Use of an On-line Student Response System: an Analysis of Adoption and Continuance

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Abstract

The goal of this project was to initiate the use of an internet-based student response system in a large, first year chemistry class at a typical Australian university, and to verify its popularity and utility. A secondary goal was to influence other academic staff to adopt the system, initiating change at the discipline and Faculty level. The first goal was achieved with a high response rate using a commercial on-line system; however, the number of students engaging with the system dropped gradually during each class and over the course of the semester. Factors affecting student and staff adoption and continuance with technology are explored using established models.

Introduction

The burgeoning literature on the use of student response systems in tertiary teaching has been reviewed both generally (Caldwell, 2007; Kay & LeSage, 2009), and specifically looking at applications for chemistry (MacArthur & Jones, 2008). In spite of extensive and growing evidence that, when appropriately used, such systems can improve engagement and performance, these systems are not used widely in teaching chemistry in Australia. They are used at approximately 30% of institutions, but even at institutions where they are available, less than 5% of chemistry academic staff use them (Mitchell Crow & Schultz, 2012, Schultz, Mitchell Crow & O'Brien, 2013).

The literature to date focuses on hand held student response systems, often called clickers. These items can be purchased either by individual students, or by institutions (or Faculties) and lent to students; the consequences for engagement of the different models have been examined (White, Delaney, Syncox, Akerberg & Alters, 2011). In either case, for large classes they constitute a significant expense and administrative load. An alternative that has more recently been developed by several different individuals and organisations uses the students' own mobile telephones. Polls allow students to choose their answer using a standard mobile telephone, usually through the short message service (SMS) function. There are now reports of phone-based systems being used for formative (Habel, 2011; Maier, 2009) and summative assessment (Lin & Rivera-Sánchez, 2012) and for in-class experiments (Cheung, 2008; Reimers & Stewart, 2009). Even more recently, internet applications, which allow students to use their own internet-enabled mobile device (telephone, tablet or laptop computer) to answer polls on a website, have been developed. Few publications using such on-line systems have appeared; they have so far mostly been described in reports and presentations (Farkas, 2012; Gewirtz, 2012; Higdon, Reyerson & McFadden, 2011; Nugent, 2012; Price, 2012) although at least one full research paper has appeared (Hoppenfeld, 2012). Both of these recent alternatives allow academic staff to obtain and display feedback from students during class in the same way as is done with the hand held clicker systems, without the purchase of any hardware. Internet applications have the added ability to allow text entry, so that students may pose questions, discuss topics of interest or comment on the material.

A very recent book describes adoption and application of student response systems generally (Wankel & Blessinger, 2013). One chapter in that book has a detailed discussion of the advantages of on-line student response systems for improving student learning (Schell, Lukoff & Mazur, 2013). The authors have developed their own on-line student response system (Learning Catalytics) that has some additional functionality over the system used in this project, but their discussion of the advantages of an on-line system (such as allowing students to enter text) over traditional clickers applies to this work as well.

For any student response system or other technological teaching innovation, academic staff members and students must spend time familiarising themselves with the interface, and in all cases, technological difficulties can impede the planned activities (Kay & LeSage, 2009) (e.g. lack of mobile phone or wireless coverage, website crashing, slow responses). This can be contrasted with the simple method of asking students to raise their hands in response to in-class questions for formative feedback. It has been argued (Caldwell, 2007; Hoekstra & Mollborn, 2011; Kay & LeSage, 2009) that lack of anonymity will reduce response rates when show of hands is used. However, full student engagement with an electronic system is also difficult to achieve, and so the relative advantage in timesaving may indicate that the low-technology method is better. Nonetheless, as Schell and her co-workers describe in their recent chapter (Schell et al., 2013), the use of electronic systems allows data capture to track conceptual change and knowledge transfer as measures of effective learning. Clearly the use of such a system has potential far beyond simple show of hands if data are subsequently reviewed, including aiding the improvement of student response questions through analysis of answer rates and correct answer percentages.

The stages of adoption of new technology in teaching have been cogently explained by Towns (2010) in the context of student response systems, adapting a model from Moore (2002) on technology diffusion. Moore described the chasm that exists between so-called innovators and early adopters, who are likely to purchase new technology, and the early and late majority, who are much less likely to do so. Towns applied these concepts to the specific example of academic staff using student response systems (clickers) in tertiary teaching. In addition, she suggests some strategies to encourage their use across the chasm. Emenike and Holme (2012) have more recently surveyed the extent of student response system use by academic staff in the United States (US), and note that in that context, as in Australia, they have not yet crossed the chasm to an early majority of users. One difference between the US and Australian contexts is that in the US, a proportion of summative assessment is frequently associated with student in-class responses, whereas most Australian universities do not permit this. Further, a recent article in this series by MacArthur (2013) suggests that we need to determine pedagogies suitable for use with clickers specific to chemistry.

