Introduction

Student retention and engagement have been found to be a major problem in many universities. It has also been found that the structure of a program and the pedagogical methods play a significant role in engaging students and assuring the required degree of retention (Kulatunga & Rameezdeen, 2014). Engaging students through interactivity in a classroom is typically limited for the following reasons (Siau, Sheng & Nah, 2006): 1) class times are inflexible; 2) there is insufficient student participation, because only one student (or the instructor) can talk at any given time in oral questioning and answering episodes; 3) students may not be willing to express their opinions in front of a class for fear of embarrassment; and 4) no mechanisms are available for instructor to assess whether students understand the course materials and there is a need to adjust the pace of teaching.

From the other side, in-class assessments provide students with an opportunity to interact directly with the lecturer and their peers. The instructor can also benefit from knowing more about the degree of students' understanding of the content as early as during the lecture time. This could simply be done by asking particular short answer questions to which, at best, one student can participate. If a great number of participants is desired, the limitation such as the duration of the class or the size of the class may impair the communication. These types of impediments, along with the intention to provide equal chances for all the students to contribute to their learning (Keough, 2012), have led to the introduction of a variety of methods including Classroom Response Systems (CRSs) or Students Response Systems (SRSs) approaches (Green, Chang, Moll, & Tanford, 2015; Kulatunga & Rameezdeen, 2014; Wang, Chung, & Yang, 2014). Response system-based methods are additional tools to the classroom environment, but not a curriculum within themselves.

In comparison to lecture formats with no response system, CRSs (also sometimes referred to as clicker) allow students to receive frequent and on-going constructive feedback on their answer to the instructor's questions, along with a comparison of their answers to the answers of their peers. Consequently, CRSs allow instructors to provide real-time clarification of class misconceptions, by which CRSs showed (Blood & Gulchak, 2013; Lantz & Stawiski, 2014) a significant contribution in the amplification of learning as well as an increase in the students' test scores at all different levels; from elementary and high schools (Wang et al., 2014) to 1st-year (freshmen), 2nd-year (sophomore), and final-year (junior and senior) university students, in wide range of disciplines, and different courses within a particular discipline (Bojinova & Oigara, 2013; Green et al., 2015; Keough, 2012; Lantz & Stawiski, 2014; Singer, Nielsen, & Schweingruber, 2012; Stowell, 2015; Wang et al., 2014).

CRSs have been in use for a great part of the last two decades, researched and documented for some academic disciplines, and viewed positively by both learners and instructors; however, it is still worth investigating this advanced technology and its widespread application, especially in the teaching of engineering courses. As a result, this research aims to investigate the merits of the use of CRSs in terms of improved classroom interactivity, students' experiences, engagement and learning outcomes (Oigara & Keengwe, 2013). Another of its objectives is to compare the learning outcomes for different student cohorts, taught with and without using CRS through a survey questionnaire assessing students' opinions and experiences.

Background

In recent years, the learning and teaching pedagogy has had to frequently reinvent itself with the continual introduction of new tools, different platforms and innovative approaches to learning and teaching. Many Universities in the developed countries including Australia have started to use CRSs in order to make classroom activities more effective by actively engaging students. However, it is important to use CRS in an innovative way to achieve the benefits of blended learning combined with the best features of face-to-face interaction. CRS provide a new dimension for interactivity in the classroom and active discussion which can help students to achieve learning outcomes. When interactivity is present, students are not only more motivated to learn, but also more attentive, participative and likely to exchange ideas with instructors and fellow students (Balaji, 2010).

