and waits until 60-70% of the students have indicated that they do. This figure is a product of experience, and balances the need to give students time to answer and the boredom of those who have already completed the task.*
>
> *(Poulis et al, 1998)*

In order to develop these skills, it is suggested in the reviewed literature that lecturers practise using the software and rehearse in a lecture theatre or a hands-on workshop. However, there are also examples where an assistant was present to provide technical support, at least in the early stages of using the equipment. All of these solutions have resource implications, which are discussed in the next section.

7. Considerations for successful adoption and integration

Burnstein *et al* (2001) argue that "the principal barrier to further use and evaluation of keypad merits in our science courses is simply inertia on the part of faculty." Similarly, Cue (1998) observed,

> *It is one thing to convince people of the effectiveness of the interactive engagement approach and another to convince them to adopt interactive engagement for their next class if our previous experience in introducing the classroom use of the overhead projector, computer and other audiovisual equipment are of any guide. Thus, no effort was spared to make the use of [the system] as convenient as possible.*
>
> *(Cue, 1998)*

Both of these statements indicate that if this technology is to be adopted and used effectively, careful consideration must be given to (a) supporting these processes so as to encourage use and (b) reducing any barriers that may prevent uptake. The main issues relevant to this process are identified below, focusing on academic development and resources (financial and human, both start-up and ongoing).

Academic development and conceptions of teaching

The motivation to using a voting system effectively arises from the view that active learning is worthwhile. Van Dijk *et al* (2001) observe that

> *A lot of lecturers are reluctant to accept claims on the merits of activating instruction, which can be found in educational theory. Activating students requires time, which lecturers would normally devote to lecturing. They often voice the concern that they will not get enough material across when giving interactive lectures and that this consequently will negatively affect the student learning.*
>
> *(Van Dijk et al, 2001)*

If a lecturer holds the conception that lectures are best used to present content, they will be resistant to changing their teaching style to incorporate interactivity. Thus they

are unlikely to be convinced by the potential of a voting system, or else may adopt the system but use ineffectively rather than supporting interactive teaching (Simpson, 2001).

It may therefore be most constructive not to introduce a voting system as merely a technical tool but in conjunction with opportunities to explore conceptions of teaching.

Similarly, Van Dijk *et al* (2001) comment on the importance of student expectations with respect to lecturing practices.

> *The trend in the data seems to implicate that for interactive lecturing practices, giving a good quality lecture and creating a friendly and interactive atmosphere are not enough. It appears to be important for lecturers to be explicit about their lecturing style and the purpose of their working method.*
>
> *(Van Dijk et al, 2001)*

Again, the lecturer must be convinced of the potential in order to be able to involve the students in this way.

Providing support to help academic staff integrate the voting system successfully

If academic staff are to be supported in their investigation of alternative conceptions of teaching, College will need to provide fora in which this can take place. Some opportunities already exist (for example, the secondment scheme and MA in Academic Practice offered by Education & Professional Development); however, if these innovations are to be adopted more widely, then comparable opportunities may need to be provided within faculties or departments. Without conceptions of teaching that place value on active engagement, the adoption of these technologies is likely to prove counter-productive.

However, irrespective of the conception of teaching held by the lecturer, there are resource implications associated with the adoption of these technologies. Pedagogic support and guidance has already been noted; there is also a requirement to provide technical assistance (Burnstein *et al*, 2001) which is likely to have implications for staffing levels in Media Resources and Information Systems.

Resourcing

As well as the 'soft' costs of staff time, there are direct cost implications associated with the adoption of such systems. Costs vary greatly depending on the number of students (which determines the number of handsets that must be purchased) and whether a radio or infrared system is selected. Further detail about the variation in costs between systems is available in Section 10 (Appendix: System specifications and costs). However, to cater for a lecture of 250 students, the costs range between £10,000 and £60,000. Clearly, the potential benefits and levels of anticipated use will need to be carefully considered before making such an investment.

Selecting the appropriate technology

As mentioned in the introduction, systems can be either radio or infrared. Radio is increasingly common, although infrared is the cheaper option, since radio-based systems offer advantages such as not needing to be in a direct line with the receiver; registering votes more quickly; avoiding conflict when several students vote at the same time; and allowing a greater range between handset and receiver. Given this pay-off between costs and features, the intended location and extent of use must be considered against the various system specifications and prices to ensure a 'good fit' is achieved.

The need for permanent installation

It is feasible to move the voting system equipment from site to site:

> *We use a suitcase holding 40 keypads for transporting our system from building to building. To move 75 keypads, we have constructed a storage box on wheels. Larger portable storage units for keypads can be constructed or are available commercially.*
>
> *(Burnstein et al, 2001)*

However, clearly the effort involved in such an exercise can rapidly become a barrier.

