Using Electronic Voting Systems for Active Learning

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Abstract

The focus of this paper is the use of Electronic Voting Systems to engage engineering students in the learning of mathematics. Some academic staff members from the Mathematics Education Centre at Loughborough University have been using Electronic Voting Systems since 2007/2008 year to teach mathematics to undergraduate students from Mechanical, Automotive and Aeronautical Engineering departments. A study was designed to investigate the views of staff and affected students about the use of Electronic Voting Systems in mathematics classes. At the end of the first year of use, staff generally perceived them as an effective teaching tool. However there remained many unanswered questions for staff. In particular, how do we ascertain the types of questions which better engage students and which facilitate deeper learning?

This paper discusses findings from the literature. It then describes the setting up of a University-wide staff interest group in Electronic Voting Systems at Loughborough University and some of the issues addressed and different pedagogic approaches which were adopted by staff when using Electronic Voting Systems. Finally it highlights resources which have been developed for using Electronic Voting Systems to teach mathematics. These have been developed following mini-project funding and include a website with over 300 questions, designed in PowerPoint and ready for use, and links to question banks developed elsewhere.

Introduction and Literature Review

Throughout the UK, there has been concern with the level of engagement of students in the teaching that takes place in universities. Sometimes this manifests itself in poor attendance. At other times students attend but play a passive role in the process. In 2007, Loughborough University, via its Teaching Support Unit, purchased an Electronic Voting System to, amongst other things, facilitate student interaction and engagement in lectures.

Some of the earliest reports of the use of Electronic Voting Systems (EVS) in classrooms include those of Cue (1998), and Hake (1998). Caldwell’s (2007) review of existing literature on handset use is a comprehensive and detailed work that covers every aspect of handset use including description of the technology, use of questions, effect on student performance and association of handsets with ‘peer learning’. The study also includes guidelines for writing good questions and best practice tips. A very helpful book is that edited by Banks (2006). It provides some historical context, followed by practical cases in a variety of subjects, with associated discussions of the pedagogy associated with them, and finally outlines some of the directions that EVS may take in the future. Further electronic resources with comprehensive information on the use of EVS include the repository created by Steve Draper of Glasgow University (http://www.psy.gla.ac.uk/~steve/ilig/).
Papers with specific focus on the use of EVS in Mathematics include McCabe, Heal & White (2001), Lomen and Robinson (2004), and Cline, Zullo and Parker (2007). A more comprehensive overview of 10 publications on the use of EVS in Mathematics and Statistics can be found in Retkute (2009).

The single, most important benefit of EVS use, identified from literature review, is its capacity to enhance, catalyse or increase student engagement during lectures. This was reinforced by the finding from surveys of students at Loughborough University who were introduced to EVS in the study of engineering mathematics. 145 students completed a questionnaire on the use of EVS in class. The results showed that the majority of students were extremely positive about the usefulness and overall advantageousness of EVS use in classes. Results also showed that EVS use did increase the likelihood of students participating and engaging in class. Students identified the main benefits of EVS use and their two most important benefits related to feedback. These were, ‘Checks whether I’m understanding course material as I thought I was’ and ‘Allows learners to identify problem areas’. Further details are available in King and Robinson (2009).

Following a description of the technology involved, this paper now presents results from a staff survey at Loughborough University, which led to the setting up of a very successful staff interest group in EVS. The work of the staff interest group is then briefly described. Finally the paper describes the setting up of a website with resources to be used with EVS in the teaching of mathematics. Example questions are provided to demonstrate questions with different pedagogic benefits.

**The Technology**

EVS is a technology that affords a lecturer the means to give students, especially in a large class, the chance to engage with course material by having them answer questions in class - with immediate feedback provided. The EVS system being used by Loughborough University is TurningPoint (www.turningtechnologies.co.uk). Its enabling software is embedded in Microsoft PowerPoint. So a lecturer can prepare multiple choice questions (MCQs) as a series of PowerPoint slides for, for example, formative assessment purposes. The students respond by clicking the corresponding alphanumeric answer choice on their EVS handsets (Figure 1).

![Figure 1 - Students using TurningPoint (EVS) handsets to register their responses to a question in class. Used with permission of Turning Technologies](image-url)
Student responses are then displayed on the PowerPoint slide in the form of a suitable chart (see Figure 3). The lecturer may then decide to elaborate on any relevant issues arising out of the question and answer display session.

**Results of Staff Survey and Setting up of Staff Interest Group in EVS**

The views of 8 staff that used EVS at Loughborough University were ascertained via a questionnaire, observations, a ‘blog’ and follow-up interviews. The results showed that EVS is generally seen as an effective teaching tool, as its use can enhance student engagement by increasing their participation in class, give lecturers valuable feedback on student understanding, make the classroom more ‘fun’, and enable lecturers to change teaching practice and curriculum in response to student feedback. However, there are technical and pedagogical issues to be overcome in realising the full potential of EVS. Further details are available in King and Robinson (2009b).

