

VICTORIA UNIVERSITY OF WELLINGTON  
*Te Whare Wananga o te Upoko o te Ika a Maui*



## Clickers, best uses and benefits

MMIM592

by

Renato Herrera Hernández

300180359

Supervisor: David Mason

Submitted to the School of Information Management,  
Victoria University of Wellington  
in partial fulfilment of the requirements for the degree of  
Master of Information Management

June 2011

## **Abstract**

This study provides an analysis of the use student response systems in undergraduate and postgraduate classrooms. Research was conducted utilising a qualitative analysis approach, grounding theories by reviewing related literature, interviewing lecturers and conducting class observation. The study was carried out over two consecutive trimesters, summer 2010 and first trimester of 2011, at Victoria University of Wellington, New Zealand. By conducting this research it is hoped to help improving the quality of teaching. Within this study, it was determined that student response systems are useful for both engaging student and increasing their overall enjoyment of the class. The benefit of using student response systems in the classroom was also found to be dependent on preserving the novelty of the technology and keeping students' responses anonymous, by redesigning lecturers to have proper student response system questions in order to make the most out of the technology. Overall, this study determined that the decision whether or not to utilise student response systems in the classroom should be made based on the level of education of the class and its objectives, whether it is a lecture, tutorial or seminar, with clickers working best in large size, undergraduate classrooms.

## Table of Contents

<b>Abstract.....</b>	<b>2</b>
<b>Introduction .....</b>	<b>5</b>
<b>Literature Review .....</b>	<b>7</b>
<b>What Are Clickers? .....</b>	<b>7</b>
<b>Purposes of Using Clickers .....</b>	<b>8</b>
<b>Benefits of Using Clickers.....</b>	<b>10</b>
<b>Disadvantages of Using Clickers .....</b>	<b>11</b>
<b>Improved Learning?.....</b>	<b>12</b>
<b>Appropriation of the Technology .....</b>	<b>13</b>
<b>Best Practices .....</b>	<b>14</b>
<b>Methodology.....</b>	<b>16</b>
<b>Data Collection.....</b>	<b>18</b>
<b>Findings .....</b>	<b>20</b>
<b>Novelty of the Technology .....</b>	<b>20</b>
<b>Engagement and Participation .....</b>	<b>21</b>
<b>Anonymity.....</b>	<b>21</b>
<b>Class Size .....</b>	<b>23</b>
<b>Best Practices .....</b>	<b>23</b>
<b>Issues .....</b>	<b>26</b>
<b>Reasons For Not Using Clickers in a Class.....</b>	<b>27</b>
<b>Discussion.....</b>	<b>30</b>
<b>Limitations of the Research .....</b>	<b>32</b>
<b>Implications .....</b>	<b>33</b>

**Conclusion..... 34**

**References..... 36**

## Introduction

Student response systems, also known as clickers, have been revolutionizing the ways in which teachers are able to get students to interact in their classrooms by engaging students with interactive tools in order to improve participation and learning. Research shows that students want technology incorporated into their learning environments (Mills & Douglas, 2004), such as digital projectors, sound systems or laptops for each student, which suggests that clickers should be used more often in the classroom as a tool for lecturers to get students more engaged in the material. Although a majority of the research performed on this topic suggested that clickers are of great benefit to students, this research paper will present alternative theories suggesting that clickers may not always be appropriate in every situation.

Clickers consist of individual remote controls for each student in the classroom that allows them to vote or answer multi choice questions that the teacher presents to the entire class. These responses are captured by a receiver, usually connected to a computer in the classroom, which contains software set up to collect the students' responses and provides instant feedback regarding what answers were given by the participants.

Lecturers are often faced with the challenge of engaging diverse class audiences that can consist of over 200 students at various skill levels. Along with traditional approaches, like asking open questions and getting students into groups, student response systems have been used in these situations to help lecturers engaging larger portions of the class. A majority of the research performed on these tools has been conducted in these large learning environments, such as traditional University lecture halls. This research is unique because it focuses on classes of all sizes, both large and small, and explores the perceptions of lecturers who believe that student response systems are not beneficial in every class size or every class topic.

This research aims to find the best practices of using student response systems in the classroom and explores the different motivations that lecturers have for using them. The data will be gathered through the use of one on one

interviews and class observation, taking in insights from lecturers, tutors, and the students in the classroom. This method of data collection differs from most studies that have researched clicker technology, which approached the topic using quantitative methodologies, resulting in findings which typically supporting the use of clickers. During these interviews, it was revealed that not every lecturer is ready to use student response systems just yet. Data collected for this project determined certain lecturers favour more traditional teaching methodologies, the results of which were also studied in this research to provide a broader understanding of when clickers are most appropriate and how to make the best use of them. In addition to presenting data about when clickers are not appropriate for the classroom, this paper will suggest future methods to ensure that lecturers are getting the most out of the technology when it is utilized.

## Literature Review

### What Are Clickers?

Clicker technology, also referred to as electronic or student response systems, has been of great aid for lecturers who aim to engage students to more actively participate. Because clicker technology allow participation anonymously, students do not care as much about being incorrect, as compared to normal participation like raising hands or speaking up (Martyn, 2007). Clicker technology has been tested in the classroom since early 1970s (Casanova, 1971) in more recent studies is often described as being similar to the one used by the audience in popular TV show “*Who Wants to be a Millionaire*” (Stuart, Brown, & Draper, 2004, p. 95).

Acceptance of clickers has been identified to be dependent on the generation within which the audience, who in typical studies are students, belongs (Hwang & Wolfe, 2010). Students from Generation Y, which includes people born within the mid 1970s and early 2000s, make up a majority of the participants in past research, are more likely to be accepting of clickers because of their technological nature. This is because students from this generation are characterised as having a dependency of technology such as iPods, text messaging and other various technological gadgets. Moreover, these students often have a desire for instant gratification, which clickers can provide if the professor configures them to do so, allowing for students to have an overall increased enjoyment of the lecture (Hwang & Wolfe, 2010). Students from Generation Y also tend to prefer active learning to passive learning, with studies determining that by engaging students in activities during lectures, they are able to improve a student’s ability to learn a subject (Crossgrove & Curran, 2008).

Although many studies have found that clickers are beneficial to the classroom, “like any technology, these systems are intrinsically neither good nor bad; they can be used skilfully or clumsily, creatively or destructively” (Wood, 2004, p. 796). Because clicker acceptance has been attributed to particular characteristics of students from the Generation Y, it is debatable if

students outside this generation will benefit as much from the technology. Preszler, Dawe, Shuster and Shuster (2007) found that older students from higher levels of academia did not have as positive opinions about the use of clickers as students in lower education levels. This raises the question regarding to how long can clickers remain appealing to students and if it will be a worthwhile investment for education institutions in the long term.