It is important to note that not everyone who tries a new technology continues to use it, so the factors leading to continuance are also relevant. A comprehensive model explaining consumers' intention to continue using new information and communication technology, and their continuance behaviour, has been proposed (Bhattacherjee, Perols & Sanford, 2008). In this model, the interrelated factors of post-usage usefulness, disconfirmation, satisfaction and information technology (IT) self-efficacy lead to continuance intention, which, combined with facilitating conditions, leads to the continuance behaviour. A recent paper by Yeh and Tao (2012) analysed fourteen separate factors that may contribute to student intention to continue using student response systems through integration of four different theories: expectation confirmation theory, information systems success model, agency theory and motivation theory. Their resulting empirically supported research model parallels that of Bhattercharjee et al. (2008) regarding confirmation and satisfaction from expectation confirmation theory. In addition, within the information systems success model, Yeh and Tao (2012) found that the service quality of the system was more important than the system quality or information quality, but all three were significant inputs to satisfaction. Interestingly, they also found that no factors from agency theory, including incentives (such as marks for participation) were a significant factor in determining intention to continue use. Finally, only one factor from motivation theory was significant: intrinsic goal orientation. These findings are highly relevant to the current project, because although many staff and students are interested in trying a new technology, whether they continue to use it depends on the factors just listed. Student continuance was monitored during this project in a short longitudinal study, and an indication of staff continuance was also obtained.

The current Australian environment for promotion of new technology in tertiary science education has received support from the Federal Government through the funding of the Science and Mathematics Network of Australian University Educators (SaMnet) (Rifkin, Sharma, Crampton, Yates, Matthews, Beames, Varsavsky, Johnson, Jones, Zadnik, & Pyke, 2012; Sharma, Rifkin, Beames, Johnson, Varsavsky, Jones, Yates, Crampton, Matthews, & Pyke, 2012). This organisation was formed in 2011 with the goal of supporting leaders of change in tertiary science teaching in Australia. Within that framework, the present project aimed to influence the behaviour of members of a typical chemistry department. SaMnet provided training in leading change as well as a forum for sharing experiences with other SaMnet project leaders. Of 21 SaMnet projects that were in the initial round, this was the only project specifically about implementing student response systems; at several of the institutions hosting SaMnet projects, clickers are already used in science teaching. Leading change is an established area in the business context (Kotter, 1996), with recognised strategies and pitfalls. Strategies for leading change in the educational context have been proposed (Fullan, Cuttress, & Kilcher, 2005). A recent book on leading change in the tertiary sector describes academic technology projects at the University of Minnesota, with chapters illustrating innovative leadership at all levels (Duin, Anklesaria & Nater, 2012). However, the difficulties of leading change in the tertiary context have also been recognised (Brownell & Tanner, 2012) and many of these were encountered in the present study.

Context and Methods

The institution in this study is a large urban university, with large classes in first year chemistry (up to around 500 in a single class). The cohorts are very diverse, both in background and program of study. Typically two or at most three members of academic staff teach into each class over a single semester. Each staff member teaches up to seven weeks per semester, with three hours of lecture timetabled each week. The staffing arrangements change gradually over time, but most academic staff teaching into first year chemistry do so every year for multiple years; a pool of around ten members of staff is involved. In the semester in question, two staff members taught half of the semester (6 weeks) each and the enrolment in this unit was 346.

Although clickers are used at this institution in another Faculty, they were not available in the Science and Engineering Faculty due to their cost.[1] Therefore, the use of a newly developed on-line student response system was proposed. Initially, this was to be developed in-house and require student login, and had no cost associated with its use. Unfortunately the pilot of that system failed during the first week of its use, and so a commercially available on-line student response system, GoSoapBox (GoSoapBox, 2012), was used. GoSoapBox had only very recently been launched at the time of adoption, and several useful changes to the system were made over the course of the semester. Other changes have been made more recently; for example, a smart phone is no longer required to participate in polls; any mobile telephone is adequate. This type of system first appeared in 2011 and several commercial alternatives are now available (Nugent, 2012). These systems require students to have an internet-enabled mobile device such as smart phone, tablet or laptop computer, and to log in to a website using a code distributed by the lecturer. The minor cost of registration with the on-line provider was covered at the institutional level. Note that GoSoapBox has subsequently changed their business model to charge per student rather than per staff member, so this cost is likely to increase for large classes.