To date, there has been limited systematic research that compares different pedagogical uses of CRS, despite their popularity continues to grow significantly. Besides, analysing the benefits of CRS and their impact on students' learning outcomes and exam performances is critical to the future effective use of CRS. Even though many studies have tested the performance of CRSs for enhancing learning outcomes (Camacho-Miñano & del Campo, 2014; Cotes & Cotua, 2014; Fisher, Exley, & Ciobanu, 2014; Jonathan, Lili, Media, Abubakar, & Montadzah, 2014), the scholarship of pedagogy with regard to CRS technology is still emerging. That is, apart from the widespread usage of CRS and a general agreement on the positive influence of using them, in order to improve the effectiveness of investing institutional resources, case and pilot studies for particular course, program or institution are deemed necessary. For instance, Keough (2012) has performed intensive thorough studies into the effect of CRS on learning and teaching and carried out 66 studies in 16 different disciplines which were focused on student perceptions and outcomes of usage of CRS. Interestingly, in his list of 16 reviewed disciplines, there are no engineering courses. Hence, the potential benefits of CRSs in the provision of effective and engaging contemporarily assessment method (both formative and summative) in engineering courses is deemed central. As a result, this project aimed to investigate the merits of the use of CRS in engineering schools compared with traditional lecture-based teaching methods, and in terms of student engagement and learning outcomes. Finally, some recommendations are given on how to use the CRS to achieve the best result.

Methodology

While CRS has been used in teaching power engineering and other engineering courses in the Griffith School of Engineering, their effectiveness has not been measured and quantified. A variety of data were collected from different power engineering courses in Electrical Engineering disciplines. In the university-wide end-of-semester "Student Evaluation of Courses (SEC)" and "Student Evaluation of Teaching (SET)" survey, specific questions related to the effect of clickers on students' engagement and performance in two power engineering courses were included. These SEC and SET outputs were compared with other engineering courses (taught without using clickers) to determine the effectiveness of using clickers. Besides, in order to quantify the impact of clickers on students' engagement and learning outcomes, students were invited to complete a short voluntary and anonymous questionnaire, designed to capture the positive and negative aspects of using clickers during lectures. This survey was undertaken in 2013-2015, with appropriate ethical clearances obtained for its continuous use.

The main objectives of the clicker-based assessment design in our study (modified from Beatty et al., 2009) are to: (a) motivate students and encourage them towards deep levels of learning through career-driven questions; (b) improve course learning outcomes and effective communication skills by creating discussions based on questions using clickers; (c) assist students to develop critical cognitive skills and cooperate in the learning process through effective communications and higher expectations; and (d) inform and adjust teaching and learning pedagogy according to formative and summative assessments. Questions related to analysis, synthesis and evaluation, which require critical thinking and judgement, was included, with data collected both during (survey questionnaire data) and after the semester (SEC, SET and performance data). Different student cohorts in the School of Engineering were asked to complete qualitative evaluations of their use of clickers throughout the semesters via questionnaires which were targeted to verify the effects of clickers on students' learning outcomes.

Case Study

Clickers have been used in the teaching of two power engineering courses since semester 2, 2013. From the preliminary analysis conducted in semester 2, 2013, it was found that attendance in classes which used this technology were always greater than 80%; significantly higher than other lectures, despite numbers normally decreasing significantly as the semester progresses. Consequently, in Week 12 of the total 13 weeks of that semester, the students were asked whether *clickers helped with attention/engagement/active learning.* More than 90% felt that they were very effective in enabling engagement and interaction with both their lecturers and peers. This was in accordance to what is already found in the literature (for instance Lasry, 2008; Patry, 2009) that clickers have the potential to increase student engagement and may serve to facilitate student learning. The preliminary study also examined the degree to which students believed that using clickers helped them to understand course content and remain engaged during the class time. More than 70% commented that clickers had helped them in some way to understand the course materials better, and almost 90% said that clickers had assisted in keeping them engaged during lecture times. About 75% of participants commented favourably on the instant feedback aspect of clickers and 85% saw clickers as a motivational tool. In SEC, students commented that "*The RF remotes* [i.e. clickers] *and quizzes were good to keep students interested and created good open discussion in classes"; "The lecturer has made an obvious effort to engage the students throughout the course, particularly with the use of the multiple choice quizzes (using the clicker) to provide good feedback to the students".* Therefore, the preliminary study showed that student impressions of the technology were closely connected to the learning context in which clickers were used.

