Use of Mobile Technologies to Enhance Student Engagement in Large Lectures: An Initial Exploration and Experiment

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Abstract

The pressure of increasing class sizes to gain financial economies of scale is seen by some as reducing the quality of the educational outcomes for students, with some of this reduction in quality focussing on the increasing lack of engagement and feedback between students and teachers/lecturers as class sizes increase. One aspect of engagement that diminishes as class sizes increase is the use of small group discussion around a topic, with one member of each group explaining their findings to the rest of the class with this then allowing the teacher/lecturer to give immediate feedback to the rest of the class.

Much of the literature surrounding the introduction of technology into the learning process has focussed on engaging students outside of the traditional face-face learning environment whether in a full or pure eLearning sense or as a supplement to face-face delivery. There has been some attention in the literature paid to the use of technologies such as "clickers" and other examples where technologies such as mobile phones and other wirelessly connected devices have been used with the explicit aim of enhancing student engagement.

This paper seeks to explore some of the pedagogical value that can be gained by the use of small group discussions with feedback, and how in larger classes of 200 or more students, some of this value can potentially be retained through the use of mobile technologies such as short-message-services (SMS) so that the students can give their group's response and the whole class can receive feedback from the lecturer within 2-3 minutes. This means that this approach is much more aligned to the literature surrounding the use of classroom response systems and clickers than it is to the literature surrounding mLearning.

A literature review is conducted that covers some of the background behind the paper including the benefits of small group discussion with feedback; and some examples of how SMS, "clickers" and similar technologies have been used within a classroom setting. This is followed by a description of a model for how a readily available product (SMS-Studio), with some extra development, can be used to enhance the engagement of students in large classes. The results of initial experiments into its use in a large first year information systems class of more than 300 students are also presented.

The paper concludes that the trial of the system has been successful when it comes to the cost of participation for students; the engagement of students; the filtering of responses from students; the ability to give quick feedback to the students on their responses; and the student reaction to the use of the system.

Keywords
Student Engagement, Student Learning, Mobile Technologies, Classroom Response Systems

Introduction and Methodology

The aim of this paper is to present the background and results of initial experiments into the use of mobile technologies to facilitate small group discussions and feedback in a large first year information systems course. While the use of mobile technologies suggests that this is an mLearning experiment, the use of the technology within a traditional lecture format and the immediacy of the feedback from lecturer to student sees this experiment being aligned with previous studies related to classroom response systems and clickers as opposed to mLearning.

The structure of the paper includes a brief literature review of the use of classroom response systems (CRS), clickers, short-message-services (SMS) and other related technologies within the classroom with the aim of increasing student engagement. This literature review identifies some of the issues and benefits associated with using such technologies in the classroom.

This is followed by a description of the system that was developed for the purposes of this study, which is in essence an off the shelf product (SMS-Studio) that is used to capture text messages and send them to a database, which has been developed to provide long term storage for the responses and to create a front end for quick feedback to students in the classroom.

A description of the experiments using the system in lectures for a large first year information systems course is presented along with the results of the experiments. This is followed by some analysis and discussion, which is followed by some recommendations and conclusions.

Literature Review

This section reviews a number of prior studies and concludes by identifying a number of important threads that are relevant to this paper.

Flies and Marshall (2006)

In a review of the literature on the use of classroom response systems (CRSs), Flies and Marshall (2006) highlighted that there are a number of areas for a concerted research effort in there use. They did however conclude that much of the existing literature was related to general learning literature and in particular the use of different learning models. Flies and Marshall (2006) went on to indicate that there was significant agreement that CRSs will promote learning when they are coupled with appropriate pedagogical methodologies.

Flies and Marshall (2006) also indicated that much of the research at the time had focused on individual use of the classroom response systems as opposed to small group use of CRSs, although they did note a small number of researchers that used CRSs in association with small group work. Logistical difficulties for academic staff; added costs for students, and students reacting differently to the use of the technology were also highlighted by Flies and Marshall (2006) as being issues in the implementation of CRSs that necessitated clear benefits being evident from their use.