Use of students' own mobile internet devices raises an equity issue, because not all students own such devices and their cost is relatively high. Some institutions provide all students with a tablet or other laptop computer but at this institution that was not the case. Prior to the beginning of semester, students were informed by email and via the Learning Management System that an on-line system would be used. They were recommended to bring their internet-enabled devices to participate, and were provided with information about borrowing laptop computers from the library. During the first lecture, it was explained to the students that making a genuine attempt to answer the questions was beneficial to their learning, and that peer discussion has been shown to be helpful. This was reiterated several times over the course of the lecture series.

Student and staff feedback on the system was sought as follows: students were invited to complete an on-line survey of their opinion of the utility of the system. Staff were invited to attend a lecture at which the system was used, and those who did attend were interviewed about their views on its utility and their potential adoption of such a teaching and learning strategy.

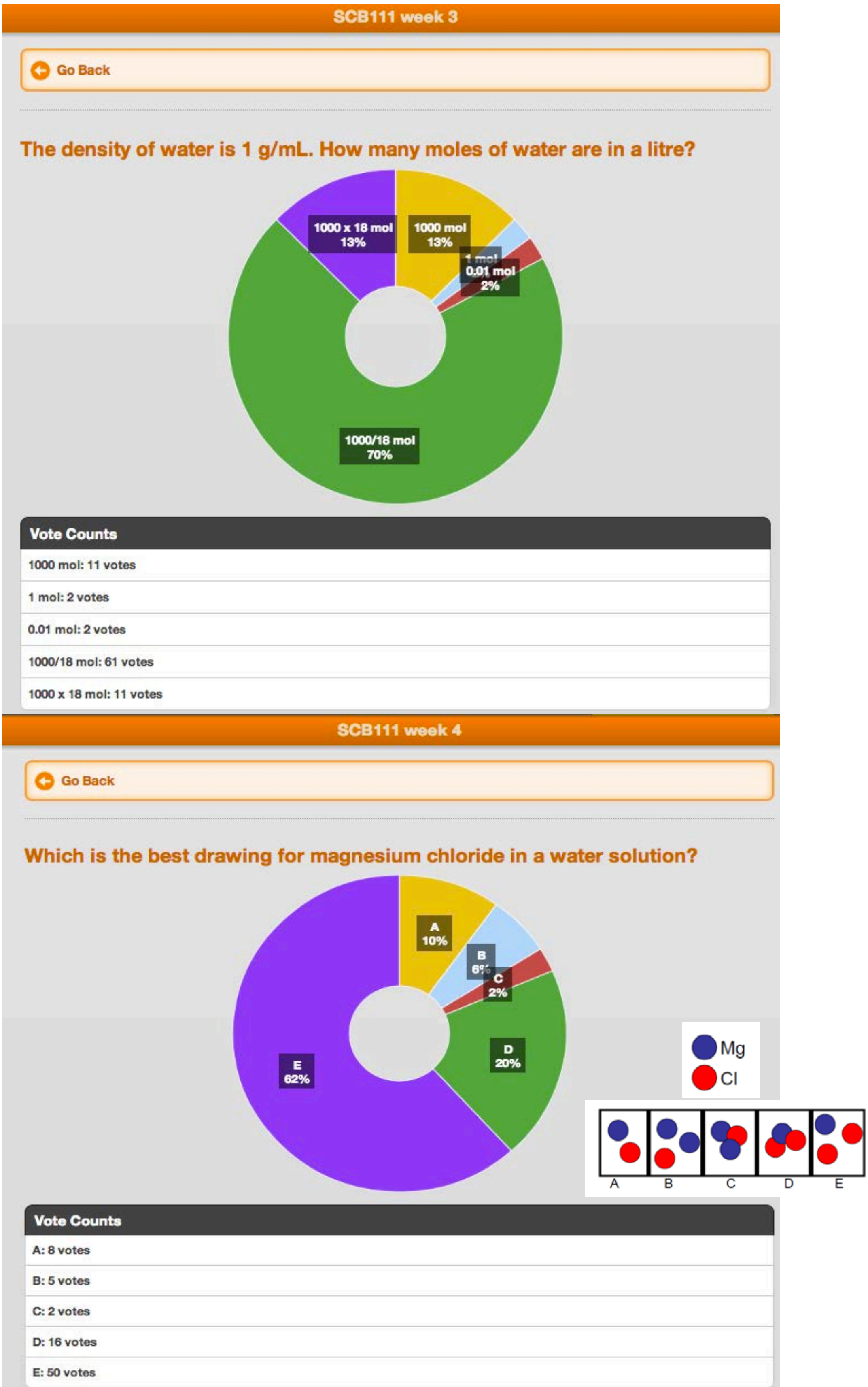
Results and Discussion

Preparation

Around two student response activities (with one to four questions) were included per hour of timetabled lecture and incorporated into the PowerPoint slides used during the lectures. The student response questions used in this case were taken mostly from free databases (Ellis, Cappellari, Lisensky, Lorenz, Meeker, Moore, Campbell, Billmann, & Rickert., 2000; Herzfeld, 1997), with some modifications. Questions and answers were designed not to require the use of a calculator, so for numerical questions, answer options were in the form of expressions (e.g. 5 x 1000/16 rather than 312.5). One reason for this was to elucidate weaknesses in basic mathematics, such as rearranging equations. Incorrect responses could then be used to start a discussion. Three typical questions, taken from weeks 3, 4 and 5, are

