AN EVALUATION OF STUDENT RESPONSE SYSTEMS FROM THE VIEWPOINT OF INSTRUCTORS AND STUDENTS

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ABSTRACT
Student response systems, often referred to as "clickers" are small hand-held devices which students may remotely respond to questions that are posed during lecture. In this research, the perspectives and lived experiences of both instructors and students who used clickers were examined. Also, the activities used by instructors were compared to Bloom's taxonomy levels to provide a new component to our understanding of the impact of clickers. Instructors saw clickers as one tool in supporting student learning in their classrooms. The improved participation, immediate feedback, impact on attendance, and relatively easy formative assessment that result from the use of clickers provided the instructors a method of engaging students. The students requested the increase in use because they felt the use of clickers did supported or improved their classroom learning. They also enjoyed the peer discussions that instructors facilitated with regard to the use of clickers. Consequently, it was found that these systems were especially valuable tool for introductory courses and for monitoring peer learning methods in the large lecture classroom.

INTRODUCTION
Student Response Systems "SRSs" (Kaleta & Joosten, 2007) or "clicker" (Bergtrom, 2006), as they are commonly called, offer a management tool for engaging students in the classroom. Many instructors at both large and small educational institutions have begun to use classroom technology that allows students to respond and interact via small, hand-held, remote keypads (Caldwell, 2007).

In order to comprehend the pedagogic developments in this area, it is necessary to understand the practical process of using the SRSs. A typical pattern of use is presented in Figure 1. During the lecture, the instructor poses a question. Each student has a handset (clicker) that allows students to select the preferred option for the answer. The handsets transmit this information to a receiver, which in turn transmits it to the voting software on a computer in the class. The handsets transmit to the receiver using wireless technologies, depending on the particular system used. After the allotted time, the software produces a histogram or bar chart of the results, which is displayed to the students using a data projector to the computer. The instructor then chooses of action to respond to the results. The software also allows the data to be recorded so that results can be analyzed later.

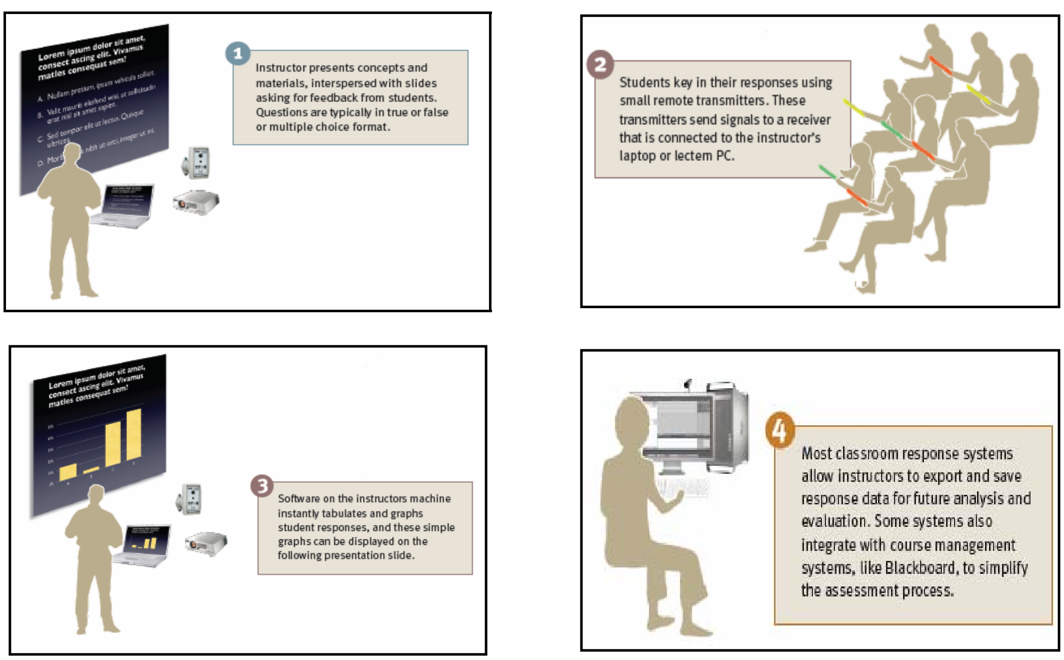


Figure 1. Schematic of the Student Response System

Most handsets allow multiple-choice responses, with up to ten answers available. The handsets can be used anonymously. However, the handsets can be mapped to a student's name. This allows the instructor to see individual's answer, either within the lecture or when reviewing responses at a later stage.

