

Chapter XIV

Wireless Interactive Teaching by Using Keypad-Based ARS

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Abstract

Lecturing large classes in tertiary education is always a challenge; one of the most difficult tasks being how to gauge students' understanding. Introducing interactivity can alleviate this problem by providing instant feedback that enables the lecturer to clarify problematical points. This is even more crucial and challenging when lecturing to large classes with students from many different cultural backgrounds. This chapter reports the authors' experience with a wireless keypad-based system in different classrooms. New deployment strategies used in this project, and educational foundations

on which they were based, are explained. The environment and the experience of using the technology from the educator's viewpoint are also described. Student feedback is also discussed, and improvements for future use are also proposed.

Introduction

It is well known that an interactive approach is the most effective way to achieve a high quality of teaching and learning in the classroom (Happern & Hakel, 2003; McConnell, Steer, & Owens, 2003; Rust & Gibbs, 1996). However, the difficulty of organizing interactive teaching and learning activities with a large, lecturing class size is also well recognised (Mazur, 1997; Panitz, 1998). An increasing number of tertiary students are coming from other countries, especially from Southeast Asia, where the teaching and learning cultural styles are markedly different from the Australian open interactive classroom teaching style. This adds another difficulty to interactive teaching and learning activities in the classroom.

Like Australian universities in general, RMIT University of Australia is a student-centred institution. The School of Computer Science and Information Technology (CS&IT) at RMIT has a typically high percentage, as high as 50%, of international students in many classrooms. The School conducted a reflective research project to explore an effective way of organizing interactive teaching and learning activities in an environment that includes a large number of students from diverse backgrounds. The aims were to engage students in a lecture environment that was traditionally regarded as requiring passive student participation (Neild, 2004; Rodrigues, Bu, & Min, 2000), and to introduce overseas students to a more interactive learning approach. The project team was headed by Dr. Jiankun Hu, and comprised four lecturers, one teaching and learning adviser, one teaching and learning specialist, and one research assistant. The project deployed wireless technology, a keypad-based audience response system (ARS) for the classroom teaching and learning, in the field of computer science and information technology. With the support from KEEpad Australia, this project leased 150 KEEpad wireless voting devices at a heavily discounted price. In the remainder of this paper, we use KEEpad to represent the company KEEpad Australia, and the keypad-based ARS system supplied by the KEEpad Australia, interchangeably. The KEEpad wireless voting device has buttons labelled with numbers 1 to 10, and letters A to I. This allows the user to choose an answer to a multiple-choice question. The KEEpad company has also provided TurningPoint software for class and statistical analysis. The TurningPoint application was embedded in the PowerPoint™ software. It can record and display the device ID, and voter selection from this device on the slide. A statistical summary showing the percentage of voting on each possible answer is displayed that can help the lecturer identify the level of students' understanding. TurningPoint operates on Windows 98, 2000, or XP. More details can be found at the KEEpad company Web site (KEEpad).

The objective of this chapter is to report some of the experiences, case studies, issues, controversies, and critical problems encountered in using this wireless interactive technology. In this chapter, we cover background, case studies, implementation issues, lessons learnt, and future thoughts.

Background

Lecture classes at many universities worldwide have very large numbers, and the situation is worsening due to shrinking funding. Having 300 to 600 students in lectures is common, which makes it very difficult for lecturers to actively engage with students. The need for more staff/student interaction was identified as the top student concern at RMIT in 2001, and remained an important issue in 2002 and 2003 (RMIT Report, 2003). Additionally, Australian universities face a cultural hurdle to achieving quality interactive teaching in the classroom. Australian universities have attracted large numbers of students from the Asia-Pacific region. The School of CS&IT at RMIT has more than 850 international students from the Asian region, who have different cultural learning backgrounds. Typically, these students do not like to be placed in front of the class, which makes it more difficult to apply conventional interactive teaching techniques such as requesting students to answer a question.

There is much literature on the different styles of eastern and western learning, and how this can impede the international students' learning (Ballard & Clanchy, 1997). Much discussion has taken place on the apparent differences in approaches between eastern and western ways of accumulating knowledge. In this discussion, there has been an emphasis placed on rote and memory learning vs. critical thinking and independent research learning (Ballard & Clanchy, 1997; Pearson & Beasley, 1996). The features of the learning environment prior to tertiary education vary in different cultures, and this strongly influences how students approach their tertiary education in Australia (Chan, 1999; Nield, 2004; Rodrigues et al., 2000). In the field of computer science and IT, teaching and learning needs to cover both highly abstract theory-based courses and highly hands-on experimental courses, which requires different teaching and learning styles. It is unclear from the literature how to enhance effective interactive teaching and learning in the classroom when all of these complicating factors are present. More literature is being presented addressing the problem of large lecture classes, and how to develop strategies to make these lectures more interactive and increase student participation (Bruno, 2002).