[1] Note that since the conclusion of this project, 600 clickers were purchased by the University and these are available for classes such as the one in this project.

shown as they appeared in the students' view (after inputting their own response) in Figure 1. It can be seen that some questions led to significant confusion, while others were answered correctly by a large majority of students.



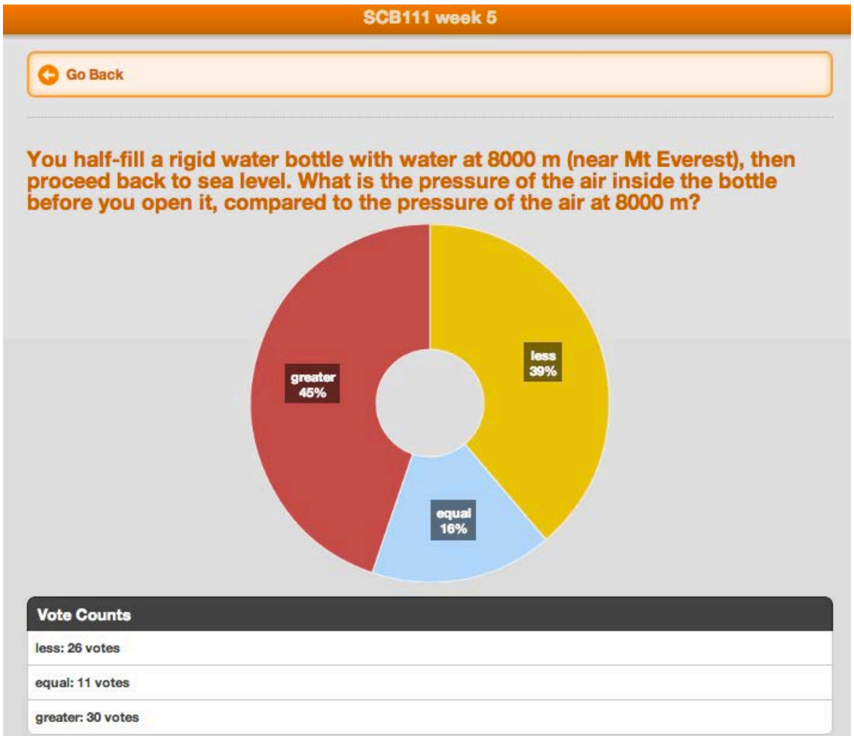


Figure 1: Screen shots of typical in-class questions used in this project*
*For the week 4 question, the images on the right hand side were included with the question on the PowerPoint slide.

The process of choosing and embedding these questions led to significant revision of lecture notes that had been used largely unchanged for several years by a number of staff members. As has been found by others, this was the most time-consuming and thought-provoking part of the process (Gachago, 2008). In particular, when looking to elucidate misconceptions and choose suitable student response questions, it became clear that the existing structure of some of the lectures was repetitive and unclear. Revising the lecture notes in order to add student response questions was therefore a worthwhile use of time, because all too frequently, the same notes are used with minor corrections, and structural change of the lecture (such as content order) does not occur for long periods. In this case, each set of student response activities took around one hour to choose, modify, and insert into the lecture slides and into the on-line system; that is, for the 6-week lecture block, around 20 hours.