The key advantage of using the SRS (Student Response System) is that it can give feedback to both students and instructors on how well the entire class understands concepts presented. Once this feedback is obtained, an instructor can modify the course of instruction, or students can work out misconceptions by peer or classroom discussion (Kay, 2009). The SRSs have been used to improve student interaction, engagement, and attention (Draper & Brown, 2004; Hinde & Hunt, 2006), increase attendance (Bullock et al., 2002), stimulate peer and class discussion (Pelton & Pelton, 2006), provide feedback for both students and instructors to improve instruction (Caldwell, 2007), and improve learning performance (El-Rady, 2006; Judson & Sawada, 2002; Kay & LeSage, 2009a; Kay & LeSage, 2009b). The fundamental differences between the SRSs and traditional classrooms, benefits to using the SRSs, and challenges associated with the SRSs are described in following sections.

Fundamental differences between the SRSs and traditional classrooms

Feedback can be acquired by multiple means, asking volunteers to share answers, including a show of hands, use of small individual whiteboard or tables to display answers, or using colored cards (flashcard) to represent multiple-choice responses, in a traditional lecture (Draper et al., 2002; McCabe, 2006; Kay, 2009).

However these methods have notable drawbacks. A show of hands after students have answered a question for the second time is the simplest method. It gives a feel for the level of the class' understanding and allows the instructor to pace the lecture accordingly. The main drawback is a loss of accuracy, in part because some students may hesitate to raise their hands and in part because of the difficulty in estimating the distribution. Besides, some students are inclined to copy the responses of others. In addition, when hands are lowered, the data is lost (Abrahamson, 2006; Burton, 2006; Pelton & Pelton, 2006; Slain et al., 2004). Other shortcomings are the lack of a permanent record and the lack of any data collected before convinces his/her neighbor's discussion (Mazur, 1997).

In contrast to traditional lectures, the SRS-based classroom has several key advantages. The SRS allows students to enter their answers to the concept tests as well as their confidence levels, on a variety of handheld devices, ranging from graphing calculators to palmtop or laptop computers, which they share in small groups of three or four. Their responses are relayed to the instructor on a computer screen and can be projected so the students see it, too. The main advantage of the system is that analysis of the results is available immediately. In addition, student information is available to the instructor, making large classes more personal; the system can also handle numerical and non-multiple-choice questions, and sharing these handheld computers enhances student interaction (Al-Fahad, 2009; Beatty, 2004; Hussain & Adeeb, 2009; Keskin & Metcalf, 2011; Mazur, 1997; Pradhan et al., 2005).

Benefits of using the SRSs

As identified in the introduction section, whilst voting systems can support teaching and learning within lectures, any benefits will mostly depend on how effectively they are used on each occasion. In order to judge whether the system does, indeed, enhance the lecture format, it is first necessary to identify the assumptions that are made about what counts as "good" learning. Three key principles were discussed in the literature; student involvement, learning, and assessment and summarized in Table 1.

Table 1: Summary of the student response system benefits (Kay & LeSage, 2009)

Benefit	Description	References
Student involvement		
Attendance	Students go to class more	Burnstein & Lederman (2001); Caldwell (2007); Greer & Heaney (2004)
Attention	Students are more focused in class	Bergtrom (2006); Burnstein & Lederman (2001); Caldwell (2007); d'Inverno et al. (2003); Draper & Brown (2004); Elliott (2003); Jackson et al. (2005); Jones et al. (2001); Latessa & Mouw (2005); Siau et al. (2006); Slain et al. (2004)
Anonymity	All students participate anonymously	Caldwell (2007); Draper & Brown (2004); Jones et al. (2001); Siau et al. (2006); Simpson & Oliver (2007);

