

Student Response (clicker) Systems: Preferences of Biomedical Physiology Students in Asian Classes

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Abstract: Student response systems (commonly called ‘clickers’) are valuable tools for engaging students in classroom interactions. In this study, we investigated the use of two types of response systems (a traditional clicker and a mobile device) by students in human physiology courses. Our results showed high student satisfaction with the use of clickers in class. A survey also provided insights into how students perceived the benefits of response systems. We found that most students favoured the use of traditional clickers over mobile clickers, with the students reporting a number of difficulties in using the latter. These difficulties could discourage students from moving ahead to more advanced levels in programmes that involve mobile device interaction with the course teacher. Thus, innovations in learning technology should proceed with caution, and with constant attention given to students’ preferences and needs.

Keywords: Web-based response system, clickers, student perception, human physiology, classroom interaction

1. Introduction: The use of clickers in classrooms

Student-teacher interaction has been deemed an essential part of the learning process (Siau, Sheng & Nah 2006) with a strong influence on student performance. Good interaction in the classroom can foster better learning attitudes and higher achievement (Haseman, Polatoglu & Ramamurthy 2002). A classroom environment can include multiple interaction types, including student-instructor, student-student and student-content (Moore 1989), that exhibit varying efficacy in each learning situation. For example, in a student-instructor interaction in the classroom setting, the instructor can gauge the students’ understanding of the content by asking them questions, and the students can raise their hands to answer. However, some students may not be willing to answer due to shyness (Ayu, Taylor & Mantoro 2009; Mula & Kavanagh 2009) or fear of being wrong (Voelkel & Bennett 2014). An audience response system can be helpful in this situation, as it allows students to answer questions anonymously rather than in the conventional way.

At present, there are two main types of response systems: the traditional clicker and the more recently developed Web-based device. Both systems involve similar clickers comprising three main components: an answer keypad with a signal emitter (fused into a single unit), a signal receiver and a processing unit. The answer keypad allows students to input their answers, which are sent by the emitter to the processing unit. In the traditional system, as noted by Stav, Nielsen, Hansen-Nygaard and Thorseth (2010), the keypad-emitter component is a clicker device, whereas in the Web-based system it is usually a mobile phone. The signal receiver (placed in the classroom) collects the signals emitted by the clickers in the traditional system, or the signals are transmitted through a phone or Internet network in the Web-based system. The signal receiver also sends the signals to the processing unit for analysis. The processing unit – typically a computer in the traditional system and a server in the Web-based system – analyses the signals received and generates statistical results using the system’s operating software or an installed program.

Numerous empirical studies on the use of traditional response systems have generally reported positive responses from users. For example, the findings from Alexander, Crescini, Juskewitch, Lachman and Pawlina (2009), Fifer (2012), Oigara and Keengwe (2013) and Vana, Silva, Muzyka and Hirani (2011) indicated that students had favourable perceptions of the usefulness of clicker systems during lessons. The subjects of these studies were students taking courses in the anatomical sciences, nursing (two of the studies) and physical geography. The sample sizes in the four studies ranged from 24 to 78 students. The participants were provided with clicker sessions during their classes in which questions were displayed and answered with clickers. The students' feedback on the use of clickers was then collected by surveys. The surveys showed a range of positive responses concerning the helpfulness of clickers in class. Some students reported that the clickers helped them to maintain concentration, and that using the clickers was enjoyable (Fifer 2012). Others noted that the clickers were easy to use, and that the immediate feedback from the instructor helped them to understand the concepts being taught (Oigara & Keengwe 2013). Some of the participants said that the clicker system increased their comprehension and retention of the lecture content (Vana et al. 2011). Others said that the clicker system helped them review the material presented (Alexander et al. 2009).

Despite these advantages of traditional clickers reported in previous studies, the devices do have the following disadvantages:

- instructors must buy the clickers and their batteries, making it a costly system to purchase and maintain (Gok 2011); and
- the instructors must take the time to distribute and collect the clickers (Jones, Marsden & Gruijters 2006).

The newer, Web-based response systems address these problems, as mobile phones are used as both the answer keypads and signal emitters. Stav et al. (2010) remarked that such Web-based systems are likely to reduce the costs associated with dedicated clicker devices, enabling institutes such as the University of Austin (Moca 2009) to build their own systems instead of paying for the traditional commercial ones.