Accordingly, to further enhance the preliminary study and perform more systematic and thorough data collection, in this article, two courses from Electrical engineering disciplines at Griffith University have been chosen to exercise the usage of CRS. Consequently, the students of the courses have been questioned about their perception of the system and the influence of the system on their learning experience. Table 1, shows the number of participant in each of the course and years. The responses were later analysed statistically (Gogus & Ertek, 2012) to compare the learning outcomes for different student cohorts and different subjects taught with and without using CRS. Additionally, the final grade for the students of the selected course, were compared with two other datasets: a) the grade for the students' other courses which ran concurrent to the duration of the survey for this research; and b) the grade for the same courses as this research which ran in prior semesters. These are believed to be a decent indicator of the influence of the usage of CRS for each of the mentioned cohorts. Meanwhile, as for the limited number of participants, the university-wide SEC and SET surveys were also analysed; as they were believed to be valuable source of qualitative data and feedback.

Table 1: Participants in Surveys

Semester	Course	No. of participants
S1, 2014 and S1 2015	Power System analysis	25
S2, 2013 and S2, 2015	Power Transmission and Distribution	30

At the early stage of the semester, students were introduced to the concept of CRS along with necessary instruction on using the clicker devices. Afterwards and before the end of the semester, in Week 10 of the total 13 weeks, a survey questionnaire (Table 2) along with an introductory booklet were given to the students to collect their opinion and feedback about the implementation of the CRS. Responding to the survey was voluntarily and the related forms were designed in a way to remain anonymous throughout the process. The questions were intended to gather information about the students' satisfaction of the usage of CRS, the influence of CRS on their attention, attendance and participation in in-class activities and debates, and also the effect of CRS on their learning and cognition (Keough, 2012; Oigara & Keengwe, 2013). To answer to the questions, a 5-category Likert-type scale was used; comprising of 1) strongly disagree (or very dissatisfied); 2) disagree (or dissatisfied); 3) neither agree nor disagree (or indifferent); 4) agree (or satisfied); and 5) strongly agree (or very satisfied). Moreover, an open-ended question was also considered, for any general comments that students may have wished to pose concerning strengths or weaknesses of the approach. The number of responses to each question and their distribution are presented in Table 2.

Table 2: Questions of the students' survey and distribution of responses

Questions	**Average scale of responses (based on Likert-scale)**	**Percentage of responses**		
		neither agree nor disagree	**agree**	**strongly agree**
1. How positive is your overall evaluation of the "clicker" technology?	4.5	4	38	58
2. To what extent has the use of the "clicker" technology helped you to stay engaged during class time?	4.3	8	42	46
3. To what extent has the "clicker" technology provided useful feedback to you about your understanding of course content?	4.1	29	29	42
4. How effective was the clickers to test your pre-requisite knowledge for the course?	4.3	17	38	46
5. How much do you agree with the statement that more instructors at the Griffith School of Engineering should make use of "clicker" technology in their courses?	4.5	4	46	50
6. Confirmed my understanding of a concept discussed in the class	4.2	8	63	29
7. Helped with attention/engagement /active learning?	4.5	17	21	63
8. Correct a misconception or misunderstanding of a concept being discussed in the class	4.3	17	42	42
9. Provide immediate feedback about my understanding of a particular topic being discussed in the class	4.6	8	25	67
10. Clickers helped me to focus on the big picture and achieved core concept of the subject being taught	4.2	13	58	29

Results of the survey show that the introduction of clickers contributes to a dramatic increase in the students' satisfaction as can also be seen in Table 3. The lecturers also received positive feedback from many students and the school discussion group; for example: "*The lecturer has made an obvious effort to engage the students throughout the course, particularly with the use of the multiple choice quizzes (using the clicker) to provide good feedback to the students*" (S1, 2013) and *"the quizzes every couple of weeks motivates the class. The discussion about the answers also helps to cement the content. Feedback is crucial and this is being provided well" (*S1, 2014, Course Enhancement Focus Group Discussion, Griffith University). As a result of adopting these innovative teaching approaches, students' average mark increased from 64.95 (S1, 2012) to 70.27 (S2, 2013) and distinction grade from 31.8% (S1, 2012) to 46.7% (S2, 2013) as can also be seen in Table 4.