### **Purposes of Using Clickers**

In past research, lecturers have been found to combine creativity and pedagogy to create effective, innovative and entertaining clicker sessions. This is done in order to “compensate for the passive, one-way communication inherent in lecturing and the difficulty students experience in maintaining sustained concentration” (Caldwell, 2007, p. 11). This can include engaging students in discussion, assisting with preparation, and even rating professors on their current performance.

Clickers have been found to increase interaction between students by asking questions that are aimed at starting or focusing discussion (Caldwell, 2007). This can be accomplished by requiring students to interact with their peers after voting and then recollecting votes after they have debated to see if any students have changed their minds (Caldwell, 2007). Another method described by one studied noted that professors would use questions which contained multiple correct answers or only partially correct answers in order to prompt discussion (Burnstein & Lederman, 2001). Lecturers can also diagnose the understanding of material within the lecture using clickers, which can reveal students’ misunderstanding of the material in the most appropriate moment. This functionality allows lecturers to go over the topic again from a different point of view or in a different level of detail and depth in an effort to correct this misunderstanding (Wood, 2004). This is not only helpful for the lecturer by providing them feedback to improve future lectures, but also provides information for students, since it allows them to assess their own level of understanding compared to the rest of the class (Halloran, 1995).

Another common use of clickers is to assess student preparation. In cases that require reading or homework in order to move on to the next topic,



lecturers are able to ask questions regarding these assessments and are able to make use of the instant feedback to decide whether to move on to the next topic (Knight & Wood, 2005). Using clickers for quizzes enable lecturers to get all the benefits of a normal quiz but saving time in reviewing and getting the results instantaneously. “Quiz questions typically check whether students are paying attention taking good notes, preparing for class or labs, keeping up with homework, actively thinking, able to recall material from previous lectures” (Caldwell, 2007, p. 11).

Caldwell (2007) found some other uses of clickers such as, practicing problems of math, chemistry, engineering or physics; to guide thinking, review for a test and to conduct experiments. Clickers can also be used as a clap-meter to monitor whether students understand the topic being explained during the duration of a lecture. This is accomplished by setting up a clicker question, such as “Are you confused by the current topic?” which is displayed whilst the lecture happens, allowing students to respond at any time (Cutts, Kennedy, Mitchell, & Draper, 2004). Parson and DeLucia (2005) used clickers for “differentiated instruction” to track the level of understanding and progress in a class with unevenly distributed abilities, allowing them to better understand students’ learning profiles, interest and readiness.

The use of clickers provides necessary feedback on students’ progress and helps the instructor to focus on difficult concepts via facilitating meaningful interactions. (Milner-Bolotin, Antimirova, & Petrov, 2010). Wood (2004) reported in his study an example of how a lecturer can be amazed with the instant results while using clicker:

For me, this was a moment of revelation. I was not so much disappointed by the result as elated by the realization that for the first time in over 20 years of lecturing I knew, on the spot (rather than after the next mid-term examination), that over half the class didn’t *get it*. (p. 797)

## **Benefits of Using Clickers**

Evidence has shown that students remember only 20 to 25 per cent of the information that lecturers present to them, with the first 15 to 20 minutes of class being the most productive (Burns, 1985). In addition, Caldwell (2007) found that the longest time students report to comfortably undergo continuous lecture is between 20 to 30 minutes. Therefore, it seems that in order to maximize the benefit of the entire allotted time for the lecture, time could be better spent in activities other than lecturing, such as peer instruction, problem solving or responding questions using clickers. It was determined by Caldwell (2007) that periodic breaks might help relieve student fatigue and allow them to endure longer lectures.

Evidence shows that students who engage interactively with each other and the instructor in the classroom learn concepts better, retain them longer, and can apply them more effectively in other contexts than do students who sit passively listening, perhaps taking notes for future memorisation in preparation for an exam (Handelsman et al., 2004). Given that clicker is a tool for engaging students interactively, researchers have assumed that clicker would improve their learning.

One benefit of using clickers in the classroom noted by Stuart, Brown and Draper (2004) was that more students self-reported their willingness to engage in clicker sessions because of the anonymity allowed in those sessions. Many studies agree that clickers increase class participation because students' responses are anonymous; participation rate is usually close to 100 per cent (Nelson & Hauck, 2008; Stowell & Nelson, 2007). Anonymity has been found to influence levels of participation in groups of students using computer mediated systems (Connolly, Jessup, & Valacich, 1990). Studies have also found that students are more honest about their answers when using clickers to participate in the classroom, because they are unable to be socially influenced if they do not know the correct answer (Stowell & Nelson, 2007). This phenomenon was also shown in a study performed by Burke Da Silva, Wood and Menz (2007) who found that a class that did not use clickers had more students that responded incorrectly to

questions in class, as opposed to typical voting by students raising their hands.

Although many studies have found that utilising technologies, which allow the participants to be anonymous, improves participation, this increased participation is not always linked to improved performance. Valacich et al. (1992) found that when studying groups of students utilising group decision support systems, which operate in a similar fashion to clickers, that anonymity was not correlated to the performance of the student. Conversely, in a different study, group size was found to increase students' performance when using idea-generation systems, although groups size has been found to correlate to perceived anonymity by group members (Evans, 1979).

However, Caldwell (2007) also questions if the benefits of using clickers are thanks to the alteration of teaching methods as opposed to the use of clickers themselves, relating this to the "Hawthorne Effect". This phenomenon occurs when subjects being observed as part of an experiment change their behaviour simply because they are being studied (Jones, 1992).

### **Disadvantages of Using Clickers**

Although clickers have been found to improve participation in the classroom, not all studies believe they are appropriate for every teaching situation. For example, there is still a prevalent view among teachers that the main goal of the upper-level courses is to "cover the material," and using clickers reduces the amount of time available for direct lecturing while increasing the amount of class preparation time, because creating effective clicker questions is challenging and time consuming (Beatty, Gerace, Leonard, & Dufresne, 2006). Keogh & Wang (2010) also found concerns from faculty members who wondered if the novelty of using clickers could wear off, forcing them to replace the technology before it had provided enough value.

Set up time is another issue that faculty members brought up when discussing using clickers in the classroom, especially when used for the first time (Keogh & Wang, 2010). Others voiced concerns regarding who would finance the clickers when first being brought into a University, with Keogh

and Wang (2010) finding that they work best when initially financed by the institution and having students pay for them only if they lose them. This view is further supported by Immerwahr (2009), who sees potential problems if students are given the responsibility of buying and bringing to class the clickers.