The various Web-based student response systems generally use one or more of the following methods for students to cast votes using their mobile phones: (i) dialling, (ii) sending short message service (SMS) texts, (iii) accessing a polling website or (iv) using a polling application (app). With method (i), a specific phone number is assigned to each multiple-choice answer and the students answer by dialling the corresponding number. With method (ii), the students can send their chosen answer as an SMS text to the number provided. With method (iii), the students can access a polling website with a mobile phone that has Internet and Web-browsing capabilities, and then select the answer on the webpage. With method (iv), the students can connect to the polling server through a mobile phone app and answer the instructor's questions.

The potential of mobile (Web-based) clicker systems has become an interesting topic for discussion among instructors and students, with general agreement that they achieve effects similar to those attained by traditional systems. Two empirical studies have explored the use of SMS messaging (type ii) Web-based systems, and their evaluation results were positive. In Tremblay's (2010) study, the students reported that the system made their classes more interactive and less boring. They also said that they enjoyed using their mobile phones to participate. In Voelkel and Bennett's (2013) study, the students reported that the system made their classes more interesting, encouraged them to accept feedback on their learning and provided a good way to break lectures into sections, with brief interactive reviews of the material presented. Arnesen, Korpas, Hennissen and Stav (2013) studied a Web-based student response system (type iii) and found increased learning outcomes, particularly among students who were low-achievers in the class.

Another area of discussion concerns the advantages of the mobile phone clicker system over the traditional system, in that no special equipment or maintenance costs are required and the system can be used by distant learners (Jagar, Petrović & Pale 2012; Lapp, Ringenberg, Summers, Chivukula & Fleszar 2011). Some observers have noted that a Web-based system allows teachers to ask opened-ended questions instead of just multiple-choice questions (Lapp et al. 2011). The newer systems also offer additional possible functions such as anonymous or authenticated polling (Llamas-Nistal, Caeiro-Rodriguez & Gonzalez-Tato 2012).

In considering the advantages of mobile clickers described in the literature, we foresee that this system could become popular in Hong Kong classrooms. In addition, we think that the high penetration rate of smartphones in Hong Kong (58% in 2012) (Nielsen Company 2012, 2013) and the popularity of 3G/4G service (8.86 million

subscribers in Hong Kong in 2013) (Information Services Department 2013) provide favourable conditions for the use of mobile clickers in classrooms.

The operating software used in our context is a commercial ‘hybrid’ system called ResponseWare, purchased from TurningPoint Technologies. It is a ‘hybrid’ (both traditional and Web-based) in the sense that students can answer using dedicated clickers distributed by the teacher, but if the teacher desires and students have access, other mobile devices can be used to access a webpage and answer through the web interface (type iii) or a dedicated app (type iv). As with the traditional clicker system, this software works with MS PowerPoint. The students can download a dedicated ResponseWare app and install it on their smartphones, or go to the ResponseWare website using a standard browser. Before answering questions, the students must enter a session ID number that matches a question session created by the teacher online. Whether the students enter their names is optional, and the results of their responses are shown in a bar chart immediately after each question.

Classroom use of innovations can be challenging. Lam, Wong, Mohan, Xu & Lam (2011) noted some of the earlier issues with using Web-based student response systems, including the fact that not all students have smart phones with the necessary capabilities. Likewise, some teachers and students lack the proper technical knowledge to use such systems. We regard this study as another pilot trial in the use of this system, and aim to identify additional beneficial or adverse effects. Yet the advantages of response systems, be they traditional or Web-based, have been recognised by an increasing number of teachers, some of whom have shown a strong interest in trying them in their courses. This study considers the results of a trial using the two types of response systems in a series of courses related to the biomedical sciences and Chinese medicine. Our objective is to explore the students’ perceptions of the traditional and Web-based response system types.

2. Background

Our study participants were biomedical students from five physiology courses offered at the Chinese University of Hong Kong from 2010–2011 and 2011–2012. The participants were majoring in a variety of biomedical and medical disciplines, including pharmacy, nursing, Chinese medicine and human biology, and most were in the first year of a three-year curriculum (see Table 1). The majority of the participants, with the exception of the human biology students, had never been exposed to any form of clickers. With the support of a special internal grant, we purchased 200 traditional clickers and began a pilot study in 2010 by gradually introducing them into selected physiology courses with small class sizes.

We expected the use of clickers to transform the learning dynamics of these courses and facilitate a multi-dimensional teaching mode to improve student learning, especially in courses with large classes. In an earlier study (2009), we received overwhelmingly positive responses from students in smaller classes (data not shown). Thus, from 2010 to 2012, we implemented the use of clickers in additional classes with larger numbers of students (see Table 1).