Student participation

During the lecture periods, the student response activities were conducted in accordance with a modified version of the peer instruction model (Crouch & Mazur, 2001). Prior reading was not required, although the lecture slides were available in advance. After a short introduction to each topic, a question or set of questions was posed, and the students were asked to choose their answers on their own, in silence. After a reasonable period (usually less than five minutes), in which the incoming response rate was monitored, the answer distribution was displayed to the students. The students were then asked to turn to their neighbour and to try to convince them of their response, or to confirm their reasoning. Depending on the distribution of responses, this was sometimes for a short period (less than a minute), but usually around three minutes. Following this, the lecturer explained the reasoning leading to the correct answer, and answered any specific questions from students. Repolling the students after discussion as is recommended by Mazur (Crouch & Mazur, 2001) was rarely attempted, because it seemed that the students lost patience and were interested only in the correct answer; at that point, around ten minutes had already been spent on each student response activity. Also, the on-line system used did not have the ability to store a set of responses, so if they were cleared for repolling, the first set of responses would have been lost. A tablet computer was used to run the polls so that the PowerPoint presentation was not interrupted during polling; the results could then be displayed by using a visualiser to project the screen of the tablet.

The chosen on-line system was robust and easy to use for both staff and students. The system was primarily used for in-class polls for the activities described above. The text entry feature was also enabled and student inputs were read after each lecture, and responded to as appropriate. However, there were some limitations of the system, such as the inability to use images in either question or answer options; this function has since been added. A second limitation of the commercial system was that students were not required to give their real names, and sometimes, inappropriate comments were made anonymously, which distracted other students.

One benefit of the on-line system was that in the semester in question, student numbers were unexpectedly high and the lecture theatre available was too small to accommodate all of the students. For this reason, the lecture was projected in real time into a second lecture theatre. The on-line student response system offered the students sitting in the other room the ability to participate in polls and to engage during the class in a way that would be impossible with clickers or typical lecture formats.

The on-line systems were used for six weeks by one member of academic staff and a maximum of 116 students engaged with the system in one week, which was around half of those present at the lecture. Table 1 summarises the adoption and continuance data from this project over the six weeks that student response questions were used. Note that in week 1, the in-house system was used and failed after 100 students logged in. This had several negative effects over the whole semester; first, some students were put off from attempting the commercial system in week 2 after their frustration in week 1. Second, the students had been made aware of a system that would require their official institutional log-in, and some were disappointed that the commercial system allowed anonymity; one commented *"It was okay when it was through QUT, but as soon as we started using GoSoapBox and people could remain anonymous, there were a lot of silly comments and questions being posted."*

Table 1: Numbers of students signing in and responding to on-line student response system

	Week 1*	Week 2	Week 3	Week 4	Week 5	Week 7
Total number of students who signed in	> 100	108	102	116	82	65
Range of number of responses to individual questions	NA	63 - 94	64 - 89	23 - 93	33 - 73	19 - 50
Median number of responses to individual questions	NA	82	82	47	57	24
Total number of polls	6	8	6	28	14	17

* In week 1, the in-house system was trialled and failed

Although around 350 students were enrolled in the unit, lecture attendance was around 220 - 280 students. Thus, the total number of students signing in remained at nearly 50% of the class present until week 5. The progress examination was held in week 6, which may have affected participation in nearby weeks. However, even the lowest week, week 7, had 65 students sign in and up to 50 responding to a poll; this corresponds to around 25% of those present. Assessing the stage of the technology adoption life cycle by the proportion of students using the system, usage in all weeks corresponds to the early majority (Emenike & Holme, 2012). That is, for students, adoption could be thought to have crossed the chasm. It should be noted that this model is drawn from the sales context (Moore, 2002), and there was no financial cost to students in using the system in this project. It is also worth noting that even in contexts with marks attached to responses, student participation does not reach 100%; in one study, only 40% of students wanted to continue with student response systems after one semester (Yeh & Tao, 2012).

Only 13% of the students who responded to the survey had previously used clickers or other student response systems, so for over 85%, it was first time adoption. Some mentioned that they had never heard of such a system. Others, who had used clickers, commented that clickers were quicker than with the web interface. One comment, relevant to staff continuance was *"But they [the lecturers] didn't persist with it, even when it was working quite well."*

Table 1 shows that the total number of polls used each week varied widely. This was partly because, for certain topics, good conceptual questions were readily available in a multiple-choice format, but also because the instructor became more comfortable with the teaching method after the first few weeks. The polls were usually asked as sets, with up to four questions on a single topic displayed together on a PowerPoint slide and the students asked to answer all of them. With hindsight, 28 separate polls were too many, and the temptation to ask several questions on a single topic (in that case, solution concentrations, acids and bases, and oxidation and reduction) should be resisted. It would be more helpful to have fewer, carefully selected key questions, because the students can practice outside of class.