Pedagogical considerations identified in the literature by Flies and Marshall (2006) included the timing of feedback to the possible use of next generation systems including wireless devices, with most of these considerations surrounding increased student interaction and participation in their own learning.

Flies and Marshall (2006) went on to identify a number of implications for further research which are reproduced in Table 1.

Implications for Further Research
Tightly controlled comparisons in which the only difference is the use, or lack of use, of a CRS.
CRS use in connection with diverse pedagogical approaches: (a) Group-based methodologies that are combined with group-based CRS use. (b) Varying degrees of anonymity in response collection. (c) CRS use for purely formative assessment modalities that scaffold learning.
CRS use in connection with diverse populations and content areas: (a) Same content area, but different populations. (b) Same population, but different content areas.

Table 1 – Implications for Further Research Identified in Flies and Marshall (2006)

Scornavacca, Huff and Marshall (2007)

The work of Scornavacca, Huff and Marshall (2007) described the development and trial of a short-message-service (SMS) based classroom interaction system. The theoretical background for this work included the use of large lecture theatres to produce effective and scalable approaches to teaching large classes, and how this approach can be used at the expense of student interaction which can result in reduced student engagement, motivation and learning as described in Freeman and Blayney (2005).

Using interactive technologies to engage students in peer discussion and activities, when guided appropriately by the lecturer can lead to effective learning outcomes for students as suggested in Mazur

(1998). This was subsequently cited by Scornavacca et al (2007) who went on to describe how the use of such interactive pedagogies requires significant overhead effort on the part of lecturers/teachers and that as a consequence, larger classes of 100 or more students are where most benefits lie.

The system developed in Scornavacca et al (2007) was based around the assumption that a large proportion of students have SMS enabled mobile phones with them during lectures, and that these could be used to enable the lecturer to receive messages from students during a lecture. The system developed involved the use of a SMS management tool (SMS Studio) and was used in two different ways during lectures. Firstly it was used to allow students to send messages to the lecturer during the lecture that could be responded to during the lecture or afterwards (open channel mode). Secondly it was used to present students with a discussion topic to be discussed in small groups, and then respond to multi-choice questions based on the topic (m-quiz mode). Approximately one quarter of the students participating in open channel mode, and over half of the students responding in m-quiz mode.

In the conclusions to Scornavacca et al (2007) it was identified that the additional channel of communication was of benefit to both students and lecturers and that there was a perceived increase in the quantity and quality of feedback from the students. It was also identified that an area for further research was related to any change in student learning and performance when using such a system, and whether this would be different across a range of contexts and subject areas.

Freeman and Blayney (2005)
The use of handheld keypads to gain feedback from students in an economics course instead of students raising their hands in response to questions was the subject of the work by Freeman and Blayney (2005). In their conclusions they identified that requiring students to respond to in class questions during class time can assist learning, but that the use of such devices is a costly alternative to asking students to respond to a question by a show of hands, even though this allows for quick feedback in large classes.

In the trial reported on by Freeman and Blayney (2005) the same pedagogical approach of small group discussion was used irrespective of whether the feedback mechanism was by show of hands or the handheld keypads. This enabled a comparison to be made between the two different feedback mechanisms using the same learning pedagogy. Students involved perceived some advantage when using the handheld keypads when it came to their interaction and understanding. The concept of anonymity was looked at as being one of the driving factors behind this perception, and that this may encourage students who are unsure about their response to engage and interact more than they might with a more public display of a show of hands.

Beatty, Gerace, Leonard, & Dufresne (2006)
The importance of designing effective questions for classroom response system (CRS) teaching was highlighted in Beatty et al (2006). In this study they used a "question cycle" (reproduced in figure 1) as the core in-class instruction in physics courses. Part of their findings included that instructors who used a CRS needed a good understanding of how to pose

appropriate questions for their use. The question cycle involved posing a question for discussion in small groups before covering any related content. The students responded to the question in multi-choice format with the results being shown in a histogram which are then used as the basis for discussion with the entire class. Beatty et al (2006) identify a three part framework for designing questions for use with a CRS. The three are being (a) the role that the questions play; (b) the goal of asking the question; and (c) how the goal of asking the question is accomplished.

