A System to support Interactive Teaching in the Lecture Theatre

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***Abstract*—This report describes a system that was adopted to allow students to provide feedback on their level of comprehension during a lecture. It was found that technologies like *Smartphone* and even *Bluetooth* do not yet have sufficient penetration amongst students to allow them to be used for such feedback. SMS messages are universally available and it was found that a simple message could be sent in less than a second once the destination phone number was loaded. The system displays a histogram showing understanding level which is continually updated during the lecture. It also displays comments and question in a scrolling area of the screen. It is up to the lecture whether this is displayed privately or arranged so that everyone can see it. The system also supports students registering their names and can generate a reliable attendance list and also monitor a student's level of understanding and support simple quizzes during the lecture. The software has been tested with a Nokia 6280 phone, but would work with many Nokia devices with almost no change. The system has been tested on a small number of students but will be used in a large lecture theatre shortly with bigger classes and a video of this provided on the web site.**

***Index Terms*—Interactive teaching, lecture feedback, SMS messaging, interactive quiz, lecture attendance monitoring**

I. Introduction and Aims

Class sizes have been growing for many years in UK universities, and this has made interaction with students increasingly difficult. In small classes (say less than 30) most students are prepared to ask questions if they are struggling to understand , but they are intimidated in larger groups. In small classes students have a sense of inclusion and involvement that enhances their learning and motivation. Gibbs et al [1] found that this is lost in larger classes leading to reduced satisfaction and less effective learning. This supported the earlier findings of Feldman [2]. The aim of this project is to use technology to facilitate feedback from students and also to facilitate interactive questioning by the the teacher. It is hoped that this would increase the sense of involvement of the students and allow the lecturer to continuously monitor the level of understanding of the material presented.

II. Background

This is not a new idea, and such devices are available commercially. A typical product is "Interactive Presenter" [1] which provides exactly the functions envisaged in this project, but the expense of the system for a large number of students prevents large-scale uptake. There are also expenses involved in ensuring that a large number of hand-held devices have healthy batteries and distributing them and ensuring their return at the end of lectures. However, there is already strong evidence that they are useful and effective. For example Uharil found that [3] 80% of medical students found the use of interactive devices had improved their learning in lectures.

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[1] http://www.interactivepresenter.com/

Another issue is lecture attendance. There is a strong correlation between attendance and performance for students taking a course. This will be due in large measure to both these factors being a measure of motivation. However, it is also true that continuing attendance tends to increase motivation while students that absent themselves often become alienated and demotivated. The author's experience has been that simply monitoring attendance has a large effect even in the absence of any sanction or reward. The average attendance in the last 6 lectures of a module in one year was below 30% when no monitoring was carried out. This increased to 85% the following year when a register of attendance was maintained. There are difficulties in maintaining an accurate record.

III. Outcomes

The project has not really gone to plan as envisaged in the original proposal for a number of entirely practical reasons. However, the objectives have been achieved using an approach that proved practical with the current state of technology as possessed by the students.

A. The Choice of a Mobile Technology

The minimum requirement is for a unidirectional Multipoint to Point (MTP) Network that is capable of communicating messages with an information content of say 3 bits. A fairly large number of devices needs to be accommodated, with 256 being a reasonable target. Of course it is desirable to be able to have more devices and more sophisticated two-way communication links, as that would support larger classes and more sophisticated interaction, but this is not essential to meet the goals of the project.

The following possible technologies were considered to achieve this:

- **A hard-wired system based on IC logic:** Such a system is fairly simple to design and interface to the base computer. However it involves the construction of a great deal of hardware, even if this is a straightforward process, and the installation of wiring to each seat in a lecture theatre. This was considered a practical but anachronistic solution and not taken further.
- **An infra-red system:** Such a system would be similar to multiple "remote controls" as commonly used with televisions and other video and audio equipment in the home. Integrated circuits are available which make such designs straightforward to implement. This approach is viable but requires a line of sight connection. That is students would have to be able to see the receiver sensor. Reasonably priced transmitters are of rather short range and this would be a difficulty in large lecture theatres. IR technology is rapidly being overtaken by wireless in peer to peer connections, for example between a phone or printer and a

computer. Moreover there is no effective standard for IR protocols which tend to be product specific.