		Stuart et al. (2004)
Participation	Students participate with peers more in class to solve problems	Bullock et al. (2002); Caldwell (2007); Draper & Brown (2004); Greer & Heaney (2004); Jones et al. (2001); Siau et al. (2006); Stuart et al. (2004); Uhari et al. (2003); Van Dijk et al. (2001)
Engagement	Students are more engaged in class	Bergtrom (2006); Caldwell (2007); Draper & Brown (2004); Latessa & Mouw (2005); Preszler et al. (2007); Siau et al. (2006); Simpson & Oliver (2007)
Learning		
Interaction	Students interact more with peers to discuss ideas	Beatty (2004); Bergtrom (2006); Caldwell (2007); Elliott (2003); Freeman et al. (2007); Kennedy et al. (2006); Sharma et al. (2005); Siau et al. (2006); Slain et al. (2004); Stuart et al. (2004); Trees & Jackson (2007); Van Dijk et al. (2001)
Discussion	Students actively discuss misconceptions to build knowledge	Beatty (2004); Brewer (2004); Draper & Brown (2004); Jones et al. (2001); Nicol &Boyle (2003)
Contingent teaching	Instruction can be modified based on feedback from students	Brewer (2004); Caldwell (2007); Cutts (2006); Draper & Brown (2004); Elliott (2003); Greer & Heaney (2004); Hinde & Hunt (2006); Jackson et al. (2005); Kennedy & Cutts (2005); Poulis et al. (1998); Stuart et al. (2004)
Learning performance	Learning performance increases as a results of using the SRS	Bullock et al. (2002); El-Rady (2006); Fagan et al. (2002); Kaleta & Joosten (2007); Kennedy & Cutts (2005); Pradhan et al.(2005); Preszler et al. (2007); Schackow et al. (2004); Slain et al. (2004)
Quality of learning	Qualitative difference when learning with the SRS (e.g., better explanations, thinking about important concepts, resolving misconceptions)	Crouch & Mazur (2001); Caldwell (2007); d'Inverno et al. (2003); Draper & Brown (2004); Elliott (2003); Greer & Heaney (2004); Nicol &Boyle (2003)
Assessment		
Feedback	Students and teacher like getting regular feedback on understanding	Abrahamson (2006); Cline (2006); Draper et al. (2002); McCabe (2006); Pelton & Pelton (2006)
Formative	Assessment is done that improves student understanding and quality of teaching	Beatty (2004); Bergtrom (2006); Brewer (2004); Bullock et al. (2002); Caldwell (2007); Draper & Brown (2004); Dufresne & Gerace (2004); Elliott (2003); Greer & Heaney (2004); Hatch et al. (2005); Jackson et al. (2005); Siau et al. (2006); Simpson &Oliver (2007); Stuart et al. (2004
Compare	Students compare their the SRS responses to class responses	Burton (2006); Caldwell (2007); Draper & Brown (2004); Hinde & Hunt (2006); Simpson & Oliver (2007)

With respect to student involvement, there is considerable data to suggest that students using the SRS are more engaged in concepts covered, participate more, pay more attention in class, and are more involved in class discussion. One of the greatest of the SRSs is that they offer the opportunity to make the lecture "more interactive without appearing threatening".

It is likely that many students hold back from answering or responding through peer pressure or the potential embarrassment of publicly giving the wrong answer. This in turn may mean that only the more confident or able student respond, when they are least in need of instructor attention (Durbin & Durbin, 2006; Fies & Marshall, 2006; Kay, 2009).

With respect to learning, numerous studies have reported that students feel they learn more when the SRS is used in higher education classrooms (Greer & Heaney, 2004; Pradhan et al., 2005; Preszler et al., 2007). Furthermore, many experimental studies have been done where SRS-based classes score significantly higher on tests and examinations than classes who are exposed to traditional lecture formats (Kaleta & Joosten, 2007; Kennedy & Cutts, 2005; Reay et al., 2005; Reay et al., 2008).

Regarding assessment, the SRS helps improve the feedback cycle by ensuring anonymity, collecting, and summarizing responses from all students in larger classes very quickly, and limiting the copying of answers (Abrahamson, 2006; Beatty, 2004; Draper & Brown, 2004; Pradhan et al., 2005; Simpson & Oliver, 2007). In addition, the regular use of the SRS can offer feedback to both the instructor and students as to how well concepts are being understood (Bergtrom, 2006; Bullock et al., 2002; Dufrense & Gereca, 2004). Timely feedback to students about their performance can be greatly assisted by the use of the SRSs. Because answers are marked electronically and automatically, feedback on performance and presentation of the right answers can be achieved quickly (Kay, 2009). Students can then see how their performance compares to that of the rest of the group. When used for peer assessment students can gain immediate feedback on their work. The instructor can also gain feedback in this way. They can, for example, see how well the lecture has performed and use the information immediately to provide appropriate action such a re-describing a misunderstood item.

Challenges associated with the SRSs

Three categories of challenges were predominant in the literature. Technology, instructor, and student based challenges. Each of these challenges is presented in Table 2.

With respect to technology, on occasion, signals from some remote devices do not register on the instructor's computer, a particularly stressful experience when students are being evaluated for grades. Regarding new methods of learning, some students react adversely to the use of the SRS because the overall approach to learning changed. They are accustomed to lectures and a switch of methods leads to stress, frustration, and resistance at first. Other students are distracted by the use of the SRS (Kay, 2009).