Table 1: Course Information for 2010–2011 and 2011–2012

Student Majors (2010–2011)	Programme Type (Undergraduate - U, or Postgraduate – P)	Year	(2010–2011)	(2011–2012)
			Total number of students	Total number of students
Pharmacy	U	1	79	88
Nursing	U	1	196	202
Nursing	P	1	59	83
Chinese Medicine	U	1	41	32
Food/Nutritional Sciences /Human Biology	U	2	45	82

*Due to the course arrangement, in 2011–2012, the students majoring in Food and Nutritional Sciences were combined with those in Human Biology.

Students studying human physiology sometimes encounter difficulties in understanding the long, complicated molecular and physiological mechanisms and the complex ways in which human organs coordinate. The use of clickers in our participating classes was thus intended to provide students with opportunities to:

- review a summary of the topic-specific concepts and theories presented in class,
- consolidate their knowledge of facts about selected body organ systems,
- identify their topic-specific weaknesses and common mistakes,
- allow immediate discussion with the teacher and
- facilitate an interactive atmosphere in class.

Clicker question slides were shown to the students at the end of each topic’s lecture series. In most cases, the students were encouraged to discuss the questions with their classmates for a minute, after which they selected their answers from the given options. A histogram of how the students responded to each question showed up immediately, along with the correct answer. The teacher would then initiate a discussion or elaborate on the question, and the students could ask further questions. In this way, the students could consolidate their grasp of the contextual concepts and check their understanding with the teacher. The teacher was also able to identify the students’ major weaknesses and provide immediate feedback.

Given the increasing popularity of mobile smart devices among university students (such as smartphones, iPads and Android tablets), students are often assumed to be willing and ready recipients of new information technology and gadgets. We expected a favourable transition from traditional clickers to systems using mobile devices. We asked two classes, each with a moderate number of students, to answer some clicker questions at the end of their lectures using their smart phones or other mobile devices with Internet connections. The students were first given a few minutes’ introduction on how to log into the mobile software system. Those who did not own a smartphone were given a traditional clicker to log into the system at the same time. After the clicker session, the students were given a survey form to evaluate the experience.

2.1 Situation 1: Use of traditional clickers

In our first study (2010–2011 and 2011–2012), students from all of the selected courses used traditional clickers (see Table 2). The number of clicker questions was limited to a maximum of five to eight after each lecture to ensure sufficient time for class discussion. More clickers were used in the 2011–2012 period due to requests from students in various courses. For each lecture involving a clicker session, traditional clickers were distributed to students at the beginning of class. The operation software used for the system was XPRESS from the Sun-Tech International Group Limited. This system articulated the student responses in the form of MS PowerPoint bar-chart slides, which appeared immediately after all responses were received for each question. The teachers procured the supply of clickers and receivers from a local rental service.

Table 2: Percentage of Lectures that Used Traditional and Mobile Clickers

Student Majors (2010–11)	Total no. of lectures	No. of lectures that used clickers (T = traditional, M = mobile)	% of lectures that used clickers	Student Majors (2011–12)	Total no. of lectures	No. of lectures that used clickers (T = traditional, M = mobile)	% of lectures that used clickers
Pharmacy	38	3T	7.89	Pharmacy	38	3T	7.89
Nursing (Bachelor)	22	2T	9.09	Nursing (Bachelor)	22	3T	13.68
Nursing (Master)	35	3T	8.57	Nursing (Master)	35	8 (7T, 1M)	22.86
Chinese Medicine	20	3T	15.00	Chinese Medicine	20	4T	20.00
Human Biology	34	3T	8.82	Human Biology	34	6 (5T, 1M)	17.65

2.2 Situation 2: Use of Web-based mobile clickers

Two courses in human biology and nursing (year 1 of a Master’s programme) in 2011–2012 (see Table 2) were selected for the Internet-based response system trial. These two classes were of moderate size, and their students showed relatively higher ownership of smartphones or mobile devices with the necessary capabilities. Students who were already accustomed to using traditional clickers from previous classes were given a short introduction on operating the Web-based clicker system, including how to connect to the online software for the mobile clickers using their mobile devices. Students who did not own mobile devices with Internet connections were provided with traditional clickers that could also connect to the polling server, thanks to our previously explained ‘hybrid’ system. In both participating courses, the response sessions involved a maximum of five questions.