There was a significant drop in the number of students attempting each question during a single week (consisting of a two hour lecture block and a one hour lecture), with the first few polls garnering the highest number of responses and the last few, the fewest. It should be noted that a different subset of signed-in students attempted each question and very few responded to all questions. Some comments in the survey are relevant in this context; several students said that they only attempted questions that were not too easy, others, that they only attempted questions that they understood. By week 7, the final week of instruction from this lecturer, less than 20% of students present in the lecture attempted most of the polls. That is, even the students who adopted the technology in the first few weeks did not continue with it past the progress examination in week 6.

This behaviour can be analysed according to the model proposed by Bhattacherjee et al. (2008) and confirmed by Yeh and Tao (2012). The factors relevant to that model, specific to student use of the student response system, are:

- post-usage usefulness: the survey responses were largely positive regarding improved learning through engaging with the on-line system, although some students found the use of the system distracting.
- disconfirmation: this is the extent to which the system matched the students' expectations before using it. In this case, the expectations would have been low

because over 85% of students had not previously used any student response system. It was explained to the students that participation was expected to improve their learning, which was the main source of expectations about the system.

- satisfaction: this results from disconfirmation and is an affective measure after using the system.
- IT self-efficacy: none of the survey comments mentioned personal difficulties using websites generally; these students are frequent users of the internet and the site is very simple to use so it is unlikely that this is a major factor leading to discontinuance.

The above four factors together lead to continuance intention, which, combined with facilitating conditions (information systems success model factors), leads to the continuance behaviour. In this case the conditions included free wireless internet, and a lecturer who was enthusiastic about using the system and giving opportunities for students to participate. However, some students found the system slow to respond and frustrating, also the physical design of the lecture theatre with small desks was not conducive to having another item within reach. These were not facilitating conditions, and constitute poor service quality in the Yeh model (Yeh & Tao, 2012). The observed poor continuance behaviour can therefore be deduced to result most likely from dissatisfaction or the flaws within the information systems success model (service quality, system quality and information quality).

Student feedback

In spite of the decline in use of the system over the weeks in which it was offered, the survey responses were very positive about the impact of the system. The results of the survey, conducted in weeks 9 - 11 of the semester, are presented in Figure 2 and Table 2.

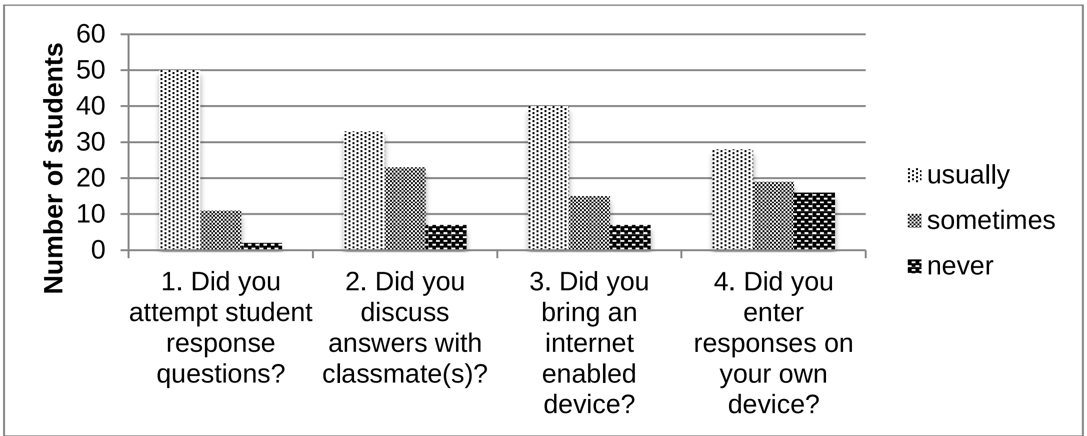


Figure 2: Frequency of responses to preliminary survey questions

Critically for all subsequent interpretation, this survey, based on an opportunistic sample of students who followed a link in an email invitation sent to the whole class, may have oversampled students who participated in the student response system. This is evident from the result of the fourth question, where nearly 75% of responding students (47 of 63 respondents) indicated that they usually or sometimes entered their responses. This contrasts with the data in Table 1, showing that less than one third of the class ever signed in (although it is not known which individuals these were each week). Comments on this question were mostly positive, but relevant to continuance is the comment *"I tried to at first, but it was just too clunky and time consuming so I stopped"*. A total of 63 students responded to the survey, close to 20% of the class and over 25% of those who attended regularly, but their responses may not be representative. The survey invitation emphasised that the views of people who had not used the on-line system were also sought but the same factors that make students likely to join such a system presumably affect their likelihood of responding to an internet-based survey.