Table 2: Summary of the student response system challenges (Kay & Lesage, 2009)

Challenge	Description	References
Technology-based challenges		
Bringing remotes	Students forgot or lost remotes and could not participate in class	Caldwell (2007); Reay et al. (2005)
SRS did not work	Remote devices did not function properly	El-Rady (2006); Hatch et al. (2005); Sharma et al. (2005); Siau et al. (2006)
Instructor-based challenges		
Responding to student feedback	Less experienced instructors cannot adjust to student feedback	Abrahamson (2006); Hu et al. (2006)
Coverage	Cover less course content if the SRS is used	Beatty (2004); Beatty et al. (2006); Burnstein & Lederman (2001); Caldwell (2007); d'Inverno et al. (2003); Burton (2006); Cutts (2006); Draper & Brown (2004); Fagan et al. (2002); Freeman et al. (2007); Hatch et al. (2005); Sharma et al. (2005); Siau et al. (2006); Slain et al. (2004); Steinhert & Snell (1999), Stuart et al. (2004)
Developing questions	Time consuming to create the SRS questions	Allen & Tanner (2005); Beatty et al. (2006); Boyle (2006); El-Rady (2006); Fagan et al. (2002); Freeman et al. (2007); Horowitz (2006); Paschal (2002); Robertson (2000)
Student-based challenges		
New method	Students find it difficult to shift to a new way of learning	Allen & Tanner (2005); Beatty (2004); Fagan et al. (2002); Siau et al. (2006)
Discussion	Discussion leads to confusion or wasting time	Draper & Brown (2004), Nicol & Boyle (2003); Reay et al. (2005)
Effort	Too much effort is required by students when using the SRSs	Trees & Jackson (2007)

Summative assessment	Using the SRS for tests may not be popular with students	Caldwell (2007)
Attendance for grades	Students do not like the SRSs used for monitoring attendance	Caldwell (2007)
Identifying students	Students want to remain anonymous	Abrahamson (2006)
Negative feedback	Students feel bad when receiving negative feedback	Carnaghan & Webb (2007)

The SRS is a new technology and has room for technological improvement and advancement. For example, students' responses sometimes could not be detected and received by the receiver. The receiver was not able to receive more than one concurrent response, or the transmitter was not within the range of the receiver. System can only capture quantitative data, thus limiting the responses to multiple-choice or true-false questions. Since using the wireless handheld transmitter was fun to the students, some of them did not take it seriously-by clicking multiple times on purpose, by clicking on answers that were obviously incorrect or by clicking on answers that were out of the range/choices given.

Many researchers have discussed that there are several key problems with current research on the SRSs including: a lack of systematic research, a bias toward using anecdotal, qualitative data, excessive focus on attitudes as opposed to learning and cognitive processes, and samples derived from limited educational settings. Several researchers have maintained that the majority of the SRS data collected to date is anecdotal or qualitative (Fies & Marshall, 2006; Kaleta & Joosten, 2007; Schackow et al., 2004). However, both qualitative and quantitative data is needed to fully understand the use and impact of the SRSs (Kay & Lesage, 2009a). This research provides both qualitative and quantitative results with the statistical analysis obtained from lived experiences of both instructors and students.

METHOD

In this study provided a unique look at the use of clicker technologies in university classrooms. The perspectives and lived experiences of both instructors and students were captured through rich, thick descriptions (Geertz, 1973). In addition, the actual activities used by instructors were compared to Bloom's taxonomy levels (Anderson & Krathwohl, 2001) to provide an entirely new component to our understanding of the impact of clickers. The attitudes of the students were also investigated quantitatively. The quantitative method was probed also to elucidate the gender differences in attitudes toward the SRS.

Four main research questions toward the purpose of the research guided this study were determined as follows:

1. How do instructors describe their experience of incorporating clickers into their university level classes?
2. Are instructors who incorporate clickers aware of the cognitive development of their students?
3. How do students report their experience of using clickers in their classes?
4. How do male and female students differ in their attitudes toward the SRS?

Participants

Six faculty members of various academic ranks who were using clicker technologies in their teaching and representing a broad range of disciplines, experience with clickers, and academic rank were selected. Firstly, an e-mail was sent to each of the instructors outlining the study details and requesting their participation in the research. Of the first six instructors emailed, all but two agreed to take part in the study. One pointed out that he was not currently teaching a class using clickers but noted a colleague who was teaching that course with clickers. When researcher contacted the colleague he agreed to participate. Another instructor did not respond to researcher's e-mail request for participation in the study, and thus another instructor from the list with a similar academic rank, discipline, and clicker experience was contacted and did agree to participate. One instructor who agreed to participate recommended also including a colleague with several years of experience with clickers.

Researcher's final sample of six instructors included two professors (chemical and physics), one associate professor (chemical), and one assistant professor (geology), two lecturers (geology and physics). The gender distribution was split three female and three male. University and college teaching experience ranged from 8 to

37 years and experience using clicker technologies ranged from less than two years to over ten years. The SRSs were applied at chemical, geology, and physics engineering departments.

Once the six instructors were selected and agreed to participate in the study, researcher attempted to recruit two students from each instructor's class in which s/he is using clicker technologies. The students were recruited by an in-class announcement by the instructor or the researcher. Students were asked to participate in a group interview relating to their experience with the use of clickers in that particular classroom. Rather than purposeful sampling, students self-selected themselves into the study by responding to the recruitment solicitation.