Not only were lecturers concerned about whether clickers would be appropriate for their classrooms, especially at higher levels, but students have also reported mixed feelings about the technology. One study found that students have expressed that clickers would be even better if used for assessment at some level, which would imply losing anonymity to the lecturer (Keogh & Wang, 2010). Another study performed by Milner-Bolotin et al. (2010) found that the most common complaint from students, when asked about the use of clickers in the classroom was that class attendance being rewarded by recording the answers which were given by students. These two studies make it clear that students are unsure about what are the best practices for using clickers in the classroom, whether they should be used simply as a way to increase participation, or whether they should be used as a tool for assessing student understanding of material.

### **Improved Learning?**

Since the early implementation of clickers took place, researchers have been trying to justify the use of this technology as means to improve students' learning and studying whether it affects students' anxiety towards specific subjects (Brown, 1972). Many studies have tried to find a link between the use of clickers and improved learning, typically by comparing two classes using clickers as the dependent variable and evaluating students' performance in the exams. In a study conducted by Stuart et al (2004) student learning did not increase merely by clicker use, determining that "student learning depends on pedagogy; yet, technology can enhance delivery mode" (Hwang & Wolfe, 2010, p. 276).

Other studies have found a variety of different results as to whether clickers can be attributed to improved learning and exam performance. Preszler et al. (2007) found that clickers increased exam performance.

Studies have also been performed which found no link between the use of clickers in the classroom and performance when comparing results of exams and quizzes (Martyn, 2007; Stowell & Nelson, 2007). Regardless of what results were discovered when attempting to link exam performance to clicker use, all studies determined that the main benefit of using clickers is not increased performance in exam results, but providing a tool which helps to increase participation, interaction, and discussion while also increasing overall material retention and class enjoyment (Caldwell, 2007; Hoffman & Goodwin, 2006).

Despite the literature regarding the effectiveness of clickers as a tool for improving the learning of material, clickers have been found to have a direct effect on student's perceptions of the classroom. Studies have shown that clickers improved students perceived performance in the course, exam preparation, learning, and interest in the lecture (Nelson & Hauck, 2008). Nelson and Hauck (2008) also found a direct correlation between the use of clickers and students perceived learning, despite little evidence to support this belief. Studies have also linked increased enjoyment of the lecture to the presence of clickers (Stowell & Nelson, 2007). Whether or not clickers improve learning, they shift the lecturing approach, making the class more dependant on the students than on the lecturer (Trees & Jackson, 2007). In order for clickers to be successful in the classroom, it is important that lecturers need to understand and accept this shift in approach to allow students to fully appropriate the technology.

### **Appropriation of the Technology**

Adaptive structuration theory, based on Anthony Giddens' structuration theory, helps explain the various ways that users utilise technology, and how external factors affect development of different uses of technology. Adaptive structuration theory focuses on social structures, which are rules and resources provided by technologies such as clickers, and institutions like a University as the basis of human activity (DeSanctis & Poole, 1994). The theory proposes that there are structures in technology and when technology is combined with manual procedures, it creates new structures within the

technology. These new structures offered by technology “must be blended with existing organisational practices, radical behaviour change takes time to emerge, and in some cases may not occur at all” (DeSanctis & Poole, 1994, p. 142).

Utilising clickers in the best possible way requires set up and manipulation of the software and hardware that give shape to a clicker system, thus creating what DeSanctis and Poole (1994) define as structures in action. The setup of the system allows lecturers to innovate or be creative; potentially they could turn the system into a successful tool or into an annoyance for the class. Orlikowski (1992) proposed that it is not technology that determine behaviour, rather people generate social constructions of technology utilising resources, and norms embedded in an institutional context. Lecturers work within their pedagogical framework which if furthermore guided by the vision of the institution that they work at, thus both generate social constructions of clickers.

Adaptive structuration theory, points out the broad range of possibilities that lecturers have when using clickers, to fight creatively the threats of the novelty wearing-off. Most importantly, adaptive structuration theory states that perceptions that users have about technology vary widely between different groups, thus clicker implementation and use is expected to be different in every educational institution, faculty, course level and with every lecturer.

## **Best Practices**

Better pedagogy is possible by using technology only when it is aligned with a lecturers educational philosophy and beliefs (Beatty, 2004). For clickers to be effectively used within the classroom, lecturers should not mistake the benefits of the technology to shape and improve their pedagogy with clickers perceived ability to provide an entirely new teaching theory. Beatty (2004) found that a good approach is giving up control to students, letting them interpret the question rather than attempting to influence their interpretation. Zhu (2007) also recommends that when lecturers create clickers specific questions that they ensure they create wrong answers that seem plausible to students to prevent them from easily eliminating wrong answers.

Although questions which utilise clickers often appear as multiple choice, their scope can be greatly expanded by using questions which have multiple correct answers, or are simply used to gauge opinions, unlike those typically used in quizzes which are used to judge student performance. Beatty (2004) found that using clicker questions which allow students to discuss with their peers after answering the question, but before revealing the right answer, allows students to change their minds and think more critically about the questions being asked. Clicker questions have to be crafted with an understanding of the medium and utilise meta-communication, challenging students to think deeply about the questions instead of focusing on quick responses (Beatty, 2004). By utilising this method of teaching, lecturers are able to differentiate between students' knowledge of jargon and their understanding of concepts (Zhu, 2007). While lecturers will want to make the questions challenging for the students, they need to be aware that increasing the difficulty of clicker questions will also increase the cognitive load, which can cause the opposite of the desired effect of utilising clickers by reducing student's retention (Wieman, 2007).

## Methodology

Clicker technology have been utilised in the classroom for years, yet the practices that allow lecturers to make the most out of the technology have not been extensively explored. This research aims to determine what are the best practices and benefits of using clickers in the classroom as a tool, for improving teaching, focusing on classrooms that had been previously ignored by other studies, such as those that are smaller or of a higher level of education.

This research was conducted using the qualitative analysis approach of Grounded Theory, which emphasises on “the generation of theory and the data in which that theory is grounded” (Glaser, 1978). The theories inducted utilising this approach are grounded in observations or data gathered from sources such as, review of records, one on one interviews and surveys.