A range of tactics were also identified in Beatty et al (2006) with these being (a) tactics for directing attention and raising awareness; (b) tactics for stimulating cognitive awareness; (c) tactics for formative use of response data; and (d) tactics for promoting articulation, conflict and productive discussion.

In their final summary and conclusions Beatty et al (2006) mention the that effective questions for use with CRS should be developed with a threefold pedagogical objective of (a) a content goal; (b) a process (cognitive) goal and (c) a meta-cognitive goal:

- The cognitive goal is the topic to be covered
- The process goal is the set of cognitive skills to be addressed and developed
- The meta-cognitive goal is the perspective about the overall subject that is to be reinforced

Beatty et al (2006) go on to conclude that this threefold objective can be met through four complementary mechanisms:

- The posing of the question can focus the students' attention on particular issues
- Students' pondering of the questions can stimulate cognitive skills
- Displaying the answer histogram can convey information regarding the students' knowledge in relation to the rest of the class
- Discussion can impact students' engagement and learning, and inform the teacher of how the students are engaging with the material

Four different tactics were identified for maximum learning:

- Remove non-essentials
- Compare and contrast
- Interpret representations
- Strategise only

Beatty et al (2006) go on to indicate that the design of effective questions for a CRS can be challenging and time consuming even when done using a framework similar to that used above. They also highlight that well designed questions are only one aspect of a question driven approach, and that pedagogy, the way in which the instructors use questions to interact with students in the classroom, is more important.

Beatty et al (2006) conclude by stating that question driven instruction as carried out in this study is based on formative assessment, and as such is self correcting, and as a consequence can provide valid feedback to the teacher regarding student learning.

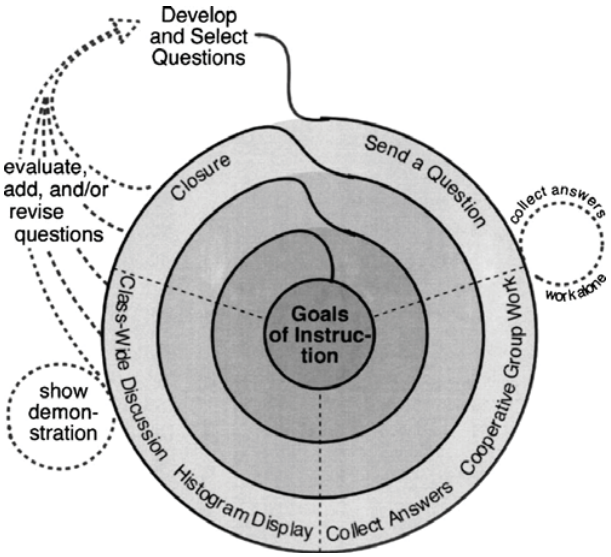

Figure 1 – The question cycle used in Beatty et al (2006)

Nelson and Hauck (2008)

In a case study of the use of clickers in an introductory management information systems course Nelson & Hauck (2008) found that use of clickers significantly improved students' perception of their performance in the course and that the use of the clickers also met with higher rates of class attendance and of student performance. It was also found that the more the clickers were used, the higher the students' perceptions were when it came to active learning, motivation and providing feedback.

Part of the background to the Nelson and Hauck (2008) study was the desire to increase student engagement and sustain student interest across a large core introductory course. The overarching research questions in this study were "How can classroom response systems be used to assist with overcoming inherent challenges of large lecture classrooms?" and "what system features and traits should be sought in a classroom response system?"