These interviews provided triangulation by source and also student opinions about the use of clickers. It was intended to secure two students from each instructor's class to interview as to their perceptions of the use of clicker technologies within that course and across campus. A total number of twelve students representing six instructors were able to be interviewed. The students represented various academic learning levels, from freshman to senior level. Student opinions and feelings about clickers may vary based on their year in school. Having only one semester left before graduation and being required to purchase a clicker during that semester might play a role in the student's perception of the use of clickers. However, the hunch was not fully realized because of the limited sample size of students researcher interviewed. In addition, students may voice varying opinions based-on the number or courses and experiences they have had with clickers. For example, if a student has had a number of experiences, s/he may have a different perception of the use of clickers than one who has had a very limited experience or only a single, either positive or negative clicker experience. As well, interviewing students in even a small group of two may affect their responses. Unfortunately, each student was not able to be interviewed individually because of student scheduling and time constraints and this might have impacted the results. However, still the interviews of twelve students provided some valuable information relating to their opinions and feelings about the use of clickers in the classroom. The student sample including six female and six male students consisted four freshman, four sophomores, two juniors, and two seniors. Furthermore total number of 523 volunteer students (241 males, 262 females) from the class of the instructors supporting the research was given the SRS attitude survey. The student were also freshman (n=135), sophomore (n=129), junior (n=131), and senior (n=128).

Procedure

The data of this research was collected with the help of three sources which are interview, observation, and survey.

An e-mail request was sent to those instructors chosen from the list of instructors currently using clicker technologies. On agreeing to take part in the study, the instructor participants signed an informed consent document and were asked to supply a class period in which researcher could observe them using clicker technologies. To see how to design clicker questions and evaluate the benefits and drawbacks of clickers, the courses of the instructors supported to this research were observed. This was purely a descriptive and exploratory observation during which field notes were taken; researcher served as a non-participatory observer in the class. Following the classroom observation, an agreed on date was set to conduct 30 minutes of semi-structured faculty interview. Transcriptions of the interview were provided to each instructor participant by e-mail as a member check for validity of the transcription. All six participants confirmed the validity of their interview.

In addition, researcher asked each instructor to provide four sets of classroom slides showing their range of use of clickers. The slides were considered document artifacts and analyzed for levels of cognitive process according to the revised Bloom's taxonomy (Anderson & Krathwohl, 2001). The instructors were asked to make an in-class announcement to the students for volunteer students. Interested students were directed to contact researcher by e-mail for participation and assured that their participation not only would be voluntary, but would be anonymous to all parties except the researcher. The students` interviews were audio-taped and transcribed using the interview question protocol. They consisted of either a group of 2-3 students or an individual student and lasted 25 minutes. Students were also allowed for free-flowing discussion on opinions and thoughts. The purpose of the student interview was twofold: to provide a voice to the students as to their perceptions on the use of clickers in the classroom and to provide triangulation related to the method and frequency of use of clickers in the classrooms represented. Both were partially accomplished through the student interviews. Also to examine gender differences in attitudes toward the SRS, the SRS survey was applied to volunteer 523 students at the end of the semester.

Data Analysis

The phenomenological approach was used in this research. The basis of phenomenology is an interpretive paradigm that investigates the qualitatively different ways in which people experience or thinks about something

(Marton, 1986). Phenomenography, an approach to educational research that appeared in publications in the early 1980s (Marton, 1981; 1986), initially emerged from an empirical rather than theoretical or philosophical basis (Akerlind, 2005). Phenomenology begins with an exploration of phenomena, in this case the phenomena of using or experiencing clicker technologies in university lectures. Following a traditional qualitative analysis approach, data collection and analysis occurred concurrently in this research.

The contextual experiences of instructors and students are the units of analysis for this study. In addition, researcher reviewed clicker slides used by the instructors for cross comparative analysis. This analysis of interview data from instructors and students, document artifacts, and observational data allows for triangulation by data source and method, thereby increasing the credibility and dependability of the study. Researcher transcribed and reviewed the interview narratives for emerging themes relating to the use of clickers to engage students in higher-level cognitive thinking. Researcher also reviewed the clicker technology slides and coded their contents according to a taxonomy table looking for emerging themes and patterns. A quantitative summary of the slide analysis was also formulated. The observation field notes were compared to the student and instructor interview narratives and documents supplied by the instructors. Finally, students completed the SRS attitude survey at the end of the semester. This survey consisted of nine, seven point Likert scale (from strongly disagree "1" to strongly agree "7") items. Items were constructed based on a review of the SRS literature and focused on general attitude, student involvement, learning, and assessment. The internal reliability for the total nine-item scale was 0.89 (Kay, 2009).