Concern about equity, because not all students may own a suitable device, was lessened by the results of preliminary question 3 in Figure 2; over 88% of students who responded brought a mobile internet device to lectures at least some of the time. Comments to that question indicated that smart phones and tablet computers were favoured, and the weight of a computer was sometimes a factor.

In the discussion of the preliminary questions shown in Figure 2, it should be emphasised that the implementation of the on-line system had two elements, which can be examined separately. First, structuring lectures around conceptual questions, for which students were given time to think, then answer, then debate their choice, before working through the correct answer, is a teaching and learning strategy that does not depend on sharing the answer using an anonymous on-line system. Martyn has compared using clickers with having the same in-class questions discussed and answered using show of hands; for her small sample, no significant difference was observed in the outcomes of the two groups (Martyn, 2007). The second element in this project was the use of an on-line system to enter answers and see the class responses, with response rates described above. Martyn found that the students using clickers had more positive perception data, indicating that there may be impacts beyond examination performance.

In this project, although fewer than 20% of the students responded to most of the questions through the on-line system in the final week, all students may have benefitted from the teaching strategy, which allowed structured reflection and discussion. However, with low numbers answering the questions, it was difficult for the lecturer to know whether the misconceptions were widespread. In their survey responses, some students suggested that only confident students were answering on-line, in spite of anonymity, which might have biased the lecturer's view of how well particular concepts were understood. *"I do understand that it's helpful for the lecturer to receive instant feedback, but please be mindful that your go-soapbox results are probably biased towards those who are finding the content easy or have had some previous chemistry experience, and may not be reflective of the whole class, or those who are struggling."*

The responses to preliminary question 1 in Figure 2 show that 97% of survey respondents attempted the in-class questions. Feedback was very positive and Table 2 shows that students think that attempting these questions assisted their learning and improved their grade. A typical comment was *"I really enjoyed discussing the questions with my friends, for it facilitated my learning, as did doing the problems myself at first. Rarely in other lectures do I get problems to tackle myself. The lecturer usually demonstrates how to do the question straight up. This is of course helpful, but I really liked how Dr. Schultz taught us content and then posed problems to which we had to use that new content to solve ourself. This helped me with my learning very much."* It was also obvious observing the behaviour during the lecture periods that almost all students were making genuine attempts to answer the questions, and during the discussion period, all were talking animatedly and looking at the questions. This contrasts with observations of behaviour in traditional lecture formats, where few students are apparently engaged with the material. Preliminary question 2 in Figure 2 indicates that 89%

of respondents did discuss their answers at least some of the time. Comments were mixed, for example *"no didn't feel confident about my answers and didn't want to look stupid in front of my classmates"* versus *"The discussion component was very helpful."* The peer instruction literature (Smith et al., 2009) indicates that students benefit from the strategy even when none knows the correct answer.

A five point Likert scale was used for the final ten items on the student survey, and the results are shown in Table 2. These items are taken from Martyn's Perception Survey (Martyn, 2007) with slight modifications to separate the in-class questions from the use of the on-line system.

Table 2: Likert scale questionnaire responses (*n* = 63)

Statement	Likert score (5 = strongly agree; 1 = strongly disagree)	Standard deviation
1. The use of student response questions and discussions improved my understanding of the unit content	3.94	1.05
2. The use of student response questions and discussions increased my feeling of belonging in this unit	3.82	0.91
3. The use of student response questions and discussions increased my interaction with the lecturer	3.97	0.87
4. The use of student response questions and discussions increased my interaction with other students	3.73	0.98
5. I enjoyed participating in student response questions and discussions	3.79	0.93
6. I think that participation in student response questions and discussions will improve my grade in this unit	3.69	1.06
7. I would recommend using student response questions and discussions again in this unit	4.06	1.00
8. I enjoyed using the on-line system to enter responses	3.49	1.15
9. I think that using the on-line system to enter responses will improve my grade in this unit	3.23	1.09
10. I would recommend using the on-line system to enter responses again in this unit	3.69	1.15

Statements 1, 3 and 7 in Table 2 had very positive responses, showing that students felt that they learnt the content better, interacted more with the lecturer, and would like to have the same strategy used in future. These results are close to those of Martyn (2007) for the group of students that used clickers. In contrast, statements 8 and 9 were only very weakly positive; using the on-line system was not particularly enjoyable and the students did not think it would improve their outcomes. Nonetheless they were more positive about statement 10, that the on-line system should be used again. This is somewhat surprising, given the very low response rate to polls in the final week that they were used. The difference between the responses to statements 7 and 10 ($t(122) = 1.91$, $p = 0.058$) show that the students may perceive the value of the teaching strategy separately from the polling system.