Wireless, interactive teaching promises an innovative solution to these learning problems. When the lecturer asks a question, students can use this technology to answer such questions anonymously. From the percentage of correct answers, the lecturer can identify any learning problems immediately, and so, take remedial actions. The peer instruction teaching technique can also be used to allow students to discuss ideas with their neighbours, and to challenge one another on the veracity of their answers. This new teaching and learning scheme is based on Mazur's ConcepTest (Panitz, 1998). Dr. Eric Mazur developed the 15-minute lecture, and ConcepTest, for the teaching of physics to large classes (Mazur, 1997). These ideas have been further developed, and are used in other science subjects (Apple, Nygren, Williams, & Litynski, 2002; McConnell, Steer, & Owens, 2003). Although it has been successfully used at a number of universities in the US and Europe, no systematic method of deployment appears to have been followed.

The School of Accounting and Information Systems at the University of South Australia has used this technology for peer review of collaborative group-work (Banks, 2003).

Banks reported that such an application caused uncomfortable feelings for students, and received negative feedback. Such applications can cause even more problems for Asian students, indicating the need for further research before implementation. RMIT University, through its teaching and learning portfolio, encourages the development of strategies that improve learning outcomes for all students. It supports best teaching practices, which include interaction between students and facilitators; quality, appropriate feedback to all students; meeting the different needs of different students; appropriate pacing of the delivery of materials; encouraging the development of lifelong learning skills; higher student participation, which helps to motivate and engage students in their own learning. Within its charter, RMIT provides grants and seed funding to encourage and support learning strategies such as active learning. In 2004, the Academic Development Group in the RMIT Science and Technology (SET) Portfolio provided funding for several action research projects in teaching and learning during the second semester. This ARS application is one of these research projects.

Case Studies

The wireless, interactive teaching technology has been deployed in five different courses conducted by four different lecturers. In this chapter, we select two courses to report as case studies. The first course is programming oriented, and the other one is concept oriented, which is representative of the discipline of computer science and information technology.

Case Study I: Programming Oriented Course

The course is Web Page Construction, taught by the third author. For many students, this is their first course at our University. It was designed as a postgraduate course, and the lecture is given from 9 am till 12 noon on Saturday morning. However, there are many undergraduate students, as well as the postgraduate students, in the course. For many students, this is an elective, so not all are students of computer science or information technology degrees. There is no prerequisite for this course, so students may have no knowledge of programming. The lecture for which the students used the KEEpads was entitled “Introduction to JavaScript.”

During the previous lecture, the students had completed the ethics form, and all the data from the class had been collected onto a spreadsheet. There were 51 students altogether, and they appeared interested to join in the KEEpads trial. From this data:

- 11 were from China, 8 from Australia, 8 from Indonesia, 4 from Malaysia, 2 from Sweden, 11 other, and 3 were left blank.
- 14 spoke English as their first language, 3 spoke English plus another language, 31 had other first languages, and 4 left this section blank.

Thus, the class was predominantly of Asian origin, and mostly spoke languages other than English. The staff designed questions for the end of each major concept to see if the students had understood that concept.

At the beginning of every lecture, using this technology, the lecturer displayed the registration slides to determine the cultural mix at the beginning of that lecture. This was not the first lecture to trial the KEEpads, and the previous lecturer had suggested that the students liked to experiment with the KEEpads at the beginning, so perhaps we should ask some “fun” questions. The initial data collection appeared not to work, as the registration boxes on the bottom of the screen were not going red. However, the graph did appear. The lecturer changed the background, reset the slide, and asked the question again, and a similar graph appeared. Therefore, the lecturer believed that at least the students were answering truthfully, as the same response was provided the second time. Unfortunately, the polling bar at the bottom of the screen did not work for the registration slides.

After covering the material for the first concept, the lecturer displayed two summary questions:

- Which of the following is NOT true? (followed by several options from A to F)
- Which is not a typical use of JavaScript?

For the first question, 65% got the answer right, and for the next one 94 % got the correct answer, so it appeared that students had understood that section well.