Creswell (1998) provided an outline of analysis for a phenomenological study design Researcher followed his design which includes a focus on data management, reading and writing memos, description, classification, interpretation, and representation or visualization. Data management included recording audiotapes and taking field notes. Reading through texts, making notes in the margin, and the formation of initial codes followed. A constant comparative method of analysis as described by Glaser & Strauss (1967) was employed. Each statement had equal worth and statements were grouped into meaningful units or categories. Finally, a rich, thick description (Geertz, 1973) of the data was formulated, with the overall goal to develop a description of what students and instructors experience and perceive with regard to the use of clickers for fostering higher-level cognitive thinking.

To ensure rigor and credibility of this study, several verification methods were employed. Creswell (1998) provided eight procedures for ensuring the trustworthiness of a study: triangulation, prolonged engagement, negative case analysis, clarifying researcher bias, member checks, peer review, thick description, and external audits. Creswell (1998) recommended that "researchers must engage in at least two of these in any given study". In this study, researcher used the following strategies as outlined by Creswell: triangulation, prolonged engagement, peer review, member checks, thick description, and clarification of researcher bias.

RESULTS AND DISCUSSION

The results of the interviews, observations, document artifacts and survey provided by the instructors and students were presented in the following sections.

1. Results of the interviews done with instructors

Semi-structured interviews based-on the interview question protocol were conducted with each of the six instructors. The purpose of the interview and question protocol was to explore the instructors' methods of using clickers and to examine their experiences with using clickers in the classroom. *Four* themes emerged from the six instructor interviews.

I) There are various uses of clicker technologies for per instructor

General knowledge questions, problem solving questions included in upcoming exams, questions for formative assessment of the class about classroom procedures, questions related to course content that is about to be covered with or without point, questions as a review of course content previously covered with or without points, questions about high interest or current event topics.

An example toward using of clicker may be given the course of the lecturer in geology engineering department. "*As an example of assessing understanding, after teaching the students about the types of geologic faults, I can then show them pictures of faults and ask them what type of fault is shown, and type of stress and strain produced it. As an example of assessing changes in world-view, I ask the students how old they think the earth and the universe on the first day, and then after the geology section of the course I ask them again to see the changes in their conception of the age of the earth and universe. I also ask them about their views on evolution before the evolutionary lectures and then again afterwards"*.

II) Instructors view clicker technologies as a tool that enhances classroom learning and teaching
A subtheme within this idea of clicker technologies as a tool to teaching and learning was how clicker technologies are a tool to pace and modify their current teaching practice. Instructors mentioned that they have become much more thoughtful in the design of their lecture presentations. Instructors mentioned how clickers' slides provide for better pacing of the lecture presentations and allow for a reminder of what it is they want to discuss that day in lecture.

Another subtheme that emerged is that *i> clicker* (www.iclicker.com/dnn/) *technology has* provided a tool for the instructor to think about what questions they want to ask their students during their lectures. The associate professor in chemical engineering department declared "*certainly, because the questions associated with clickers are conceptually connected to a discipline's habits of mind, methods and objects of inquiry, ways of communicating, ways of knowing, and more*". He told *"don't use them for frivolous questions just to take attendance. That will probably make the students resentful of clickers. Ask questions that really pertain to the material that has been taught so the students can get immediate feedback on their level of understanding. Also, questions on the student's thoughts before and after being taught a subject can help an instructor tell what methods are most effective in learning".*

Instructors felt clicker questions generate discussion because students can see immediate feedback as to the responses of the entire class. Students know immediately that they are not the only person who got the answer correct or who feels a certain way about a topic. Instructors also described using the responses as a means for generating further discussion and for modifying their presentation of the content on the spot. The professor in chemical engineering department told, "*I just like the fact you can get feedback right now, right away, and use the teaching moment".* When asked about the benefits of clickers, this idea of immediate feedback for both the student and instructor continued to emerge. She continued, "*that they give each student an opportunity to contribute his or her ideas, and because the contribution is anonymous to the rest of the class, there is no punishment for being wrong. This makes students think more deeply, take a few more risks, and interested in why they were off the mark or correct*".

III) Instructors believe clicker technologies have a positive impact on student engagement and attendance
Student engagement and increased attendance were commonly mentioned by the instructors interviewed as a benefit of clicker technologies. And while none of the instructors interviewed used clicker technologies as many their course points or for solely tracking attendance, they saw the benefit that associating points to the questions has on student engagement, attendance, and possibly even academic performance. The professor in physics engineering department with 40 years of teaching experience explained *"I am sure it has increased participation. But the big thing we noticed right away is that the test scores went up. We draw our questions from a test bank, so we expect sort of similar performance across the years and last semester was then best semester we've had for a long-time, long-time in scores for the class. I think the best part is that we think it has cleared up questions before the exam".* The assistant professor in geology engineering department about attendance in the class said "*Students are more likely to come to class if their clickers are being used in some way to take attendance or for borderline grade cases as I do. The students also enjoy being able to speak-back to the instructor by clickers".* The lecturer in physics engineering department told "*positively, the questions focused their attention on particularly important issues".* The lecture in geology department declared *"I have not measured attendance before and after the use of clickers so it is hard to tell. I get a sense that a slightly larger proportion of students attend since I started using clickers".*