> *My problem was carting over 16 keypads, radio stuff, PC and projector, setting it all up, then getting all the keypads off the students, disassembling it all and carting it back! This put a damper on my enthusiasm.*
>
> *(Jones, personal communication, 2002)*

Feedback from students also confirms this.

> *The main problem identified by students is that too much time sometimes is involved in setting up the equipment in lecture theatres other than the Boyd Orr where the receivers are permanently installed ... Factors like these can affect the views of students and lecturers.*
>
> *(Draper et al, 2002b)*

The implementation plan at Hong Kong University of Science and Technology (HKUST) addresses this issue by proposing that receivers and software be installed in all lecture theatres and classrooms, so that only the handsets need to be moved (Cue, 1998).

Although portability allows the system to be used in a variety of rooms, it appears from the literature that locating the facility permanently in one well-chosen theatre may lead to greater and more effective use. However, such a set-up may restrict the number of lecturers who can use the equipment, particularly if the theatre is booked by lecturers not using the system. Thus in order to make maximum use of such a resource, some priority system for room bookings may have to be introduced.

In addition, a number of other practical problems have been identified. These include handset batteries running out (although students can use a spare handset), set-up

problems with other equipment such as data projectors and trouble installing the software on some laptops and PCs. All of these issues highlight the need for sufficient and timely technical and audio-visual support.

Efficient administration of handsets

Unless the handsets are part of a wired system or tethered to the seating, they are portable. There are thus distribution and security issues involved in ensuring that students have the handsets when required but that the equipment is not left unsecured when unused.

Some solutions to this problem have been proposed. Burnstein *et al* (2001), for example, used a system where,

> *with an average of 55 in each class, students were assigned a numbered keypad for the course. Before each class, they exchanged their ID card for a keypad. […] We do not carefully monitor the distribution and return of keypads, except that students are asked to leave their ID cards in the keypad storage slot and at the end of class reverse the procedure. Occasionally keypads are missing, but are apparently taken accidentally since they always are returned by the next lecture.*
>
> *(Burnstein et al, 2001)*

However, as noted elsewhere, carrying out additional technical activities in addition to the normal demands of lecturing can be demanding (Draper *et al*, 2002b). The University of Glasgow employed teaching assistants to resolve this problem:

> *Other assistants turn up with the handsets, supervise distribution and re-collection at the end. With large classes (200-300) it may be best if you provide one or two student assistants yourself to help with this: warn them to turn up a few minutes early, and help with the distribution.*
>
> *(Draper, 2000c)*

Another approach is to issue and loan handsets on a more long-term basis. Hong Kong University of Science and Technology loan handsets for the duration of each student's study, with the administration of this service provided by the Library. Arizona State University operates a system whereby the student buys the handset from the campus bookstore and can sell it back at the end of the semester for a reduced cost. (See http://acept.la.asu.edu/courses/phs110/index.html for further details.) However, these solutions do not rule out the problem of students forgetting to bring their handsets – when Draper used this approach he reported that "about a third would fail to bring them on any one day" (2002c).

Thus locating this resource permanently in one space may make it easier to use and administrate, as well as potentially increasing the level of its use.

Operating an efficient technical and administrative service

From experience, Draper (2002c) observes that, "It is *much* less stressful for a lecturer, no matter how practised at this, if there are assistants to fetch and set up the

equipment, leaving the lecturer to supervise the occasion". He goes on to list the roles they may take:

- "Consultants for getting you set up in advance, installing software on your laptop and/or training you on a borrowed PC laptop.
- An assistant to take the receivers and laptop to the lecture theatre and set up.
- Assistants to dispense and recover the handsets."

This is also supported by experiences at HKUST, where part of their implementation plan included "assigning a trained teaching assistant to sit in as a back-up technical helper to new faculty users the first few times they use [the system] in their class" (Cue, 1998). Student feedback shows that they notice an inefficient set-up process, resenting the fact that this takes up time that could be used for teaching (Draper et al., 2002b). However, provision of such support has resource implications, so that advance arrangements would be necessary for use of such services (Draper, 2000c).

8. Conclusions and recommendations

In this report, an overview has been offered of the literature on the use of electronic voting systems to support lectures. From this review, a number of conclusions can be drawn.

Firstly, voting systems are a tool rather than a teaching approach. As such, there is no guarantee that their adoption will 'cause' good learning. Indeed, when used with poor preparation or for the sake of using new technology, students were clear in their criticisms of the system. However, there is evidence that when these tools are used by a teacher who values students' active engagement they support increased motivation and attainment. Their role in supporting feedback on the learning process is particularly valuable in this respect. Also, the literature suggests that staff who are seeking to be more interactive in their lecturing style welcome the provision of a tool that supports this.