During the next section on JavaScript language control structures and operators, when the review question slide was displayed, it was not announced, but the students answered immediately with 77 % correct. As 14% had given an incorrect answer, the lecturer provided further explanation of the misunderstood concepts. Students were confused by the next summary slide, where they selected alternatives A, B, C, D with the following percentage distribution: 16%, 13%, 39%, and 32%. This slide had one alternative answer split over two choices, and so the 39% and 32% options were really the same option, which was the correct answer. Those who selected the 16% and 13% options had not understood that particular language concept. Therefore, the lecturer reviewed this section.

During the break, two students approached the lecturer and asked about that question, explaining their incorrect selections. This was a useful outcome, as the explanation had enabled these students to gain a better understanding of these concepts. It also indicated that these students were shy about asking their question in front of the whole class.

The final section went reasonably quickly, but the students were now more talkative. They asked if these types of things were to be in the exam, and they voluntarily replied to some rhetorical questions. Ninety-four percent of the students got the second to last summary slide correct, and 100% the last.

The final evaluation slide gave the following results:

- 14% Shorter lectures with discussion time enabled me to learn more.
- 45% The use of technology during lectures helps me to learn.
- 7% I thought that student participation in peer discussion was of value to me.
- 17% I prefer the whole of the session to be lecture time.
- 14% So long as there are detailed notes, the lecture/discussion time is not important to me.
- 0% I found the session disruptive to my learning.
- 3% I found the lecture difficult to follow using this technology

These statistics indicate that the majority of the students liked the technology.

The lecturer believed more discussion could be generated in the lecture, and so plans to organise more thought provoking, difficult, and tricky questions, requiring students to make more effort, and think to find a solution. However, on the whole, the lecturer is happy with the results of this lecture. Beforehand, the lecturer had been very unsure whether or not the technology would work. But despite a few difficulties with the registration slides, the technology appeared to work well. It did involve extra time setting up before the lecture on the day, and also handing out the KEEpads. Retrieving them was also time-consuming, as all the students ‘piled down the front together at the end. A lot of time was involved beforehand for those involved in learning the software and installing it. The lecturer needed to borrow a laptop with the software working, and organise suitable questions. However, the time and effort was worthwhile to find out that the students had followed and participated much more than the lecturer had realised, rather than simply looking out on what often seems to be “a sea of faces.”

Case Study II: Concept Oriented Course

This course is Broadcast Network Engineering, taught by the first author, and has 108 enrolled students. It covers intermediate-level material in the fields of data communication and networking. Most of the concepts, such as TCP/IP protocols, digital encoding, and so forth, are rather abstract. Such features make it very hard to obtain timely feedback regarding how well the students have understood these concepts. Therefore, introduction of wireless, interactive teaching technology to identify the problems, on the spot, is valuable. This is a second semester course with 12 2-hour lectures.

The lecturer started to use the wireless, interactive technology from lecture five onwards. In the prior lecture, ethics forms had been distributed and collected. In the 58 completed forms, nearly 90% of the students were shown to have a non-English speaking background. No literature has been found showing how to prepare experimental slides. We decided to display five registration slides to collect information about the participants’ learning background, such as nationality, country of origin, language used in primary

education, and so forth. At the end of the lecture, we placed evaluation slides to collect students' feedback regarding this technology. Feedback questions included "By using the KEEpad, I was able to answer questions without embarrassment." The evaluation feedback from the first lecture was excellent. However, several problems have been observed in the subsequent lectures.

1. **Registration problem:** It was found that a significant number of students came to the class a little bit late, and hence, missed the registration phase, which could cause problems in collecting accurate voting data. It was also found that students may get bored with the registration phase, which has up to five slides that are irrelevant to the course.
2. **Evaluation problem:** The evaluation slide was placed at the end of the lecture. However, it is very difficult to control lecture timing, so there may be no time left at the end of the lecture to arrange this part. This might occur if the lecturer allocates extra time to cope with unexpected problems found in the question answering process.
3. **Timing problem of the lecture:** The deployment of the wireless, interactive teaching and learning has introduced enormous uncertainty into the lecturing. As the voting process takes a significant fraction of time, the lecture notes had to be redesigned. Sometimes the voting clearly indicated that students' understanding was well below the lecturer's expectation, in which case, the lecturer has to take extra time to make remedies. Although this interactive response phenomenon is exactly one of the advantages of deploying the wireless, interactive teaching and learning technology, it renders the task of controlling the flow of the lecture nearly impossible.