In the literature review conducted by Nelson and Hauck (2008) a number of factors that promote effective learning in the classroom were identified including active learning, providing feedback, increasing attention span and motivation. All of these are seen as being particularly challenging in large lectures as cited in Beatty (2004) and with Net Generation learners as cited in Robinson and Ritzko (2006). The importance of feedback was also cited in Bangert-Downs, Kulik, Kulik, and Morgan (1991) with the timing of the feedback being seen as especially important as cited in Azevedo & Bernard (1995) and Kulik and Kulik (1988)

In the conclusions to the study it was stated that the use of CRS technology can fundamentally change the classroom environment for both students and instructors. The benefits to the students as indicated by this study were: increased interest and participation levels during classes; increased comprehension of material; and greater perceived performance in the class.

Kennedy and Robson (2008)
This piece of work described the use of tablet PCs and Classroom Presenter software and how they are used by instructor and students within a first year mathematics course in an undergraduate information technology degree. Slides on the instructor's tablet are sent via a wireless network to the student tablets. The students use electronic pens to write, draw, or annotate the slide and then send their work back to the instructor. The instructor can display, discuss and comment on selected responses.

Some of the key findings of Kennedy and Robson (2008) included the importance of the use of the right types of questions; the concept of using revision questions to start classes; that students have reacted positively to the experience; and that students will work together on the questions as there is one tablet for each pair of students. One of the key aspects to the success of this particular project has been the ability for the instructor to select "interesting responses" to share with the class and that the feedback to the student can happen quickly.

Important Threads Identified
Eight important threads that are relevant to this particular paper can be seen in the literature that has been reviewed.

1. The cost and simplicity of the devices is an issue that was identified in Scornavacca et al (2007) where mobile phones were used because the vast majority of students have a mobile phone with them. In Freeman and Blayney (2005) the cost of the handheld devices was seen as being a factor that would result in similar approaches not being adopted. In Kennedy and Robson (2008) the cost of the tablets used could well prove to be a stumbling block in adopting this form of technology.

2. The importance of pedagogy before technology while implicit in a number of the studies was explicit in both Flies and Marshall (2006) and Beatty et al (2006).

3. The importance of anonymity was identified as being a major issue in Freeman and Blayney (2005).

4. The importance of the impact on learning and not just on student engagement was an issue that was identified in Flies and Marshall (2006), Scornavacca et al (2007) and Nelson and Hauck (2008). In these studies there were typically reports of students being happy using CRS or SMS technologies, but that it was in some cases problematic to measure the impact on learning.

5. The importance of providing feedback to students, and the timeliness with which the feedback is given was an issue identified in Kennedy and Robson (2008), Nelson and Hauck (2008) and in Flies and Marshall (2006).

6. The importance of constructing effective questions was identified in both Beatty et al (2006) and Kennedy and Robson (2008).

7. The application of the technology to large classes as opposed to smaller classes was specifically mentioned in Scornavacca et al (2007) where it

was hypothesised that at least 100 students would be needed in a class to overcome the overheads associated with using such technologies in the classroom.

8. The creation of an additional communication channel was identified as being of use in Scornavacca et al (2007).

Amongst the eight threads identified, there are two relating to barriers (cost and simplicity in thread 1 and the overheads in thread 7), with the other six threads relating more specifically to the benefits to student engagement and learning.

Description of System

The software (SMS Studio) that was used in the study by Scornavacca et al (2007) was purchased and forms the backbone of the system. The essence of this software is that when it is running and a mobile phone has been plugged in to the USB port of the computer that it is running on, the computer sees the mobile phone as being a GSM modem. The software can be configured so that when a text is sent to the phone a service runs. Each service can, amongst other things, remove the text from the phone and issue a range of commands. One such command can be to execute an SQL command, such as the INSERT command to a specified database connection.