- **Smartphones:** These mobile phones run Windows mobile edition and are relatively easy to network to a Windows XP base station. The power of such an arrangement would be enormous, and would be similar to having a networked teaching facility with a computer screen and keyboard available to each student. This was the route envisaged as approach that would probably be adopted in the original grant proposal. However, in practice a severe difficulty was encountered. There are still rather few suitable products on the market (see [2]) and these are expensive. A "show of hands" in a lecture indicated that only two students owned a suitable device. Clearly this approach does not yet have the critical mass take-up to meet our objectives at present.
- **Bluetooth:** This is a wireless-based technology, similar to WiFi, but using a different frequency hopping strategy and lower power levels. Texas Instrument estimate that 60% of mobile phones will be equipped with this technology by 2008. Computer Science students seem to be quite sophisticated purchasers of such phones and tend to require more "high end" features than the average user. A "show of hands" indicated that it was already the case that a majority of final year undergraduates already had access to a bluetooth enabled phone, laptop, or PDA. This percentage can only increase and so this was deemed a viable approach which would enable a classroom demonstration to go ahead.
- **SMS:** Another approach would be to get students to send a text message to a specified telephone number in agreed format. For example it does not take more than a few seconds to text a digit from 0 to 9 to indicate their level of comprehension. SMS messages asking questions would also be interesting and answers to a quiz could be sent as a space or comma-separated message.
  Initially I thought that the cost of this approach to each student would be a a highly negative factor and would rule it out. It costs me 10p to send each text message on my phone, although I only send a dozen or so each month. If say five messages were sent by each student in a class of 100 this represents and expenditure of £50 overall. It seemed unfair to expect an already hard-pressed community to pay for offering feedback. I was surprised, on asking for the students' opinion, that most were unconcerned about this. Everybody in a large first year class had a phone that could send SMS and a majority were on a that gave them more free SMS messages per month than they actually used. For others the cost was 5p or less. Nobody objected to sending say four or five texts in the course of a letcture. The method also has the advantage of allowing much more detailed feedback to be given.

In conclusion, it was decided that all of the solutions above were technically viable. The *Smartphone* approach would have led to the most versatile interactive environment, but was impractical as too few devices were available. Radio is preferable to infra-red but is otherwise rather similar. This approach would require students to download an application to their phone, and this is not possible for every phone and might prove problematic for some students who are not used to doing this. Furthermore, only about 40% of students possessed a phone which offered *bluetooth*, although this percentage is increasing quite rapidly. Having installed such an application the sending of feedback is free and requires few key presses. This was initially thought to be the best way forward, and some progress was made in developing a client application for phones with the Symbian operating system (eg Nokia) and a PC host program. This reached the point where it would connect to a single phone and accept and transmit a single numeric key press. It was then realised that different client programs would be needed for different phones as they used different operating systems. Worse still, each client had to be tailored to a given phone or at best a series of phones (eg Nokia 40 or 60 series) even when they ran the same operating system. This meant that there was no prospect of developing a testable application and the SMS approach was adopted instead.

[2] http://www.microsoft.com/windowsmobile/smartphone/default.mspx

IV. Putting it into Practice

Using SMS messages for feedback in a lecture offers the considerable benefit that just about every student is equipped to participate. Most do not seem concerned about the cost or are on a contract such that such messages are effectively free.

In order for this to work effectively students should be asked to set their phone settings appropriately and preferably to create a new *profile* for lectures. The phone should be rendered *silent* and not to accept incoming calls. Instructions for doing this for Nokia phones was presented at the start of a test lecture. The target phone number for lecture feedback was given and students were asked to store this in their *contacts* list. A code was agreed for feedback of levels of comprehension from 0 to 9. Nine meant *I understand perfectly* while zero indicates *no understanding at all*. Students were free to text such information at any time, but they were encouraged to do so after the explanation of a significant topic was complete. The lecture was paused for ten or twenty seconds and a histogram displayed to see if it was appropriate to proceed. Detailed questions could also be sent at any time, but again were encouraged at the end of a topic or in the last ten minutes of the session.