Interestingly enough, such problems and solutions have not been reported in any published literature. Although Mazur's ConcepTest has been used in a scheduled timely manner, based on a "15 minute learning fatigue period," it has not involved the time uncertainty for making unexpected remedies. The lecturer has also found it infeasible to adopt such a prescheduled, timely, Mazur ConcepTest, as it is extremely difficult and costly to arrange the flow of the lecture material in such a way. Even if the lecture material can be arranged in such a way, the timing uncertainty problem mentioned above can easily destroy the lecture schedule. Upon reflection, the lecturer took several actions for the last three lectures. The first action was to reduce the number of registration slides from five to two. Other actions included redesign of all lecture notes to better accommodate the voting process, and the redesign of the voting questions based on controlling the flow of concepts in the lecture, instead of Mazur's conventional fatigue timing. To accommodate the timing uncertainty, the lecturer has also limited the number of voting questions to four in each 2-hour lecture, and has designed an optional question to adjust the lecturing timing dynamically. A snapshot of the evaluation obtained is given below:

The final evaluation slide gave the following results:

- 25% By using the KEEpad I was able to answer questions without embarrassment
- 16.67% Shorter lectures with discussion time enabled me to learn more.
- 41% The use of technology during lectures helps me to learn.
- 8% I thought that student participation in peer discussion was of value to me.
- 0% I prefer the whole of the session to be lecture time.
- 0% So long as there are detailed notes, the lecture/discussion time is not important to me.
- 0% I found the session disruptive to my learning.
- 8.3% I found the lecture difficult to follow using this technology

These statistics also indicate a very positive result from our deployment strategy for this technology.

Implementation Issues: A Practical Approach

Hardware Issues

One set of equipment was leased from the KEEpad Company for the duration of this project, and used by all faculty members participating in the project. The hardware comprised

- three, wireless receivers with attached networking device and stands,
- one, wireless network hub,
- USB port connector and USB security key,
- 160 student transmitter devices (for student responses).

Also, the School provided a staff notebook computer with PowerPoint™ installed. KEEpad software was installed on this computer by the research team. The four lecturers involved in the project used the KEEpad devices for a different course. Three of these courses involved lectures at RMIT City Campus, with one course involving lectures across two campuses.

KEEpad student response transmitters were usually placed on a table at the front of the lecture theatre, in the plastic storage pockets provided by KEEpad. Students were instructed to collect one of these devices, depositing either their student card or a driving

licence in the location from where they collected the transmitter. In most cases, the process of installing, distributing, collecting, and dismantling hardware requirements for this teaching approach decreased the amount of time available for lecture delivery by approximately 10 minutes. The same hardware configuration was appropriate for all four courses in which the KEEpad equipment was used, therefore, the one set of equipment was shared by all faculty members involved in the project. This required cooperation amongst the staff to ensure that the equipment was available when required for all lecture groups involved, and this generally worked quite well.

Faculty and staff participating in this research project were already well versed in the use of PC computers, and also connecting and configuring peripheral devices. After a demonstration of the components comprising the KEEpad system, and the overall configuration of the system, staff were encouraged to experiment with setting up and dismantling this equipment so that this could be done in a timely manner during the lectures.

Staff Issues

The KEEpad Company provided staff training in the use of the hardware and software components of the wireless, interactive system for all lecturers involved in this research project. This training covered installation of the software, development of multichoice questions, and their inclusion into lecture presentations. Lecturers were provided with access to the equipment and software during the preparation stage. Staff were encouraged to undertake practice "setups" of the gear, even if just in their office, and to conduct trial runs of their lecture presentations, with the student feedback or voting questions incorporated.

In almost all cases, the "voting" questions incorporated in the lecture presentations were multichoice questions. Typically, a "question slide" was incorporated into the lecture presentation following the coverage of a key or important concept. This required review of lecture material to identify clearly when key concepts were covered during lectures.

Incorporation of feedback questions into the lecture sequence changes the nature of lecture delivery, decreasing the time that lecturers spend on decreeing. An important consideration for the development of questions for lecture delivery, and modification of lecture materials to include these, is determining the number of key concepts to be covered, the distribution of these within the lecture sequence, and the number of feedback questions which can practically be incorporated in relation to these concepts.