In discussions with staff, it became clear however, that after the initial training session, there was little additional professional development for staff with regards to the best pedagogic practice in introducing EVS into lectures. The author thus successfully applied for an internal Academic Practice Award for the 2008-9 academic year to, amongst other things, set up a staff interest group in EVS.

From the very start it was emphasised that the aim of the meetings was to enable staff who use, or are interested in using, EVS to get together and learn more, from each other and the literature, about how to use these to best effect. The first meeting involved small group discussion and feedback to the main group on participants’ experiences and issues arising following the first year of EVS. Subsequent meetings have seen some very experienced teaching staff demonstrate different types of pedagogic uses of EVS. These included ice-breaker questions, fact-finding questions, questions checking prior knowledge, questions checking understanding of lecture material, questions testing understanding of a diagram or video, question seeking opinions, questions which initiate discussion, questions involving calculations, questions testing application of knowledge in a new situation and ConcepTesting. The latter has been used with great success in mechanics (see, for example, Mazur (1997) and is often combined with peer instruction. The staff interest group also included a report of a pilot by two participants with more advanced text-entry voting systems and the opportunity for participants to try these out. There was also a report from the author of a visit, funded by the award, to the University of Arizona, where staff have gained much experience in the use of EVS. Attention has been drawn to key literature on the use of EVS. In addition, results of surveys, of staff and student experiences of the system at Loughborough University have been reported. At the end of each meeting participants suggest what they would like to discuss at the following meeting. This involvement of all participants in planning and contributing to the sessions was one of the main factors in the continuing success of these meetings.

**Resources for Using EVS in the Teaching of Mathematics**

There are many people starting to use EVS and one of the first things they need to do is to start to write questions for the topics they teach. Many are unaware that there have been projects, particularly in the USA, which have resulted in question banks
being developed. The author thus successfully applied for sigma-cetl (http://www.sigma-cetl.ac.uk/) mini-project funding to collate information about existing resources for using Electronic Voting Systems (EVS) for mathematics and also to develop questions. A project website was developed (http://mec.lboro.ac.uk/evs) which provides information and links to relevant material. The website also provides over 300 mathematics questions which have been developed in the Mathematics Education Centre at Loughborough University. Also, the visitor to this website will find links to some key papers, and websites which review papers, on the use of EVS in general and EVS in mathematics in particular. The website was launched on the 30th of March 2010, with a one-day conference. Key-note speakers at this conference were Steve Draper, Glasgow University, and Mark Russell, the University of Hertfordshire, UK. Their presentations are also available.

Questions developed at Loughborough University cover topics typically found in a first year university course in engineering mathematics. These include differentiation, integration, differential equations, complex numbers, matrices and vectors. Figures 2 and 3 contain examples of questions developed for the author’s course on mathematics for Sport Technology. The two questions are related to the vectors part of the course. The first question (Figure 2) is an example of a straightforward calculation and requires students to use text-entry handsets to input a numerical answer. The second question (Figure 3) is a multiple-choice question and the correct answer can be selected using a standard handset. (Note that this latter question is an adaptation of a question developed by the Mathquest project in America (http://mathquest.carroll.edu/). The second question requires much more thought by the student. In this type of question one could ask the students to respond initially and then, given the responses indicated, could ask them to discuss their answers with a fellow-student and then vote again. This peer-instruction can be a very valuable pedagogical tool to encourage deep learning in class.

![Javelin Question](image)

**A javelin is released with initial velocity \( \mathbf{V}_0 = 13 \text{m/s} \) at an angle of 38° to the horizontal. What is the vertical component of the initial velocity?**

Figure 2: Straightforward question checking that students can calculate components of vectors. It requires the use of text-entry handsets.
A pole-vaulter’s run-up is in a south-westerly direction where the wind is blowing from the north at a speed of 7 km/hr. If the wind speed in the direction of the run-up exceeds 4 km/hr the jump will be disqualified. Will this jump be disqualified?

1. Yes
2. No
3. There is not enough information
4. Don’t know

Figure 3: A more demanding question which requires the student to apply knowledge of vectors to a sporting situation.

Within the EVS project website (http://mec.lboro.ac.uk/evs) there are inventories of the questions contained. Thus if you are looking for a question on differential equations, you could look up the inventory and then browse the questions which have been developed for that topic. For example, Cornell University has developed many questions for calculus, as part of their ‘Good questions project’ (http://www.math.cornell.edu/~GoodQuestions/materials.htm). The questions have been designed to inspire a deeper level of thinking and understanding.

Finally the project website (http://mec.lboro.ac.uk/evs) is an evolving resource which I hope will develop as more people start to develop questions for EVS use. If you have questions to share with the academic community, please do get in touch with the author.

References