It was found that students could maintain an open edit of a message prepared for the given phone number and were able to send feedback with three key presses (eg Erase-9-Send) and this took them about a second (Their ease of doing this surprised me, as my less practiced, and perhaps fatter, fingers find the small keys clumsy and error prone and I cannot read the letters without my glasses).

The positioning of the display showing feedback needs some thought. Initially it was paced facing the students, but was difficult for the lecturer to see. This is hopeless as it simply ends up a distraction. It makes much more sense to place it where only the lecturer can see it and then he or she has control over whether to respond and in what way. The students are not distracted. The alterative is to place it near the front of the lecture theater but at the side where everyone can see it, but it is not really a distraction. This position was adopted for the demonstration lecture.

The screen alternates between displaying a scrolling view of questions that have been posed and a histogram showing levels of understanding.

It is desirable that students register their phones before they are used. One option is to ignore messages from unregistered phones. This discourages rude or offensive messages which could be sent from outside the class. A simple registration method is for users to send a message of the form: "name: Tom Joad." And this could be done by all users at the start of a lecture, registering names in a database. Of course one will get the odd *Micky Mouse* and *Tony Blair* with this approach. A more formal registration process can be carried out preferably at registration with students showing some form of photo identification along with their phone. The number can be called to checked by calling it. With this approach one can register attendance at lectures simply by requiring students to text at some point during the lecture. A more stringent check could be for them to send an SMS at the start and the finish to indicate that they were there throughout[3]

In practice it is inevitable that students will *borrow* one another's phones and use these for *a bit of fun*. The lecturer can share the joke if this is occasional, but if this becomes a real problem the system could easily screen out offensive words, or severely restrict message formats.

V. Issues and Debates

The system envisaged here has enormous potential for many other applications. For example in a *wide game* participants could text on arrival at their *home base* and the umpire could see at at a glance which team was winning. This might also be useful with sales representatives texting their arrival at a customer's premises. Students can text in their module choices or other options. In fact any information can be collected remotely and coordinated by such a system. It will be interesting to see if the software finds wider application when it is placed on a web-site in the public domain as required by this grant.

A. The System used in Practice

The system requires a mobile phone to receive the messages and to pass these to a host computer. Initially a *bluetooth* connection was employed, but this becomes very confusing when there is a room full of active mobile phones as the computer registers all of them in range and the phone may try to *pair* with them. It is best to disable *bluetooth* on the host phone and also on the computer and to connect them together using a USB cable. That way the other phones do not interact with the host system except by SMS.

Each mobile telephone has a unique serial number and this is best used as the phone_id and as unique key for database look-up. It is a fifteen digit string, which allows an astronomical number of distinct mobile phones to exist in the universe. A SMS also contains the phone number from which the message was sent, and this (12 digits) is of course unique and a good candidate for a key.

My second attempt to implement the host system after deciding bluetooth was inappropriate for SMS used a USB cable connection and and using Nokia PC Suite to add a phone browser to the desktop. As mentioned earlier this puts messages in a hidden folder and these are updated when that folder is accessed.

Using this approach I was able to access the messages and determine if they had not been seen previously. Each message has a unique name which is stored as a key in a Dictionary. If a message id is not present it is known to be new and is processed. A simple coding scheme is used for messages based on the first character entered as follows:

- **0-9:** A comprehension level which will be added to the histogram.
- **Q:** A question or comment which will be displayed in a scrolling text area. Questions from phones which do not have a student name registered to them are ignored at present. The question itself is displayed anonymously but this could be made an option very easily.
- **N:** The students name follows and is registered by this message as being associated with the phone.

Figure (A) shows an example of the screen used to display the interactive feedback.