For this study, the SQL command that is executed each time a message arrives on the mobile phone is shown in Figure 2, with the database connection being an ODBC connection named "SMS Studio Automated System" with this ODBC connection talking directly to an Access 2007 database, with the structure of the database being shown in Figure 3.

```
INSERT INTO IncomingMessages
(Sender, Recipient, MsgText, MsgDateTime)
 VALUES ('%MsgFrom%', '%MsgTo%',
'%MsgText%', '%MsgDate% %MsgTime%')
```

Figure 2 – SQL Command Executed for Each Incoming Text Message

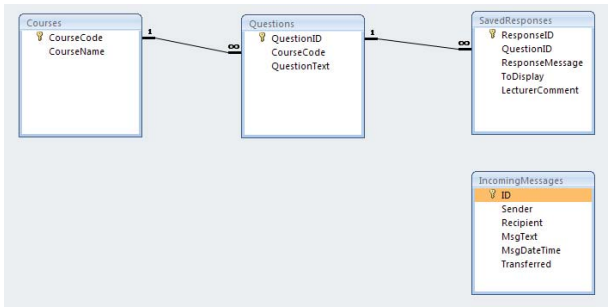

Figure 3 – Structure of Access Database

The incoming text messages are inserted into the IncomingMessages table by the SQL command. The user of the system creates questions that are asked to the class, and can transfer the messages from the IncomingMessages table to the SavedResponses table and assign them to a question that has been created.

The user of the system can select which responses to display to the class as shown in Figure 4 (but with the screen not being displayed on the projector in case there are some inappropriate responses). Once the responses to share with the students have been selected, a form can be displayed showing just those

responses at which time the screen can be shown on the projector as shown in Figure 5.

It is also possible to have two mobile phones plugged in to different USB ports and have SMS Studio recognise both of them as being GSM modems and receive and process text messages from both phones at the same time. This has allows student to send responses to a choice of two different mobile numbers from different providers, thereby making it possible for more students to participate without any cost.

Some consideration had been given to the use of SMS server technologies in this project but the costs of the technologies were too great for what in essence is a pilot study, and would also involve students being charged for each response they sent in.

At the time of writing, an Access 2007 database is being used with this being stored locally on the laptop that SMS Studio is installed on. Some consideration is being given to writing the responses to a web-based database such as MySQL using PHP and creating links to the questions and responses from the Learning Management Systems (LMS) site for the courses involved.

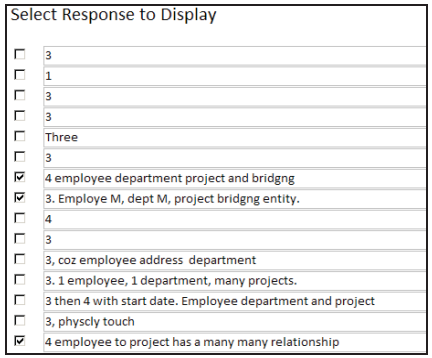

Figure 4 – Selecting Responses to Display to the Class

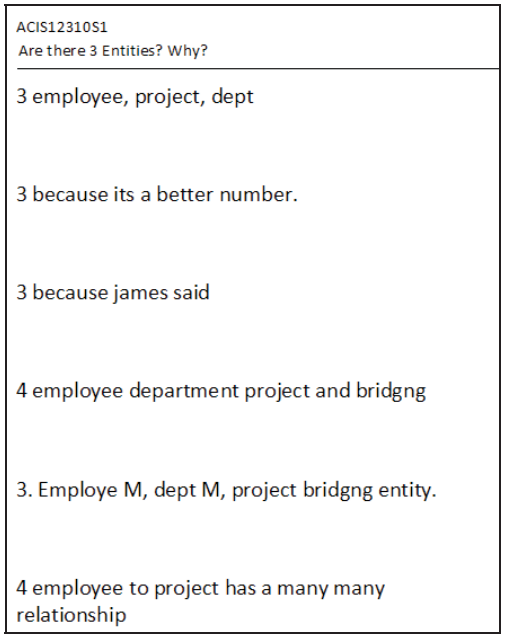

Figure 5 – Displaying the Selected Responses to the Class on the Projector

Design of Experiments

The experiments conducted to date have been in the ACIS123 (Information Systems and Technology) course which from 2010 has been a compulsory course for all students in the Bachelor of Commerce at the University of Canterbury. There are in excess of 300 students enrolled in the course with attendance typically range from 200-250 students at each lecture. The experiments conducted were:

Experiment #1
An initial trial of the system where the students were asked to text their name and favourite colour to either a Telecom or Vodafone number that was displayed on the screen.