Secondly, such systems represent an opportunity to improve lecturing. The emphasis on engagement and interaction can prompt lecturers to rethink their conception of teaching, revising widely-held opinions that the primary purpose of lectures should be broad coverage of a topic. Their presence can facilitate a variety of teaching practices that promote interaction and engagement, although it should be noted that many of these can be replicated (albeit with greater effort) without such a system.

Thirdly, introducing new forms of technology into lecturing has resource implications. There are direct costs associated with the purchase and installation of such systems (in the region of £10,000 to £60,000 for a lecture theatre for 250 students); in addition, resource will need to be made available in terms of time for the lecturer (to learn how to use the system and reflect on how it will change their teaching), for support staff (including Media Resources and Information Services) and potentially for pedagogic support (for example through involvement in a SCILTA project, a secondment to EPD or participation in a reflective forum such as the MA in Academic Practice).

Fourthly, these systems would fit well with and build upon research and developments already undertaken at UCL, for example in the areas of technology and lecturing, confidence assessment and objective testing. Organisational structures suitable to support such a development are also in place (for example, in Media Resources) although it is recognised that this additional call on these services may require resource to be set aside for staff time. Specifically, the current use of the Discourse system on the Royal Free Campus (Epstein *et al*, 2000; Van Den Bergh, 2002) demonstrates the feasibility and desirability of such an approach, and the existing site licence (covering the Royal Free, Bloomsbury and Whittington campuses) would reduce the initial outlay required for such a system. In addition, the proposed developments of the system so that it can be operated using PDAs or laptops over a wireless network would remove the need for separately-purchased specialist equipment to be installed. As such, this would seem an obvious first choice for wider use at UCL, particularly if it proved feasible to support wireless networking within specific lecture spaces and students' purchase of suitably-configured standard laptops (for example, through the proposed Student Notebook Initiative).

Finally, decisions would need to be taken to address practical issues such as the installation and mobility of the resource. From the studies described in the literature, it would seem there are great advantages to having such a system permanently installed in a single location. However, for staff to make use of this, a priority system might need to be introduced in the room bookings process.

In summary, voting systems do appear to have the potential to enhance learning and motivation, as well as providing variety and engagement within lectures. They also build naturally on existing initiatives undertaken within college. Provided that adequate resources can be made available to support lecturers interested in using such a tool, it would appear that the purchase and installation of such a system in one centrally-bookable lecture theatre would be an asset to learning at teaching.

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10. Appendix: System specifications and costs

Comment: To be completed – I will do 3 systems and have just received the bumpf from all of them to day so will read this w/e. I have requested estimated costs based on 250 students to give us a ballpark figure.

The appendix aims to give an indication of three popular voting systems by outlining features, components, standard costs and an estimate for use in a 250-seat lecture theatre. These summaries are based on publicity information and communications with the suppliers rather than independent studies. It is therefore recommended that a more detailed costing be produced for any system being considered for purchase by UCL.

Contact details of one regional supplier are given for each system; however, it is important to note that there may be alternative suppliers.

Discourse

The Discourse system is from ETS Technologies.

Features

- Can be used in computing laboratories or in a lecture theatre with portable terminals (Studycom). The Studycom is being phased out - now using radio technology in conjunction with student PCs, laptops and PDAs.
- Executable file automatically transmitted to the student PDA to allow Discourse to operate.
- Allows bi-directional free text: students can respond to the lecturer's question in their own words and the lecturer can share a response with the whole class by sending it to each student's computer, or to send a message to just one student.
- Two approaches when using free text responses: for small groups of students, the lecturer can look at all of the responses; for larger groups, can select several answers to look at. However, all students are required to answer. All responses can be saved and then looked at after the lecture.
- Also used for assessment with automatic marking

Essential components and costs

Component	Cost
Teacher Licence	£1900*
Receivers installed in lecture theatre	?
Student licence (per concurrent user)	£20
PDA with network card for each student	£350**

* software can be installed on all lecturer computers but only 1 concurrent session allowed per teacher licence

** estimated cost

Estimate for 250-seat lecture theatre

Component	Quantity	Cost
Starter pack	1	£1900
Student licence	250	£5000
Handset for each student	250	£87,500
	TOTAL	**£94,400**

Regional supplier and contact

Ian Lucas

Tel: 0208 922 6404

Email: ilucas@ets-europe.org

Reply Website
http://www.etstechnologies.com/welcome-all.htm
http://www.discourse.co.uk

Personal Response System (PRS)

PRS was developed by Professor Nelson Cue at Hong Kong University of Science and Technology and then licensed to Varitronix Ltd. for commercial distribution – thus the origins and main market are educational.