The open ended comment section at the end of the survey yielded 26 responses, several of which showed that students perceive a difference between having a lecture structured around questions with time for working and discussion, and having an on-line system into which answers can be entered.
"I prefer the in class discussions and help, but not online."
"Active thinking is good but I think the on-line polling made it harder to keep up and absorb info during the lectures."
"I didn't find the student response system assisted with interaction with the lecturer. The questions and answers built into the lecture (verbally and written on PowerPoint) where [sic] sufficient."

It is likely that encouraging students to access the internet during a lecture will lead some to become distracted by their email and other websites; one comment reflected this: *"Too distracting having to interact with mobile device."* Clickers are smaller, faster and do not offer this distraction, so they may be superior, if available. However, as Yeh and Tao have discussed, modern students prefer flexibility in their engagement and may choose to access other websites during lectures, regardless of any student response system in use (Yeh & Tao, 2012).

The bottom line of any educational innovation is whether there is an observed improvement in student learning. For this project, student outcomes were assessed through a mid-semester examination, covering only content taught using the on-line system, and a final examination, covering the whole semester. Both of these examination papers were unchanged from previous semesters and the results were identical compared to previous semesters taught without student response systems. However, the lack of improvement in examination results does not rule out improved learning; a fixed multiple choice examination is a crude instrument and aspects such as improved engagement are not measured.

Staff Engagement

Six staff members observed a lecture using the on-line student response system. The staff interviews all included several comments about the importance of the system working quickly and with no technical hitches before they would consider using it; this reflects the factors of the information systems success model (Yeh & Tao, 2012). None of the staff members has previously used an on-line response system. It is clear that the staff member using the system in this project has the role of an innovator in this context, working in a discipline and Faculty where no student response systems had ever been used (Towns, 2010). As Towns explains, to convince staff beyond the early adopters to use the system is inherently difficult; poor engagement with the system by students leads to a vicious circle in which the system is not used due to perceived unpopularity, and when it is used, students are not familiar with it because it is not used in other classes. In the staff interviews in this project, all staff said they would consider trialling the system themselves, provided it was demonstrated to be reliable, with high response rates from students. These criteria are unlikely to be satisfied until the system is adopted broadly.

In other disciplines at the same institution, a small (less than 1% of academic staff) number of staff used the on-line system in the same semester as this project. All of those staff continued with the system the following semester and the number of users increased four-fold. This indicates that although staff participation is still in the innovator stage (Moore, 2002), continuance among the early adopters is observed.

Conclusions

This project led to the first implementation of a web-based on-line student response system in the Science and Engineering Faculty at the institution in question, and was successful in that over 100 students engaged with it, and largely positive feedback was received. However, the students' marks did not change compared with previous semesters, and student engagement dropped over the semester. Student continuance is highly dependent on the quality of the system as well as their learning performance (Yeh & Tao, 2012), so it is important that the technology works seamlessly and that they perceive its usefulness.

In terms of influencing colleagues to adopt the system, it must be realised that influencing change, particularly the use of technology among tertiary educators, is a slow, difficult and long-term process (Duin et al., 2012). Given that student learning did not demonstrably improve, the chasm between early adopters and the early majority will not be crossed; the early majority requires concrete evidence of specific efficacy (Towns, 2010), which is so far lacking.

Although it is possible to use in-class questions and discussion without an electronic polling technology, it is recommended that given the low cost and ease of use of GoSoapBox, such a system is worthwhile when clickers are not available. For students who engage only with attempting in-class questions and discussing their reasoning, and do not enter responses, there is value in seeing the breakdown of responses among those who do input answers. For the teacher, there is great value in seeing the breakdown of responses and being able to read comments (typed during class) after class rather than trying to answer all questions during the busy lecture periods. Given the known benefits of Peer Instruction, which includes polling as part of the teaching and learning strategy, (Crouch & Mazur, 2001), this project has demonstrated that on-line polling is a viable alternative to clickers when these are not available. As the technology improves in speed and functionality, and more students carry smart phones, it will become easier to include in-class polling at institutions that do not have access to clickers.

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