Another subtheme is the clicker technology which has had student engagement in the classroom and therefore impacted their teaching of the content. Instructors noted active engagement with the content, a decrease in student incivility, and occasionally, an increase in student attendance. The professor in physics engineering department stated "*students seem more engaged. To my mind as I lectured, they seemed more engaged and I am even asking more concept questions, you know also clicker questions".*

IV) The benefits and drawbacks of using clicker technologies
Instructors noted technical issues and limits they encounter with clicker technology, but almost all cited personal error as the main reason for technical glitches they encounter. Instructors also cited frustration on the part of students and disappointment when technical errors occur in the classroom session. The lecturer in physics engineering department explained *they are difficult to use with open-ended questions and could squelch class discussion. They could also place too much focus on being correct rather than understanding why one is (or is not) correct".* She added, "*you only get five choices for responses. With more subtle subjects, that may not be enough".* On the other hand according to the associate professor in chemical engineering department, "*Overall,*

I have had a lot of fun with them. I have hoped that they have improved my teaching, overall they have helped improve my accessibility to the students because they ask more questions at the end of class. They are hard to get out of the room at the end of class. I think it is because they know I am interested in their responses, opinion questions, and they know I am interested".

The faculty interviews were filled with thick description of the clicker technologies, their teaching, and eventually the classroom learning environment. It was interesting to note that none of the instructors felt they had reached the pinnacle of clicker understanding and use. Each one mentioned the process as evolving and thought they could do more with the technology to improve student learning. However, another subtle theme that emerged through the overall interview process was the student-centered approach each of these instructors held. While researcher was not able to distinguish whether that approaches was held before the use of clickers or at their onset of using clickers. They seemed to feel that clickers allowed for this improvement to learning, not only by engaging students and soliciting student feedback, but also by changing the way they designed and carried out the lecture itself. Instructors went into their class sessions open to hearing what students knew and thought about content, open to the discussion that might be generated based on clicker questions, and open to modifying previously held ways of teaching in an attempt to improve the classroom environment for the students they teach. And in the process, the instructors realized this was not only beneficial but also fun.

2. Results of the researcher's observation toward using clicker

As a part of this study, an observation of each of the six instructor participants was conducted to view how they were using clickers in the classroom. Researcher served as a non-participatory observer, generally sat in the rear or middle of the classroom, and transcribed field notes as to happenings in the classroom. The observation was structured in such a manner so that the instructor did not change his/her normal teaching and use of clickers based on participation in the study. From the observation field notes, researcher conducted a cross-comparative analysis, looking for emerging themes on the observations of instructors. Four themes emerged from the observation field notes.

I) Full classroom discussion is initiated following clicker questions.

The observation revealed that almost each instructor encouraged students to hold a peer discussion relating to most of clicker questions posed. This peer discussion was fostered either before answering clicker question or after students answer clicker question but before showing the polling results. It was exciting to witness the explosion of student discussion given this opportunity. As an observer, it seemed the students were on target with their discussion and these discussions took only a limited time to complete in the overall time in the classroom.

II) Various technological tools are used in the classroom.

The instructors using clickers also used various other technological tools in the classroom. Instructors used PowerPoint, Graphics, Images, Video, etc., which is a necessity to the *i>clicker technology* (Fig. 2), was being used by each instructor. This combination of learning systems enhanced the engagement of the students in the class.

Figure 2. Student using i>clicker in the class

III) Most students had their clickers and were taking part in.

In the beginning of the course a headcount of the number of students present in the classrooms was conducted. This manual count was compared with the number of response registering in *i>clicker technology*. In every observation instance it appeared most of the students present were participating in clicker questioning a response.

Most students in this study seemed open and willing to use clickers and even desired greater use of clickers across campus. All students, regardless of their like or dislike of clickers, were able to identify benefits of clickers to their learning, given the instructor was component in clicker technology.

The only halting point was the technical issues that instructors encountered. Therefore the technical and pedagogical education instruction should be provided to instructors before implementation of clickers in the classroom, thus alleviating some of the student and instructor frustration with technological errors on the part of the students and the instructors.

In addition students often want to know why clickers are being used, how often clickers will be used, and what is expected of them on the use of clickers. While clicker technologies are relatively user-friendly, campuses should make technical assistance available to students. Instructors should also gain enough understanding of the technology to provide small technical assistance in the classroom and to explain their reasoning behind their use of clickers in the classroom.