By gathering lecturers’ perceptions and thoughts about clickers in detail and by observing classes that use the technology, this research will seek to determine the best practices and benefits of using clickers. By utilizing a qualitative approach, this study is able to get a much deeper understanding regarding lecturers and students’ perceptions of clickers, including why and how they are being used in the classroom. This will be done by taking notes of reactions and interactions during classroom observations, and by recording and transcribing the interviews. Both of these methods will allow for a thorough and detailed analysis of the data needed to apply Grounded Theory to a research topic. As stated by Glaser (1978), Grounded Theory involves intensively “analysing data, often sentence by sentence, or phrase by phrase of the field note, interview, or other document; by ‘constant comparison’ data are extensively collected and coded”.

Victoria University of Wellington, New Zealand has successfully implemented clickers as part of its information technology strategy (UTDC, 2010). Clicker technology is available for most lecturers as they request it, while the University is in an on-going process to increase the number of lecture theatres and seminar rooms enabled to carry out a clicker session.



Many lecturers of different disciplines at Victoria University of Wellington have used clicker technology, but during the course of this research it is the first time lecturers were interested in having tutors utilising clickers in their classrooms. There were also lectures scheduled during this period, which will provide insights of their experience with using clickers in the classroom. Therefore, the lecturers, tutors and the classes taught at Victoria University provide an ideal sample to be researched in order to achieve the objectives of this study.

## Data Collection

The data for this research was gathered by conducting interviews with lecturers from Victoria University of Wellington, New Zealand, who had previously used clickers within their classroom environments. These interviews were conducted on a one-on-one basis using a Dictaphone to record their answers, which were later transcribed for further analysis. Five separate interviews were conducted to record the lecturer's thoughts about what they found most successful about using clickers as a learning tool for their lectures, and where they found the technology to be lacking in its application. The lecturers used clickers in classes of Accounting, Tourism in New Zealand, Commercial Law and a workshop about clickers. Two interviews were also conducted with lecturers who chose not to utilise clickers in their classrooms in order to explore the knowledge they had about the technology and what reasons were given for not using them.

In addition to one-on-one interviews, class observations were also conducted in two lectures, Business Application Programming, an undergraduate classroom, and Research Methods, a postgraduate class. In the former, the observation was conducted from the back of the classroom paying attention to student response to using clickers. For the postgraduate classroom, students were not only observed using the clickers, but were first introduced and trained on what clickers were and how to use them. After this training was conducted, the students were then observed from the front of the classroom, in a similar fashion to the method used in Business Application Programming. In addition to the observations conducted on lecturers, class observations were also carried out over the course of fourteen tutorials of INFO101, an introductory course to fundamental concepts of computer-based information systems acquisition and use. These tutorials were all observed during the same week, with the same material presented to students in order to remove variability that comes with presenting different material to different classrooms of students. The tutorials were fifty-minute sessions divided into two main sections; the first one reviewed the submissions sheets that students

had to complete for the tutorial and the second section had a ten-question quiz that students responded to with clickers.

In addition to the data gathered from observing the students within the classroom as they interacted with clickers for the first time, observational data was also gathered on how tutors responded to the technology. All the tutors were previously unfamiliar with using clickers as an instructor, and were provided a one-time training of 30 minutes before the tutorials began. The responses to this training were recorded for analysis, as well as how tutors responded to the use of this technology in the classroom in order to provide as much information about the reception to the technology as possible.

## Findings

By analysing the notes taken while interviewing lecturers, the audio recorded, the transcriptions of key points of those interviews and the notes taken while observing in detail what occurred in the lectures and tutorials studied. The data provides insights of the use of clickers, how lecturers and tutors use clickers in their classrooms, what their concerns are about using the technology without losing its effectiveness, what the benefits of using them are, what makes them effective, reasons for not using them in particular types of classes and the issues that can occur when utilising them.

### Novelty of the Technology

In the observation of 14 tutorials of INFO101, tutors and students showed excitement when first presented with the clickers, as the technology was new to most of the students in the class. Despite the excitement, lecturers expressed the need to ensure that clickers are not overused in the classroom, causing them to lose their value and novelty. Lecturers as something to be considered when determining the most appropriate use for clickers also mentioned frequency of use. Lecturer C stated “my only reservation is that if everyone starts using clickers they’ll become bored of them”, further raising concerns regarding the technology losing its novelty. Lecturer interviewed A pointed out reservations on how students from newer generation would perceive clickers; they “may not see it as something novel”.

Despite these concerns regarding overuse of the technology, the most appropriate amount of use is mostly instinctual for each lecturer, as there is no agreed upon amount which is appropriate for all circumstances. Lecturer interviewed B said that she “wouldn’t have more than four questions in a class” whereas lecturer A stated that he would “introduce them two or three times in a class”. Tutors, who were very excited with their first experience of having a clicker session in the tutorials, expressed their willingness to using clickers in following trimesters and in more sessions.

## **Engagement and Participation**

Engagement of students during the clicker session in the undergraduate tutorials was remarkably high; the percentage of answers received for was almost 100 per cent for every question asked, which contrasted the previously held tutorials where tutors had to work harder to get a single answer by students raising their hands. Tutors expressed that they would like to use the clickers in future tutorials, In addition to getting the students to participate more than they traditionally did without clickers, it was also noted that the amount of enjoyment that the students were having also increased. It was clear that students were more focused during the clicker session and that they were paying attention expectant for the results to show up on the screen. Most lecturers believe that clickers enhance student participation because of various reasons, such as its technological novelty and anonymity, they are interested in seeing the results immediately, students “like holding their phones, they like the technology and they like the fact that they could see how many had answered correctly” lecturer interviewed C.

The results observed in the postgraduate class were very positive, as students were also enthusiastic about the use of clickers and participation was 100 per cent for almost all questions. Also, engagement of postgraduate students was as high as the observed in tutorials and undergraduate classes.

## **Anonymity**

One issue that was brought up by lecturers during the course of this research was whether using clickers for examination would be an appropriate use of the technology. Although some lecturers were interested in using the technology in this fashion, they also recognise anonymity as a key aspect that makes clickers enjoyable for students. It was mentioned that when using clickers anonymously “participation is around 90 per cent, but it would declined if they were not” lecturer interviewed A. Lecturer interviewed C also expressed hesitation at removing the anonymous nature of clickers, and does not think that assessing students using clickers is a good approach, pointing out practical difficulties, she stated that she “wouldn’t use [clickers] as an

actual test, because it's easy to press the wrong button". One lecturer, lecturer B, mentioned that if clickers are not used anonymously and they were used for marking instead, then students "would take [clickers] more seriously". For lecturer interviewed D, anonymity would not affect participation levels, when asked about using clickers for evaluation, she said that "the response rate wouldn't change" but more importantly for lecturers is the fact that "It changes the purpose of why you use [clickers], it becomes an assessment rather than a tool for improving students' engagement". In addition to the concerns of decrease in participation levels, lecturers also mentioned concerns regarding the logistical issues when using clickers not anonymously, because students would have to take the clickers with them when they left the classroom, and may forget to bring them back when they return for the next session.