Experiment #2
In a database management systems lecture the students were provided with a description of the requirements for a small relational database. The students were asked to discuss in small groups how many entities there would be in the entity relationship diagram and have someone from each group text in that number. The students were told that there would be between 1 and 6, which in essence made this a multi-choice type question.

Experiment #3
Later during the same lecture as experiment #2, the lecturer covered the need to create a bridging entity when encountering a many-many relationship. The students were given another description of a small relational database, and were asked to discuss in small groups if there were 3 or 4 entities, and why they thought there were that many. Again, one person from each group was asked to text in the response from the group.

Experiment #4
In an introductory eCommerce lecture, the students were asked to discuss in small groups the reasons why some people choose to not purchase things online. As in the other experiments, one person from each group was asked to text in their response.

Results

This section presents the results of the four experiments described in the previous section, and then goes on to outline some of the observations of the lecturers and some feedback from the students.

Results of Experiment #1
The purpose of experiment #1 was to test and see whether the system was actually working, and within 2 minutes 148 responses had been inserted into the Access database. The need to not have the responses displayed before they were filtered was apparent when there were 4 responses out of the 148 that would not have been appropriate to display.

Results of Experiment #2
With this experiment being in essence a multi-choice question, it was possible to use the "voting" service in SMS-Studio to process the response and produce a graph of the answers. The graph was displayed with 1-2 minutes of the text messages coming in. The graph is shown in Figure 6. The correct answer to the question was in fact 3, and the graph shows that the majority of students were correct.

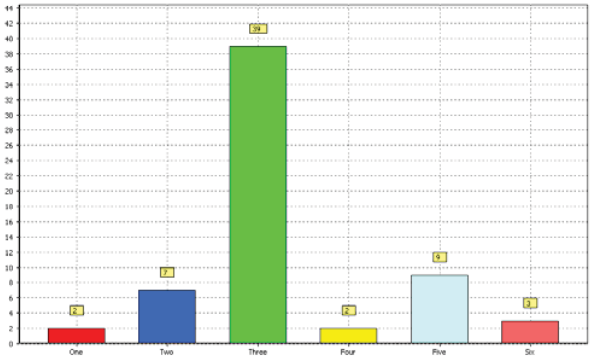

Figure 6 – Graph of Responses from Experiment #2

Results of Experiment #3

There were 76 responses received to this question of which 2 were inappropriate to share with the entire class. Of the other 74 there were 20 responses that included more than just the number of entities and included a reason why. The correct answer to the question was that there were 4 entities and not 3, with the reason for the 4th being the need for a bridging entity because of a many-many relationship.

The responses that can be seen in Figure 4 and Figure 5 showed the range of responses and some of the reasoning. The response of "3 because James said" was shared with the entire class and resulted in a light hearted moment. Some students were heard to say "oh, I get it now" when they saw the responses that had the correct answer and a reason associated with the need for the bridging entity.

Results of Experiment #4

This experiment resulted in 48 responses being received. Interestingly two were not related to the question and were:

- "U r going to fast"
- "Speak a liltle louder cnt hear at the back"

Of the other 46 responses, 13 were shared with the class with these being shown in Table 2. These responses indicated that the students collectively already had a good understanding of the issue at hand that was able to be acknowledged.