Features

- Uses infra-red wireless communications, so handsets need to be aimed at the receiver to ensure the signal is received, multiple receivers are required and must be carefully located in the lecture theatre.
- Handsets include option to attach a confidence level (high, medium or low) to the answer sent.
- Has two modes of operation, named and anonymous.
- Confirmation that answer has been received is via the computer display. For each handset, a numbered box is displayed which changes colour when then a response is received.
- Software is site licensed. Upgrades do become available, sometimes at additional costs.
- PRS software v.2.46 or after is compatible with Microsoft PowerPoint.

Essential components and costs

Component	Cost
ID programmer - includes the programmer software and cables	£125
Primary receiver (for the first 50 students), software, cables and manual	£128
A further secondary receiver (for each additional set of 35 students) and cables	£125
Handset for each student	£35

Estimate for 250-seat lecture theatre

Component	Quantity	Cost
ID programmer	1	£125
Primary receiver	1	£128
A further secondary receiver (for every additional 35 students) and cables	6	£750
Handset for each student	250	£8750
	TOTAL	**£9753**

Regional supplier
Sean Hughes
Varitronix (UK) Ltd, Display House, 3 Milbanke Court, Milbanke Way, Bracknell, Berkshire, RG12 1RP
Tel: 01344 303077
Email: sean@varitronixuk.ltd.uk

PRS Websites
http://www.educue.com
http://www.varitronix.com/product_prs.php

Reply System

The Reply system is manufactured by Fleetwood, and claims to be world's largest selling wireless voting system.

Features

- Uses radio wireless communications, so only one receiver needed. Handsets do not need a direct line of sight with the receiver unit or to be pointed at the receiver unit
- No option to attach a confidence level (high, medium or low) to the answer sent. To do so would require asking a second question about how confident the student felt about their answers and matching the two responses
- All software operates anonymously, so number of keypad would need to be mapped against a student name to get information on an individual performance.

- Confirmation that answer has been received is via the handset, using a light that comes on when and response is made and switched off when the response is received.
- No 'in-house' developed software; about 20 several businesses develop and sell Reply-compliant software which vary according to intended use e.g. emphasis could be on presentation or statistical analysis after the lecture. Synthesis is the software "written specifically for the training and education market".
- Integrates with PowerPoint

Essential components and costs

Component	Cost
Software	Various, according to purpose
Receiver	£1,050
Handset for each student	£165

Estimate for 250-seat lecture theatre

Component	Quantity	Cost
Software (quote for Synthesis for use with 250 students)	n/a	£1,900
Receiver	1	£1,050
Handset for each student	250	£41250
	TOTAL	**£44200**

A cut-down version of the Reply, called Reply EZ, will be available from next year. EZ will be limited to 50 handsets per receiver. Costs are estimated at £100 for a handset, £500 for a receiver and £1,000 Synthesis software.

Regional supplier
Russell Collins
TeamTalk Interactive, 26 Highgrove Hill, Great Holm, Milton Keynes, Bucks, MK8 9AG
Tel: 01908 565121
Email: sales@teamtalk.co.uk

Reply Website
http://www.replysystems.com

Series 8

The Series 8 system is manufactured by XTOL. XTOL is the sister company of Group Dynamics which claim to be "responsible for introducing the whole concept of electronic voting to the marketplace since 1983".

Features

- Uses radio wireless communications, so only one receiver needed. Handsets do not need a direct line of sight with the receiver unit or to be pointed at the receiver unit.
- Handsets include a small LCD panel that can display automated information (e.g. count down of time left for response). Text can also be sent to all, some, or individual handsets.
- No option to attach a confidence level (high, medium or low) to the answer sent.
- Comes with software although most recent release, PowerQ, (a PowerPoint add-in) has an initial cost per handset and an annual fee thereafter. Other software includes 'expansion modules' which address specialist needs. For example, using the assessment module allows each handset to store up to 220 responses, then for responses to be downloaded to be a PC and automatically marked.

Essential components and costs

Component	Cost
Starter pack (8 handsets plus all components to run system)	£2,750
Handset for each student	£238

Estimate for 250-seat lecture theatre

Component	Quantity	Cost
Starter pack	1	£2,750
Handset for each student	250	£59, 500 *
	TOTAL	**£62, 250 ***

*discounts apply to volume so actual price would be lower than given estimate

Regional supplier and contact
Pat McGuane
Xtol Limited, 21 Wandsworth Road, Greenford, Middlesex, UB6 7LQ
Tel: 020 8991 9500
Email: info@xtol.co.uk

Reply Website
http://www.xtol.co.uk