While lecturer interviewed C thinks that clickers should not be used for assessment she also believes that clicker questions "should parallel what will be asked in the exam", and that by doing this, students will realise the benefits of participation in clicker sessions. During the tutorials, one of the tutors asked to the class if they liked using clickers in the tutorial quiz and if they had any suggestions, to which most students responded that they liked using clickers and one student suggested that going over questions from previous exams with the clickers would be very helpful.

Tutors reported that they would want to assess results from the clicker responses. However, Victoria University of Wellington has decided to use clickers anonymously for all classes. Some tutors who used clickers in their classrooms, also asked students to write down their answers in the normal paper sheet they were used to using before, showing some scepticism and cautiousness as it was their first experience with clickers for all tutors. However, this lead to misleading results since students were able to see the correct answer on the screen after they voted, giving them just enough time to fill up the paper sheet with the correct answers instead of the answer they voted originally with the clicker.

Tutors decided to stop using the paper sheet in following tutorials, as they became more confident with the technology. Students, on the other hand, did not stop “cheating”, sometimes they were seen sharing their vote with their neighbour, by showing to them what button they were pressing, this suggests that for some students being anonymous to their classmates is not relevant.

## **Class Size**

Another concern brought up during interviews was the size of the classroom in which clickers were being utilised. Lecturers tend to believe that clickers are more useful in large classes than in smaller classes, because it makes it easier to engage most of the students, whereas in a small class lecturers believe they are capable of handling the level of engagement. This is because they can see and reach most students. “I wouldn’t use it in a class of twenty, [because] I knew half their names” lecturer interviewed C. Lecturer interviewed D has a different estimation; she thinks clickers are suitable in classes with “anything more than fifty” students.

Despite lecturers believing that big classes are more appropriate for using clickers, the tutorials observed in this study had anywhere from 11 up to 30 students. By utilising clickers in smaller classrooms, it was observed that they were still able to provide the benefits of using them in large classrooms, especially in relation to increased engagement and participation. Even though students are easier to reach in smaller classes, it is usually the same students who speak up and clickers overcame this engaging the more quite students.

## **Best Practices**

The lecturers interviewed for this study were found to use clickers for a variety of different purposes, such as using the technology to get students to engage with their classmates, think critically about the ideas presented in class, and as a replacement for traditional paper-based quizzes. One of the benefits of clickers which was repeatedly brought up when discussing the value of the technology to the lecturers was the ability to make use of real-time feedback by making students talk to their neighbours when most of the

students missed the right answer, or having the lecturer explain the correct answer before moving on with the class.

Lecturers also reported that using clickers as a means of quizzing students fulfils the purpose of a quiz even better than a paper based one, while removing the hassle of marking the quizzes. If a quiz is aimed to provide lecturers with an overall view of the understanding the class has of a given topic, then a clicker based quiz will save time and will provide instant results. A similar approach is the one reported by lecturer interviewed B who used clickers at the “start the class by asking questions to review what they have been reading”, which is a useful way of assessing students learning and commitment to the class. Because using clickers in the classroom requires some preparation time, professor lecturer interviewed A reported in the interviews that he prefers to use clickers at the beginning of the class, focusing the rest of the class in lecturing. Other lecturers reported that using clickers within the lecture is also useful, as it allows them to assess students’ retention and understanding of the current topic.

In order to make the most of the clickers, lecturers reported that it takes time to properly create a clicker session. Lecturer Interviewed B stated that creating questions requires her to “intentionally think the questions I want to ask” as well as “being careful when phrasing the questions”. It takes time to “to reorganise your teaching” rather than “in the planning of the clicker” lecturer interviewed D. Lecturer interviewed B reported one innovative way of using clickers, where she would present questions to students that contain more than one answer which could be considered correct, and then explain which one is more appropriate out of the answers which could be given.

For the tutors, this was the first time that they were using clickers, and they were trained only in the technical aspects of clickers, but they did not receive any training on what the best practices are. Nevertheless, some best practices came naturally to some tutors, as soon as the feedback showed up on the screen some tutors explained those questions with lower percentage of correctness. It was also observed during the tutorials that when the majority of students responded to a question with the wrong answer, a few tutors



provided the class with the page number in the reference book. One disadvantage of this approach noticed in this research was that it became obvious identifying students who responded with the wrong answer, since they started taking notes of the page number. Some tutors, after conducting their first clicker session, started to gain more confidence and were seen mentioning to students what questions other classes got 100 per cent correct, challenging them and increasing excitement.

What to ask in a class using clickers is probably one of the biggest challenges a teacher has to go through when planning and designing a class that integrates the technology. Although clicker questions easily replaced paper based quizzes previously used in the tutorials observed, lecturers stated that challenging students with clicker questions is key to keep their attention. This does not mean asking impossible questions, but challenging them with more than one right answer paves the way to explaining why one answer is the best, helping to make the concept being taught as clear as possible. Before revealing which answer is the best it is helpful to get students to discuss with each other, make them vote again, and see how it affects their answers. Another approach taken by lecturers is to put as options plausible answers as good alternatives. Interestingly, during the postgraduate class observed, a student questioned the elaboration of one of the questions, it was asked what they thought others struggled the most when writing their research proposal, the student alleged that he could not answer the question because there is no way for him to know what other people think. The wording of the question can be debated, but the fact that postgraduates are more critical means that lecturers using clickers have to be conscious of the type of audience they are teaching.

It is very important for an education institution planning on using clickers to have a robust IT infrastructure because sluggish computers can ruin the experience, turning into a lecturers' nightmare when trying to use clickers. At Victoria University of Wellington there are a limited number of clicker kits available that have to be scheduled and carried to each classroom, which adds logistic issues to using the technology in the classroom. For

example, in one of the tutorials observed the receiver was forgotten in one of the seminar rooms and it could not be used in the following tutorial.