Security and trust. :)
Lack of trust
Security and payment method
Security reasons and cant test out th good
Fear of security, unfamiliar with technology
Dnt have a credit card or the security of the payment nt safe
Security
Risk- cant c the actual product so dont no what its really like
1- to see quality 2- payment dificulties
Might not be a safe transacting (in terms of sending their credit card details). They cant see the physical product, it could be faulty, differnt or non existent
Because may be some old people dont know how to drive competer
Clothes sizes might not fit cant try on before purchase. Postage costs might be high
Trust ISSUES AND phyical COMPONENT..

Table 2 – Responses from Students Shared With Class

Observations of Lecturers

One of the observations of the lecturers involved in the use of the system in ACIS123 was that more students participated than would normally have done so. In fact, in the lecture prior to the first experiment, one of the lecturers attempted to have a small group discussion just prior to a break in the middle of the lecture. The students were told that after the break they would be asked for feedback. The response from the students was interesting in that close to half of the approximately 250 who were present did not come back to the lecture after the break. Of those that did come back to the lecture, only one was willing to share what they had talked about.

It was also observed by one of the lecturers that in the week following experiment #2 the students appeared to interact more verbally at that stage of the course than they had in the previous three semesters when that lecturer had been teaching that part of the course. It may be that this is related to the students discovering in experiment #2 that if they made an incorrect response, they were not made to feel inferior, and as a consequence their trust increased making them more willing to share verbally. This could point to the idea of students sharing anonymously and not being judged as being an approach to increasing the trust, willingness and confidence to share verbally. While this is not the subject of this particular paper, it could be the focus of further studies to determine whether this idea has validity.

Feedback from Students

At the end of the lecture where experiment #4 was conducted, the students were asked to text in their perceptions of the system. There were 7 responses sent in which is too small a sample size to make generalisations about. However these responses were all positive and are shown in Table 3.

Easy communication.
Its awesome. Saves speaking out in lectures
It is good
easy way
Its good cuz alot of pple dnt lik speaking up in lectures bt wif this they can still hav there say
It is good
Its a brilliant idea! I can say things and no one will know its me and its not out loud.

Table 3 – Responses from Students about Their Perceptions of the System

Analysis and Discussion

There is evidence of the eight important threads identified in the literature review in one or more of the experiments, observations of the lecturers and the feedback from students about the system.

The cost of devices and as a consequence the ease of adopting them was observed by the lecturers during the experiments, with the level of participation in the experiments also suggesting that cost will not be an issue with this approach. With the system allowing students to text to either a Telecom phone or a Vodafone phone, this has also reduced the potential cost for students when participating. These factors served to address some of the barriers that there identified in the threads in the literature review.

The importance of pedagogy before technology ties in with the importance of constructing effective questions

and the importance of the impact on learning and not just engagement. The question asked in experiment #4 was more open-ended than those posed in the earlier experiments and appeared to be part of the reason why there was a better range of responses. The feedback from the students indicates a greater willingness to engage without having to speak up in front of a large number of peers. This aspect also ties in with the anonymity issue identified in the literature which is identified in some of the student responses.

Conducting the experiments showed that it is possible to filter the responses and share those seen as being pertinent to the class within 2-3 minutes which is consistent with the importance of providing feedback, and providing it in a timely manner.

The system deals with the number of responses that can typically be sent in with a class that is larger than 200 as shown in the experiments and the responses from the limited number of students suggest that they find it to be a useful approach.

The creation of an additional communication channel was evident in the two messages sent by students about "the lecturer going too fast" and about "not being able to hear in the back row". This was not an intended use of the system in this study, but proved to be useful as the lecturer was able to slow down and speak a bit louder as a response to the feedback.

Conclusions

The system that has been developed and trialed in ACIS123 has been successful to date and has demonstrated some of the important aspects for such systems that are in the literature.

The particular aspects that have been successful include:

- The low cost of the devices and participation for students
- The level of participation in activities compared with what is possible in large lectures normally
- The ability to quickly filter the responses, share them with the class and give feedback about the responses
- The reaction of the students to the use of the system

At the time of writing, the degree of success from the perspective of the lecturers is such that the system will continue to be used in ACIS123.

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