Table 3: SEC and SET data

Semester	2012-S2 (without clicker)	2013-S1 (with clicker)	2013-S2 (with clicker)	2014-S1 (with clicker)	2014-S2 (with clicker)	2015-S1 (with clicker)
Response	12 (77.3%)	13 (60%)	13 (60%)	14 (77.8%)	14 (66.3%)	19 (73.1%)
SEC/SET	3.8/4.1	4.3/4.6	4.6/NA	4.7/4.8	4.8/4.8	4.8/4.7

Table 4: Students Grade

Semester	HD	D	C	P	Mean
Semester 2, 2012 (without clicker)	13.6	31.8	13.6	31.8	64.95
Semester 1, 2013 (with clicker)	13.2	46.7	20.0	13.3	70.27

Results and discussion

One of the topics in social sciences is about the social facilitation and the influence of the human interaction on group activities. Oswald, Blake, and Santiago (2014) explained the effect of co-action and audience presence on the increase of participation and responding in the classroom setups. They described that performing tasks in presence of others ('co-action') as well as in front of others ('audience presence') generally results in totally enhanced outcomes. Moreover, Wang et al. (2014) stated that the students hesitantly wait for their peer to be sure that are also ready to pose their opinion. Such theories and findings, nicely applies to the case of CRS and its implication. In general, CRSs offer (Blood & Gulchak, 2013): a) more interesting teaching strategies by reviewing the main ideas, end of unit or chapter stage as well as sparking discussions and competitions; b) more motivating strategies as in class-wide voting and sense of being heard; and c) innovative assessment strategies such as pre-test, post-test quizzes as well as review of assigned readings. These all have been reflected in the collected survey of this research; that is CRS is a valuable tool to be used in the teaching of engineering courses to a wide range of audience with different background knowledge, language proficiency, demography, age, physical/mental condition and goal (Blood & Gulchak, 2013). Although, if the research focuses on one course, less bias or disagreement between results may be expected (Keough, 2012), this possibility and applicability of application of CRS is tested here for different courses.

Based on Table 2, different questions of the survey consistently demonstrate the overall satisfaction of the students with a few responses (in total 4%) with the choice of "neither agree nor disagree", only one response with the choice of "disagree" and no responses with the choice of "strongly disagree". The overall grade of the students' satisfaction of the usage of CRS in this research (i.e. question 1) is 4.5 out of 5 (based on the Likert-type scale introduced above). It is also reflected in the attendance rates which were always deemed more than 80%. Apart from an overall similarity of the distribution of the responses to all the questions (see Figure 1), the average of the scores in all other questions (except question 1) is 4.3 which demonstrates a strong consistency and honesty in filling the questionnaire.