## **Issues**

It takes only an unexpected change of room to make the use of clickers problematic. During the training conducted with tutors who were preparing to use clickers for the first time, the room where the training was going to take place in was changed at the last minute to a room equipped with a projector, but no computer access, therefore making it impossible to properly complete the training. In addition to the problems encountered during the training sessions, in the first tutorial in which the clickers were utilized a software crash was encountered. This crash occurred when the timer set to progress the presentation slides was set to twenty seconds, while the slides containing clicker questions had its own timer set to thirty seconds. This caused the slide to change before the time had run out on the clicker question, causing the response gathering software to crash and rendering the clickers unusable for that specific tutorial. Encountering this issue during the first tutorial resulted in the tutor having diminished confidence on using the technology in the future and caused the students' perception of the technology to be lowered, even though they knew it was a trial use of clickers. After the students had realized that the clicker started misbehaving, they took the clicker session less seriously then before the incident.

Although problems were encountered when implementing the clickers in the classroom for the first time, not all tutors were found to have difficulty with the technology. Tutors significantly younger than the lecturers interviewed in this research who had used clickers earlier as students, had no problems whatsoever using use the clickers as a tool to instruct the students in their classroom. The younger tutors, who were second and third year students themselves, were very optimistic about using the clickers even if they had technical issues, they were keen to finding a workaround, like the case mentioned earlier when a timer was set up in the presentation slides, the solution was pointed out by one of the tutors. Tutors were scheduled to receiving technical training on how to use clickers, but there was an

unexpected change of the room where the training would be conducted; the new room had no computer installed, thus the training had to be postponed to a just a day before the tutorials, yet tutors remained positive and were understanding of the circumstances.

### **Reasons For Not Using Clickers in a Class**

In addition to the lecturers who decided that clickers were appropriate for use within their classroom, two senior lecturers decided to abstain utilising the technology during the research. In the interviews, these lecturers brought up three main factors that made them choose not to use clickers in their classes, the content of the material being taught in the class, the overall size of the class, and whether the class was at the undergraduate or postgraduate level of education.

The nature of a class varies depending on the subject and also its objectives, as a lecture and a tutorial have different objectives, the former where seen to be intended to teaching or presenting information to people about a particular topic and the latter where focused on interactively transferring knowledge. Moreover, lecturers have their own ways of teaching the material to the students, with clickers not being appropriate for the various styles. Therefore, it is comprehensible that not all lecturers believe that clickers are appropriate to be used in their class.

Among the reasons that were given for not using clickers in these specific instances, lecturers argue that the multi-choice nature of clickers truncates the possible answers, thus discouraging students from thinking creatively. Even when prompted about the possibility that clickers offer to create questions dynamically during the sessions, lecturers still viewed clickers as noise in the communication. One lecturer pointed out that when we are “learning how to do something practical will lend itself well to this technology, but trying to deal with something conceptually difficult, such as discussing the history of the payment systems in New Zealand, they may not be so appropriate.” Also supporting that the nature of the class is key when choosing to use clickers, lecturer interviewed F, who teaches two courses as part of the master of information management program said, “We are teaching

communication and critical thinking. We are training managers and there is no room for shy managers”.

Lecturers have to evaluate all tools and techniques available to use for each individual class, in small classes where face-to-face communication is possible, clickers might not bring any improvements to the teaching, According to lecturer interviewed F “Nothing has greater media richness than face-to-face communication. I can see the students’ body language, I can see their gestures, the degree of comfort or discomfort with anything, and I can get a very rich sense of where they are placed in terms of the topic being discussed”. Therefore using clickers as a gimmick will turn them into just “a poor substitute for face to face communication”.

Surprisingly, professors who instruct multiple lectures see clickers as a useful tool in some classes but not in others, depending on the topic and the level of the class. An undergraduate class better suits the use of clicker because students are being lectured to, whereas in a postgraduate class students are more actively involved in the learning process. In these postgraduate classes, students are encouraged to think critically and creatively about a case scenario or a topic and they are expected to contribute with their work experience. According to lecturer interviewed E “graduate students tend to be more vocal in the class” than undergraduate students, mainly because they can back up what they say with their experience, and do not require extra effort needed to engage them to participate. Although the literature accepts anonymity as one of the reasons for clicker success, anonymity might not be a desired response from “the kinds of students that I teach I would regard resorting to anonymity as a failure” lecturer interviewed F.

When inquired about other factors that influence making the decision of using clickers in the classroom, most lectures pointed out class size as being key, large classrooms are seen as more appropriate for using the technology. Even lecturers who were reluctant to use clickers in their classes, arguing that their classes were too small and that communication skills are key in postgraduate classes, see potential benefits of using clickers in large classes

to overcome the practical difficulties of trying to communicate face to face with hundreds of students.

## Discussion

This research aimed to explore how clicker technology is used in the classrooms at Victoria University of Wellington, and determine the best practices and benefits of using them as a teaching tool. The best practices and benefits of using clickers were inducted from analysing the interviews conducted to lecturers who had used them in the past and what was observed in the tutorials and lectures. Besides these two areas studied, other arguments arose from the information gathered, the technical issues that lecturers and tutors may face while using clickers and reservations of lecturers to use them in postgraduate or small classes.

The literature shows that measuring improved learning by analysing student exam results does not show strong links between the use of clickers and better students' performance. The literature tends to be inclined to supporting clickers with optimistic hypothesis about improved learning and hoping for wider use within lectures. However most studies that have researched clickers, examined their use within a single type class or only one area of study, but without considering if the topic is appropriate or if the class will benefit from the use of clickers. As Adaptive Structuration Theory suggests, different appropriations and uses of clickers, which have not yet developed among lecturers could unleash different effects on students' performance.

The clearest benefit of using clickers in the classroom is the increase in participation and engagement. All lecturers interviewed in this research reported that clickers helped them engage students. This effect was also observed in the class observations, where the difference of engagement between the clicker session and the rest of the class was clear. The literature also shows conclusive results, as found by Banks (2006), Dangel (2008), Twetten et al. (2007) and others, clickers increase engagement of students, particularly in small classes as well as undergraduate classes.

There is not much data in the literature regarding the use of clickers in postgraduate classes and most of the studies were focused on researching

large classrooms (Caldwell, 2007; Hancock, 2010; Hwang & Wolfe, 2010; Patry, 2009; Trees & Jackson, 2007). In the class observations conducted in this research in a master's level course, shows that clickers can be beneficial in postgraduate classes as well as undergraduate.

Data of this research shows that particularly postgraduate lecturers are very critical about how suitable clickers are within a Master level class where lectures are not content driven, but discussion based instead; lecturers expect students to participate and contribute from their own work experiences. Clickers in this case are seen as interference between lecturer-students communication. Lecturers who instruct at the postgraduate level reported being reluctant to use clickers in their class, as they believe that clickers would narrow the options for students and that they want students to be critical and creative about their answers. They like asking questions to the class that are open, even though participation will still not be near to 100 per cent. However it was observed in the research methods class that lecturers are able to create clicker questions dynamically the following way: an open question is asked to the class, answers are gathered, then all these answers are set up as choices of a clicker question, this way allowing everyone to respond even though they did not raise their hands or someone else already said his answer. Newer clicker systems are flexible enough to support this simple process (Bruff, 2007).