3. Findings

In both the traditional clicker and Web-based device situations, evaluation surveys were administered at the end of the courses to collect the students’ feedback on the experience of using clickers in class. Table 3 summarises and contrasts the students’ scores in the two situations. For Situation 1, we collected data from six classes, and for Situation 2, we collected data from two classes.

Table 3: Student Feedback (Multiple Choice Questions)

Main themes and question numbers	Question items	Situation 1		Situation 2	
		Mean scores	N	Mean scores	N
Process					
Q1	Participation with clickers increased my interaction with the instructor.	4.07	317	4.18	115
Q2	Participation with clickers increased my interaction with other students.	3.80	318	3.95	115
Q3	Using clickers improves class participation.	4.14	317	4.16	114
Q4	Using clickers allows me to pay more attention during lectures.	3.95	318	4.00	115
Understanding					
Q5	Answering clicker questions during lectures helped me to clarify whether I understand course concepts.	4.27	317	4.26	115
Q6	Using clickers encouraged me to come to class better prepared.	3.69	308	3.75	115
Q7	I believe that I learned more in this class due to the use of the clickers.	3.93	318	3.88	115
Q8	Using clickers gave me immediate feedback about my understanding of a concept.	4.26	316	4.22	115
Q9	Using clickers encouraged me to really understand the materials rather than	4.00	316	3.98	115

	just recognising the correct answer.				
Q10	Using clickers helped me to apply the concepts during class.	4.00	316	4.05	115
Q11	Using clickers helped me to identify misunderstandings and misconceptions in my thinking while in class.	4.17	317	4.08	115
Attitudes					
Q12	I enjoyed participation with clickers.	4.06	317	4.07	115
Q13	I would like my instructor to ask more clicker questions.	3.94	317	4.00	115
Overall comments					
Q14	I would recommend using clickers again in this course.	4.19	317	4.21	115
Q15	Clickers make classes more interesting and fun.	4.04	316	4.14	114
Q16	Using clickers in class helped me to do better in quizzes and exams.	3.83	317	3.83	115
Q17	I would prefer that my other courses also used clickers.	4.05	317	4.06	115
Difficulties*					
Q18	I experienced technical problems with the clicker during class.	2.54 (original); 3.46 (converted)	316	2.99 (original); 3.01 (converted)	114
Q19	The instructor experienced technical problems with the clicker during class.	2.43 (original); 3.57 (converted)	317	2.87 (original); 3.13 (converted)	114
Q20	The clicker session was time consuming.	2.60 (original); 3.40 (converted)	317	2.92 (original); 3.08 (converted)	115
Q21	It was difficult to see whether my clicker was working or not.	2.37 (original); 3.63 (converted)	316	2.66 (original); 3.34 (converted)	115

* As questions on this theme were written in the opposite direction to that used for the other themes, a lower score means a more positive response (marked as 'original'). For a better comparison with other questions,

these scores are also converted according to the scale used with the other themes (with the translated score marked as 'converted').

3.1 Learning benefits

The overall response rate of the six classes in Situation 1 was 63.0%, and the range was 31.1-89.8%. The scores ranged from 3.40 to 4.27, which indicated that the students were mildly positive towards the use of clickers in class. In Situation 2, the response rate for the human biology programme was 44.0%, and for the nursing programme it was 96.2%. The scores ranged from 3.01 to 4.26, which also indicated that the students were mildly positive towards the use of clickers in class. Note that these results represent the overall feedback on the use of both types of clickers. They do not indicate which type of clicker was rated better, because we did not ask the students which type of clicker they used in the survey.

In Situation 1, the students perceived that the most prominent advantage of using clickers in class was that they helped identify misconceptions, which clarified the knowledge presented. Of the seven questions on the theme of 'understanding', five (Q5, Q8, Q11, Q9 and Q10) had mean scores of 4 or higher (4.27, 4.26, 4.17, 4.00 and 4.00, respectively). The second major advantage was that the clickers encouraged the students to engage in the lesson. Two of the four questions in the 'processes' theme (Q1 and Q3) had scores higher than 4 (4.07 and 4.14, respectively). The responses on the 'overall comments' theme (Q14, Q17 and Q15) indicated that the students' willingness to use clickers was also quite high (4.19, 4.05 and 4.04, respectively). Likewise, most of the students claimed to enjoy using the clickers (Q12, 4.06, in the 'attitudes' theme). The questions about the clickers' ease of use got the lowest scores, but remained positive (all were higher than 3).