Use of technology that encourages or requires students to interact on a regular basis throughout the lecture time, in effect, forces a change in the lecturing strategy. The change in focus is away from a purely decreeing model to a lecturing mode that requires students to engage more actively with the lecture material, and to decide answers to feedback questions either as an individual, or from discussion with neighbouring students. By allowing more student interaction, lecturers might also be concerned that they will lose a degree of control of the lecture, and possibly that the "voice" of the lecturer will be lost in the interactive nature of the lecture. Faculty and staff involved with this project all expressed concerns of this nature during the preparation stages of this

project. However, with appropriate sequencing of content, and the inclusion of appropriate voting questions to promote student feedback, faculty and staff were provided with information to gauge the level of students' understanding, allowing them to modify the emphasis and time spent covering concepts in their lectures. Rather than causing the lecturer's voice to be lost, this can allow some gain in efficiency, as lecturers can modify their lecture sequence in response to feedback, placing emphasis, or spending more lecture time, on concepts that students have shown that they do not understand.

Student Issues

Students were required to complete "ethics documents," confirming that they wished to participate in this trial. As part of this process, all students were provided with an introductory document explaining the rationale for educational research projects, for this project in particular, and the strategy that would be used for delivering lectures.

Lecturers showed the KEEpad interactive devices to their lecture groups, and explained the process that would take place during lectures. Students were assured that any information that they might provide relating to their personal background and educational history would remain confidential.

Students in each of the lecture groups were introduced to this lecturing strategy that required student input and feedback to a greater degree. The students showed interest in the equipment, and the level of interaction that it allowed with only minimal direction.

Students provided the feedback requested of them, and participated in discussions with their peers. For the duration of this trial, students generally demonstrated that they were enjoying participating in lectures in this manner. Results from focus groups conducted at the end of this trial showed that students valued increased interaction during lectures, and indicated that their level of understanding had been greatly improved.

Lessons Learned

- Student participation enhances lecture delivery, and provides improved learning outcomes. From student interaction enabled by KEEpad interactive devices, lecturers are able to gain a much better insight into the students' level of understanding of lecture material. This enables lecturers to modify the sequence of lecture content to address student-learning needs.
- At the same time, students are engaged more fully with the lecture material, solving problems and answering questions either individually, or on the basis of discussion with peers. Student feedback from this project has shown that students believe they have a greater level of understanding of the lecture material from lectures where this strategy of increased interactivity is employed.

- Students are more comfortable answering questions anonymously with KEEpad wireless interactivity devices, and are more likely to respond to lecturers' questions than if required to answer orally.
- International students from a wide range of cultural backgrounds are more likely to interact within a large lecture class when using interactivity devices that allow them to answer anonymously.
- This type of educational technology can be a useful teaching and learning tool, both in undergraduate and postgraduate education, as shown by the above benefits both to lecturers and students.
- To further implement what we have started will need planning, professional development, and financial support. All change takes time, effort, and commitment.
- This trial indicated that the complexity involved in deployment of this lecturing strategy is much greater than our initial expectation. There is much room for further improvement.

Future Thoughts

This project demonstrated that KEEpad interactive wireless devices can be introduced into lectures with a successful result. Several of the issues that arose during this project are a result of the experimental conditions of this trial. Only one set of equipment was available, to be shared between a number of staff, delivering lectures within a busy teaching schedule.

A number of possible improvements have been identified, including the following:

- **Buying or renting hardware.** One possible approach is to install the wireless receivers and networking equipment required for the KEEpad system into a number of lecture theatres. This would substantially decrease the amount of work required to use this technology. At the same time, a major source of unreliability, equipment being set up hurriedly, with the possibility of incorrect connections and damage due to movement and constant handling, would be eliminated. Establishing specialist lecture theatres introduces timetable constraints, so one or more sets of equipment could also be made available for use in other lecture theatres.
- **Encouraging students to rent/buy/hire/borrow hardware.** A number of strategies could be used to ensure that students each have a KEEpad interactive wireless device. Strategies could be developed to allow students to rent, buy, or borrow a KEEpad interactive wireless device at the commencement of their study. Alternatively, such devices could be "bundled" with textbooks. Assistance programs could also be made available for students unable to afford one of these devices.

- **Develop a bank of concept questions for the School:** To encourage faculty and staff to adopt a teaching strategy incorporating increased interactivity, banks of concept questions appropriate for courses offered within the School could be developed.
- **Joint development projects between faculties:** Linking strategies might also be developed between faculties to develop software.

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