Regardless that engagement of students thanks to the use clickers has been attributed to students being part of the thumb generation (Immerwahr, 2009), it was observed that participation of postgraduate students when using clickers was 100 per cent for every question, but participation remained high throughout the whole class, therefore it is hard to attribute high levels of participation to the use of clickers in this case.

The set-up time of clickers was reported as time consuming by one lecturer interviewed, he overcomes this issue by having the clicker session at the beginning of the lecture. However, the literature suggests that having breaks within the class allow students to recover concentration (Caldwell, 2007), thus having the clicker session in the middle of the class could be a

good opportunity for having a break within the lecture. When set-up time is an issue, it was observed that it could be optimised depending on how the remotes are handed to students. At Victoria University of Wellington the clicker remotes are not taken home by the students, therefore they have to be handed to students in every class. In the Business Application Programming class, the lecturer located the clickers near the classroom's entrance so students can pick them up before they take their seats. Some tutors thought that handing the clickers before the quiz session, which was at the end of the tutorial, would distract students from the content being reviewed earlier.

Tutors, who were familiar with information systems, were very alert to any possibility of the software freezing or crashing. Assuming that tutors are more technological savvy than lecturers, as they are from newer generations, they seemed to be prepared to take action in case anything went wrong. The clicker software crashed in two out of the 14 tutorials observed. The most significant consequence from this technical issue is that students seemed to take the clicker session less seriously. Previous studies have taken for granted that clicker technology is mature enough and that it will work as expected, however complex information technology infrastructure within institutions do not allow making this assumptions, further research is needed in this area, since it affects the students' perceptions and lecturers or tutors confidence of using clickers in the classroom.

Given all the benefits of using clickers in the classroom, a lecturer still has to evaluate each individual class if it is pedagogically right to use them. Nevertheless, this research and the literature agree that one of the keys to successfully using clickers is keeping the answers anonymous, as most benefits of using clickers are dependant on this.

## **Limitations of the Research**

This research was conducted at Victoria University of Wellington, taking a small number of classes as a sample of study. Therefore, the findings presented herein may be influenced by factors unmeasured in this study, such as New Zealand's education system and culture, the implementation of clicker technology at the University or other variables unique to the studied sample.



This research only applied Adaptive Structuration Theory to analyse the use of clickers in the classroom, however other theories could be more appropriate for this, therefore more study in this area is needed.

## **Implications**

Clicker systems are assumed to work seamlessly in most studies, however this study found that, as with any other information system, this is not always the case and the impact in lecturers, tutors and students' attitude towards the tool vary drastically when the system does not work as expected. Therefore appropriation of the technology will be affected as well as willingness to use clickers in the future.

Event though clickers are not as complex as other information systems like a group decision support system (GDSS), it is still worthwhile studying the implications of appropriation of technology applying existing theories such as adaptive structuration theory or actor-network theory because there is a lack of research in this area.

This research has found discrepancies in perceptions of the usefulness of clickers in small classes between young tutors and more experienced lecturers. The latter were sceptical of using clickers in small classes that they could reach students directly whereas tutors showed enthusiasm for using clickers in the small tutorials. Perhaps the belief that clickers are mostly suited for large classes does not apply for tutorials, because of the tutors' lack of pedagogical training and experience. More research is needed to identify implication of using clickers in different levels of education, undergraduate and postgraduate. It is also needed more education regarding the usefulness of clickers in different types of classes, lectures, seminars and tutorials, because they have different teaching objectives, which may not benefit from using clickers.

## Conclusion

This study sought to examine the use of clickers in classrooms which had been previously ignored by other studies, such as those that are smaller or of a higher level of education, in order to find the best practices and benefits of using as a teaching tool. Through the use of one on one interviews and observing lectures and tutorials, evidence was gathered as to what applications were the most successful and provided insights into which practices were best. It was determined that clickers increase engagement and enjoyment of students in classrooms that had been previously overlooked in past studies of this technology. These two benefits were also found to be highly dependent on keeping students' answers anonymous, thus it is recommended not to use clickers as an assessment tool. This research also found that it is best to allocate specific time to elaborate clicker questions, which are challenging for students, as opposed to migrating questions crafted for different uses. Although no specific number of clicker questions was determined to be the most appropriate, it can be deducted that clicker questions should be around six per session.

This study found that although clickers are beneficial to improving participation, they are not always appropriate in every teaching situation. Several key factors were brought up during this study as important to consider before implementing clickers in the classroom, such as the topic being discussed, the education level of the class, and whether the class is a discussion or lecture based. Class size was also brought up during this study as a factor that can affect the successful deployment of clickers, but the observations conducted did not support this assumption as classes of all sizes observed the same reactions to the technology.

Even though links between improved learning and the use of clickers remain uncertain, the increased engagement and student participation are more than sufficient benefit, both for students and lecturers, which justify the use of clickers in certain classroom situations. After using clickers for the first time and despite the minor technical issues that tutors had to face, they expressed their enthusiasm to using clickers permanently and more frequently

in upcoming tutorials. Lecturers who have used clickers in their classrooms previously expressed also enthusiasm to continue utilising clickers in the future.