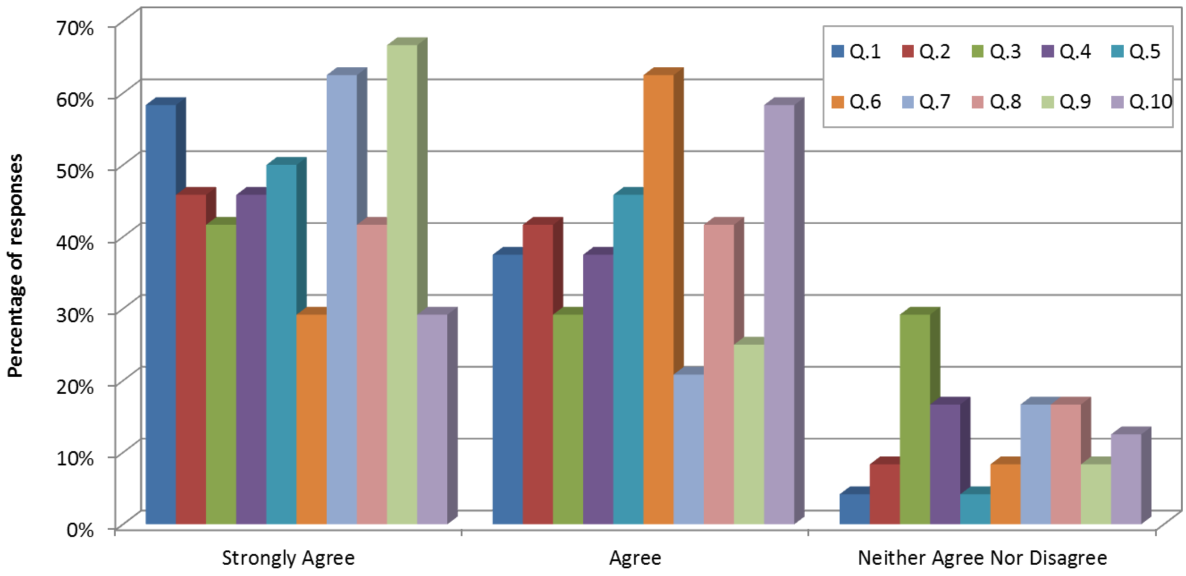

Figure 1: Distribution of different responses to questions (see Table 2)

The students strongly perceived (average response of 4.2 in questions 6, 8 and 10) that their learning was enhanced when CRS was used in their course. Moreover, majority of the students (average response of 4.5 in question 5) agreed that CRS should be used in their other courses. They responded quite significantly (average response of 4.4 in questions 2 and 7) that they felt more engaged and active during the class. The students were satisfied from the immediate feedback they received during the lecture (average response of 4.3 in questions 3 and 9) as a great tool in enhancing their learning process. Furthermore, the way their pre-requisite reading materials were tested, was shown to be of great success (average response of 4.3 in question 4). As responses to questions 6 and 8, a proper way of articulating the clicker-related questions, as well as a suitable time for asking such questions were reflected on students' response with an average of 4.2. Additionally, the results of students' grade for the mentioned courses (although could have also been affected by a number of unknown factors) were also slightly higher than the previous years, as well as other concurrent courses.

Conclusion

This paper presented the results of the investigations and the surveys conducted based the use of the Classroom Response Systems (CRSs) or 'clikcers' in different context of an engineering school. The manner to inform the student about the usage of CRS; the method for setting up the questions for the students; the time that the question is posed to the students; and the instructor's strategy in showing the histogram of the given responses after the completion of the polling time, are some of the aspects of a successful implementation of a CRS. This varies for different contexts; i.e. science students compared to law or a small class in comparison to a very large class. Accordingly, Wang et al. (2014) stated that the right question to resolve the students' misconceptions is more important than the implementation of the method.

This research outcome is based on the results of surveys which have been collected from the students of the Griffith School of Engineering. The students have been using a CRS in their power engineering courses for three semesters. Their experience and degree of satisfaction in receiving the aim of CRS were collected using a questionnaire. In all different questions of the implemented survey, students responded with a high level of satisfaction and enjoyment from the usage of CRS. This has also reflected in their overall grades in all different investigated courses compared to other concurrent or previously taught courses. CRSs methods also give this opportunity to the instructors to fine-tune their teaching methods as well as lecture materials. By knowing about the common misconceptions or inappropriate approaches towards discussions, complementary material or remedial action can be adopted for the rest of a semester before it becomes too late by the end of semester.

As for all the limitations that exist in any research, this study can suggest ways for improvement. One of the aspects could be to test the same student cohorts in their different course across different semesters of studies. Currently, there is literature which explains the decrease of efficiency of CRS after a certain period of time (Kulatunga & Rameezdeen, 2014; Stowell, 2015). On the other hand, it seems that if students become familiar with CRS in one of their courses, they can get a better outcome in their consequent courses; i.e. not only attendance to the CRS-related activities may increase, but also the efficiency of the cooperation with the instructor may be enhanced. There are also other opportunities to perform some analysis similar to this research with the use of (in general) "Bring your Own Device (BYOD)" methods; e.g. smartphone applications. Nevertheless, some literature concluded that the result would be different from using clicker (Green et al., 2015; Haintz, Pichler, & Ebner, 2014; Paul & Iannitti, 2012; Stowell, 2015).

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