The survey results for the mobile clicker context (Situation 2) were quite similar to those found in the traditional clicker situation. The most prominent advantage of mobile clickers was in helping students to identify their misunderstandings. Of the seven questions in the theme of 'understanding', four (Q5, Q8, Q11 and Q10) had scores above 4 (4.26, 4.22, 4.08 and 4.05, respectively). There were three questions (Q1, Q3 and Q4) in the 'processes' theme with scores higher than or at 4 (4.18, 4.16 and 4.00, respectively). The students were generally interested in using the system, and indicated they would like to use it in other courses, or would recommend using it again for future courses. Questions Q14, Q15, Q12, Q17 and Q13 in the 'overall comments' and 'attitudes' themes had scores of 4.21, 4.14, 4.07, 4.06 and 4.00, respectively. As in the surveys of students in Situation 1, the questions related to ease of use were also rated lowest but still scored higher than 3.

3.2 Difficulties in using the traditional clickers and other comments

All of the data concerning Situation 1 came from open-ended questions (there were no such questions in the Situation 2 survey). The Situation 1 students were asked if they i) had any difficulties in using the clicker, ii) had any suggestions for improving clicker use, iii) whether they wanted the clicker to be used for anything else and iv) if they had any other comments. The overall results seemed to be quite positive, because the number of difficulties that the students encountered was not very high. Even when they were asked to suggest improvements, some of them gave compliments instead.

For point i) (any difficulties), the response rate was low (only seven), and the answers were brief. These responses were mainly concerned with the details of use during the process, such as not enough time for answering questions or difficulty operating the clicker if it was placed too far from the receiver.

For point ii) (suggestions for improvements), there were 16 responses. Some of these were actually compliments concerning the use of clickers. Five of the responses were non-critical, such as 'perfect already', 'lecturer can know what topic needs further elaboration' or 'more of this kind'. Another eight responses concerned how the lecturer could use the system better, with suggestions such as 'the questions should not be too long or complicated', 'better to show the overall performance for each individual clicker' or 'inform students of the use of clickers in the next lesson to allow better preparation'.

For point iii) (whether clickers should be used for anything else) there were 20 responses. Most of these seemed to be positive regarding the use of clickers in other areas. Half of the responses were suggestions that clickers could also be used in course evaluation and voting while the others indicated a desire for broader use in general (with comments such as 'use it more frequently', 'other topics of the course' and 'other lessons').

Only one of the responses seemed conservative: 'Please use clickers only for question practice. It is not useful (in my opinion) for an overall review which we were expecting'.

For point iv) (any other comments), there were eight responses, most of which were positive, such as 'I love clickers', 'should use clickers frequently' or 'more clicker questions'.

3.3 Preferences

As the students who used the mobile clickers also had previous experience using the traditional clickers, they were asked about which type of clicker they liked best and why. All of the data concerning these preferences were collected from the classes in Situation 2.

In this portion of the survey, we found a distinct preference, with the majority of the participating students favouring the traditional clickers, although for somewhat differing reasons. Of the 114 students in the Situation 2 classes who answered the preference question, 99 selected the traditional clicker as their preferred type.

The most frequently mentioned reason for this preference (22 responses) was that not every student owned a mobile phone that could connect to the Internet. In addition, 19 students thought that the traditional clicker was easier or more convenient to use. There were several additional reasons given with a lower frequency, but which also seemed important. These concerns included the long time that it could take to connect to the Internet (10 responses), difficulties in connecting to the Internet (10 responses), the consumption of mobile phone battery power in accessing the Internet (3 responses), the limited quotas of campus WiFi logins (2 responses), the small screens on phones (2 responses) and other technical problems with using mobile phones (2 responses).

Only 15 students selected mobile phones or both mobile phones and traditional clickers as their preferred type of response system, and many did not give a reason for their choice.

4. Discussion

The findings for Situation 1 were generally positive and seemed to affirm similar findings from previous studies. The use of traditional clickers was first introduced into biomedical physiology courses in 2009 as a pilot e-learning project organised by the School of Biomedical Sciences of the Faculty of Medicine. The majority of students at that time had never been exposed to this e-learning tool in previous courses. In fact, the use of any kind of student response system was relatively uncommon at that time, primarily because most teachers were not yet aware of the student response systems offered by software and hardware companies. When the traditional clickers were given to the students the first time, most of them were excited about using the small hand-held devices in class. Clickers certainly showed a magical power to retain students' attention, as Fifer found in a later study (2012).