## References

- Banks, D. (2006). *Audience response systems in higher education: Applications and cases*: Information Science Publishing. Available from: IGI Global. 701 East Chocolate Avenue Suite 200, Hershey, PA 17033. Tel: 866-342-6657; Tel: 717-533-8845; Fax: 717-533-8661; e-mail: cust@igi-global.com; Web site: <http://www.igi-pub.com>.
- Beatty, I. (2004). Transforming student learning with classroom communication systems. *Educause Center for Applied Research {(ECAR)} Research Bulletin*, 2004(3).
- Beatty, I., Gerace, W., Leonard, W., & Dufresne, R. (2006). Designing effective questions for classroom response system teaching. *American Journal of Physics*, 74(1), 31-39.
- Brown, J. D. (1972). An evaluation of the spitz student response system in teaching a course in logical and mathematical concepts. *The Journal of Experimental Education*, 40(3), 12=20.
- Bruff, D. (2007). Clickers: A classroom innovation. *National Education Association Advocate*, 25(1), 5-8.
- Burke Da Silva, K., Wood, D., & Menz, R. I. (2007). *Are the benefits of clickers due to the enforcement of good pedagogy?* Paper presented at the Enhancing Higher Education, Theory and Scholarship. Proceedings of the 30th HERDSA Annual Conference, Adelaide.
- Burns, R. A. (1985). *Information impact and factors affecting recall*. Paper presented at the Annual National Conference on Teaching Excellence and Conference of Administrators, Austin, TX.
- Burnstein, R., & Lederman, L. (2001). Using wireless keypads in lecture classes. *The Physics Teacher*, 39(1), 8-11.
- Caldwell, J. E. (2007). Clickers in the large classroom: Current research and best-practice tips. *CBE Life Sci Educ*, 6(1), 9-20.
- Casanova, J. (1971). An instructional experiment in organic chemistry. The use of a student response system. *Journal of Chemical Education*, 48(7), 453-null.
- Connolly, T., Jessup, L. M., & Valacich, J. S. (1990). Effects of anonymity and evaluative tone on Idea generation in computer-mediated groups. *MANAGEMENT SCIENCE*, 36(6), 689-703.
- Crossgrove, K., & Curran, K. L. (2008). Using clickers in nonmajors- and majors-level biology courses: Student opinion, learning, and long-term retention of course material. *CBE Life Sci Educ*, 7(1), 146-154.
- Cutts, Q., Kennedy, G., Mitchell, C., & Draper, S. (2004). *Maximizing dialogue in lectures using group response systems*. Paper presented at the 7th IASTED International Conference on Computers and Advanced Technology in Education.
- Dangel, H. L. (2008). Student response systems in higher education: Moving beyond linear teaching and surface learning. *Journal of Educational Technology Development and Exchange*, 1(1), 93-104.
- DeSanctis, G., & Poole, M. S. (1994). Capturing the complexity in advanced technology use: Adaptive structuration theory. *Organization Science*, 5(2), 121-147.

- Evans, G. W. (1979). Behavioral and physiological consequences of crowding in humans. *Journal of Applied Social Psychology*, 9(1), 27-46.
- Glaser, B. G. (1978). *Theoretical sensitivity: advances in the methodology of grounded theory*: Sociology Press.
- Halloran, L. (1995). A comparison of two methods of teaching: Computer managed instruction and keypad questions versus traditional classroom lecture. *COMPUTERS IN NURSING*, 13(6), 285-288.
- Hancock, T. M. (2010). Use of audience response systems for summative assessment in large classes. *Australasian Journal of Educational Technology*, 26(2), 226-237.
- Handelsman, J., Ebert-May, D., Beichner, R., Bruns, P., Chang, A., DeHaan, R., et al. (2004). Scientific teaching. *Science*, 304(5670), 521-522.
- Hoffman, C., & Goodwin, S. (2006). A clicker for your thoughts: Technology for active learning. *New Library World*, 107(9/10), 422.
- Hwang, J. H., & Wolfe, K. (2010). Implications of using the electronic response system in a large class. *Journal of Teaching in Travel & Tourism*, 10(3), 265-279.
- Immerwahr, J. (2009). *Engaging the "Thumb Generation" with clickers* (Vol. 32). Bowling Green, OH, ETATS-UNIS: Philosophy Documentation Center.
- Jones, S. R. G. (1992). Was there a hawthorne effect? *American Journal of Sociology*, 98(3), 451-468.
- Keogh, P., & Wang, Z. (2010). Clickers in instruction: One campus, multiple perspectives. [Case study]. *Library Hi Tech*, 28(1), 8-21.
- Knight, J., & Wood, W. (2005). Teaching more by lecturing less. *Cell biology education*, 4(4), 298-310.
- Martyn, M. (2007). Clickers in the classroom: An active learning approach. *EDUCAUSE Quarterly*, 30(2), 71-74.
- Mills, J., & Douglas, A. (2004). Ten information technology trends driving the course of hospitality and tourism higher education. *Journal of Hospitality & Tourism Education*, 16(4), 21-33.
- Milner-Bolotin, M., Antimirova, T., & Petrov, A. (2010). Clickers beyond the first-year science classroom. *Journal of College Science Teaching*, 40(2).
- Nelson, M. L., & Hauck, R. V. (2008). Clicking to learn: A case study of embedding radio-frequency based clickers in an introductory management information systems course. *Journal of Information Systems Education*, 19(1), 55.
- Orlikowski, W. (1992). The duality of technology: Rethinking the concept of technology in organizations. *Organization Science*, 3(3), 398-427.
- Parsons, C. V., & DeLucia, J. M. (2005). Decision making in the process of making differentiation. *Learning & Leading with Technology*, 33, 8-10.
- Patry, M. (2009). Clickers in large classes: From student perceptions towards an understanding of best practices. *International Journal for the Scholarship of Teaching and Learning*, 3(2).
- Preszler, R. W., Dawe, A., Shuster, C. B., & Shuster, M. (2007). Assessment of the effects of student response systems on student learning and attitudes over a broad range of biology courses. *CBE Life Sci Educ*, 6(1), 29-41.
- Stowell, J. R., & Nelson, J. M. (2007). Benefits of electronic audience response systems on student participation, learning, and emotion. *Teaching of Psychology*, 34(4), 253-258.

- Stuart, S. A. J., Brown, M. I., & Draper, S. W. (2004). Using an electronic voting system in logic lectures: one practitioner's application. *Journal of Computer Assisted Learning*, 20(2), 95-102.
- Trees, A. R., & Jackson, M. H. (2007). The learning environment in clicker classrooms: Student processes of learning and involvement in large university-level courses using student response systems. *Learning, Media and Technology*, 32(1), 21-40.
- Twetten, J., Smith, M. K., Julius, J., & Murphy-Boyer, L. (2007). Successful clicker standardization. *EDUCAUSE Quarterly*, 30(4), 63-67.
- UTDC. (2010). Learning and teaching fund 2010 projects. *UTDC / Victoria University of Wellington* Retrieved June 20, 2011, from <http://www.utdc.vuw.ac.nz/resources/landtfund/2010.shtml> - 3
- Valacich, J. S., Dennis, A. R., & Nunamaker, J. F. (1992). Group size and anonymity effects on computer-mediated idea generation. *Small Group Research*, 23(1), 49-73.
- Wieman, C. (2007). Why not try a scientific approach to science education? *Change (New Rochelle, N.Y.)*, 39(5), 9-15.
- Wood, W. (2004). Clickers: A teaching gimmick that works. *Developmental Cell*, 7(6), 796-798.
- Zhu, E. (2007). Teaching with clickers. *CRLT Occasional Paper*(22).