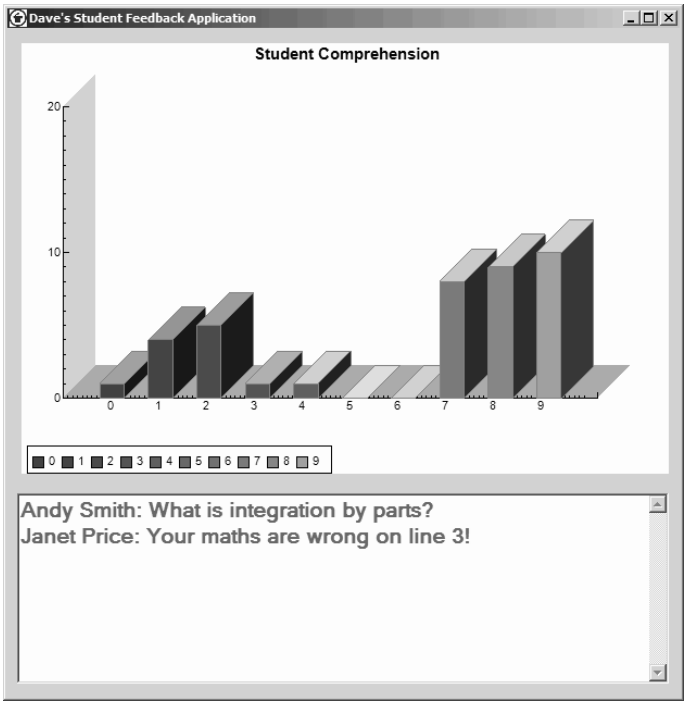

Fig. 1. A Typical Screen Showing Student Feedback

B. Some Enhancements that could easily be added

It would be better to register students phone numbers and names in a more formal process in which photo id was shown and the phone was checked to see that the number given was correct. This information could then be stored in a database or perhaps a simple text file and used until that student left or changed his or her phone. This would prevent spurious, *Micky Mouse* registrations during a lecture. In fact this has not been a problem testing the system with a rather serious-minded group of Master degree students, but would be likely to happen with large undergraduate classes.

[3] Students have a tendency to leave after signing an attendance form!

Further security can be gained by announcing a particular password string at the start of a lecture and asking all students to send a message with just that password. This will the register the students as being present at the lecture and allow any malicious *texting* from outside to be discarded. It also generates an attendance list in a relatively foolproof manner which can be stored in a database allowing a history of all attendance to be seen by the lecturer and tutors.

It would also be a simple matter to store the comprehension levels *texted* by each individual student in a database allowing the average self-assessed understanding level of each student to be discovered and also a time history of this associated with topics. The mean level of understanding could also be displayed by topic giving useful feedback on areas of general difficulty to the teacher.

A simple quiz was carried out as a test with students replying with a response of the form "Q 3 1 2 5 6 4," where the numbers illustrate the answer selected by multiple choice. This allowed the lecturer to see which questions were well answered and which poorly.

It would be a useful enhancement to be able to define quiz results in the application so as to mark them when responses were sent. The results could be stored in a database and even used as formal marks. It would be a nice feature if the mark were sent as a text back to the student. This might also be possible for some *Frequently Asked Questions* although this is a more ambitious enhancement.

VI. Resources

The main resources are this report and of course the software that was built. A video is also being prepared but this awaits the start of the new term in order for substantial class sizes to be available.

A. The Software

An SMS feedback system for monitoring understanding in lectures has been built and tested. It was found to work rather well and has enormous potential for additional features and functions, most of which are trivial to implement.

The software is very much a prototype but is provided as Visual Studio 2005 project on the web site *http://www.cs.nott.ac.uk/ dge/LectureFeedback/index.htm*

B. The Demonstration lecture

Unfortunately lectures do not start at Nottingham until the first week in October and so this deliverable was not available for the deadline of the end of September. However it will be carried out that week and a video placed on the web site as soon as possible.

References

[1] G. Gibbs, L. Lucas, and V. Simonite, "Class size and student performance," *Studies in Higher Education*, vol. 21, no. 3, 1996.

[2] K.A. Feldman, "Class size and college students' evaluations of teachers and courses: A closer look," *Research in Higher Education*, vol. 21, no. 1, pp. 45, 1984.

[3] M. Uharil, M. Renkol, and H. Soini, "Experiences of using an interactive audience response system in lectures," *BMC Medical Education*, vol. 3, no. 12, 2003.