In terms of learning benefits, the performances of traditional and mobile clickers did not seem to vary a great deal. Surveys of students taking the five courses showed that the clickers were generally well received and viewed as beneficial. Also, by and large these benefits correspond well with those commonly suggested in the literature:

- Comprehension – using clickers helped improve students' comprehension of lecture content (Vana et al. 2011; Oigara & Keengwe 2013). Related comments were reflected by Q5–Q11 in our survey. A common response that we obtained from these students was that the use of clickers at the end of class helped them reinforce and clarify difficult concepts concerning the bio-molecular and bio-chemical mechanisms of human physiology. In response to such positive feedback and to frequent requests from the students, in 2010 the school officially incorporated the use of clickers into five physiology courses: four at the undergraduate and one at the Master's level. As in Voelkel and Bennett (2013), our survey showed that students perceived clickers to be a valuable tool for reinforcing concepts and identifying misunderstandings.
- Enjoyment and motivation – Fifer (2012) remarked that clicker activities can be enjoyable and improve students' concentration. Our findings (such as the comments collected from Q4 and Q12–Q13) generally confirmed this, whether students were using traditional or Web-based clickers.

- Interaction – many researchers, such as Tremblay (2010), Voelkel & Bennett (2013) and Armesen et al. (2013) commented on the increased classroom interactions made possible by the technology. This phenomenon was also present in our study (refer to Q1–Q3).

This study did not, however, confirm that the mobile clickers were more convenient, at least from the students' perspective. Most of the participants surveyed showed a distinct preference for using traditional clickers. Those who replied to the survey indicated that traditional clickers were more user-friendly and convenient.

The challenges were of many types. There were problems with the capacity to connect to the Internet. Some of the participants reported poor Internet connections, which reduced their interest in using mobile clickers. Even though WiFi is supposed to be available in this all-campus environment, some students commented that it was not strong enough for all of the students in the classroom to go online at the same time.

Another problem was that connecting to the Internet for the mobile clicker sessions tended to use up students' phone batteries. Some students did not own the right kind of device for mobile learning. Students from the Situation 2 classes immediately commented that it took them too long to log into the mobile software system, and some reported experiencing technical problems with their mobile devices.

The software we used also created challenges. In addition to the student survey responses, the teachers pointed out other drawbacks in using a Web-based clicker system; namely, the limitations of class size and the need to purchase a licence to use the system. As the licence has to be renewed every year, this would probably impose a financial burden on some teachers. The technology used in our study was relatively expensive and had certain technical limitations. The online licences were purchased based on the number of concurrent student users. At the time of our study, we purchased 20 such licenses – a number we found to be insufficient, as there were clearly more students who had mobile devices in the classes. As a result, some students spent significant amounts of time trying and failing to log in. At that time, the system server was located overseas, which was another limitation of the technology. The classroom interactions involved long-distance online traffic from Hong Kong to and from the server in Australia, which caused the system responses to be slower, especially compared with the experience of using the traditional clicker system.

Despite the challenges, the Web-based solution has certain advantages over the traditional clickers. For large-sized classes such as those for nursing students, in which the normal class size is about 200, it was a physical burden for teachers to bring the clickers and distribute them to all of the students. This inconvenience was also mentioned by Jones, Marsden and Gruijters (2006). Collection of the clickers after class also required patience from both teachers and students. In many cases, the teachers found it necessary to assign class representatives to ensure the timely distribution of clickers amongst students.

5. Conclusion

Overall, our student surveys reported the beneficial effects of clickers in terms of student learning, but also identified a number of limiting factors in using Web-based clicker systems. Some of these issues were encountered in the previous study at our university, such as the problem of not every student owning a compatible mobile device (Lam et al. 2011). Other issues were exposed by this study (e.g., poor connections and consumption of battery power). We believe that this situation can be improved as better technology becomes available. Teachers can also benefit from the additional features of clickers. For example, the use of response systems can help teachers to revisit student responses for assessment, course design and development. However, the significance of clickers in both teaching and learning enhancement is not yet acknowledged by most teachers. There is still poor teacher participation in the use of both traditional and mobile clickers, as reflected by the relatively low percentage of clicker use in other courses.

Although we did not find overwhelming advantages of Web-based clickers over traditional clickers in this study, we remain optimistic about the future of Web-based solutions. Internet connectivity in classrooms will continue to improve, and students' ownership of suitable mobile devices is likely to experience significant changes in the years to come. Thus, student response systems should continue to evolve in terms of user-friendliness and affordability.

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