3. Results of the slide's analysis provided by instructors

As a part of their participation in this research, instructors were asked to supply several sessions of their *i>clicker* slides to be compared to Bloom's taxonomy of cognitive domains. The slides they submitted were at the discretion of the instructors. Several instructors sent a range of their use of clickers, and they were free to select the slides to be shared with me for analysis.

The purpose of the slide analysis portion of the study was multidimensional. It served as a method of triangulation to support the observation and interview results as to how often, and in what manner, clickers were being used in the classroom. It also allowed for an analysis of the cognitive level of use of clickers in relation to Bloom's taxonomy.

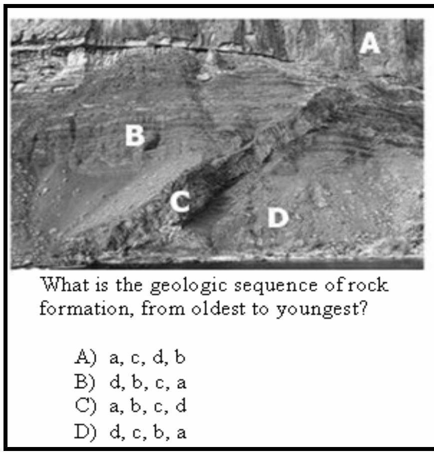
On receiving the slides, the number of times was counted in which a clicker question was asked per session, and calculated the total number of slides presented in that session. Overall, researcher analyzed 12 sessions of slides included 143 clicker questions slides, provided a somewhat quantitative aspect to the study. Table 3 outlines the slide analysis results. Also sample clicker questions toward the courses were represented in Figure 3.

The six levels of Bloom's taxonomy, from the least complex to the most complex of thinking, include: knowledge, comprehension, application, analysis, synthesis, and evaluation. Each slide was placed within one of the six levels of Bloom's taxonomy of cognitive domains with instructors. When a question was difficult to place, it was placed in the lower of the possible levels rather than in a higher-level. Consistency was a key to analyzing the slides.

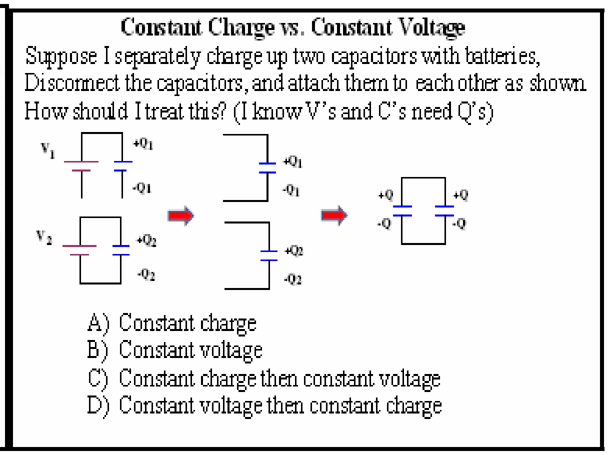
Table 3: The number of slides related to Bloom's Taxonomy

Courses	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation
Physics	17	12	19	2	2	3
Chemistry	16	4	27	3	4	4
Geology	8	-	14	-	-	8
Total	41	16	60	5	6	15

Note: Each session was 90 minutes and each course was observed four times. The physics and chemistry lectures were represented average 14 slides in each session. Also geology lectures were presented the average 8 slides.



-a-



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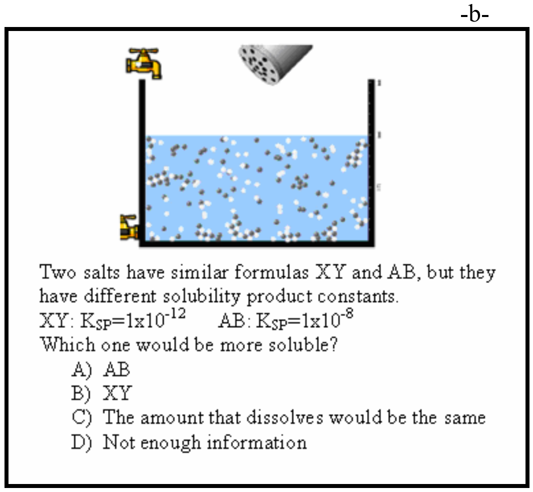

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Figure 3. Examples of applied reasoning questions presented in class with the SRS for (a) Geology, (b) Physics, (c) Chemistry courses.

What became evident in the analysis of the slides is the variety of use by instructors both within and across the disciplines represented. Recognizing this variety of use by instructors provided triangulation with the results from the observation and interviews, substantiating the idea that these instructors pose clicker questions in a variety of ways in the classroom.

It is interesting to note the large number of slides used in several of the classroom sessions. The classroom session slides analyzed did include most slides, some of which had only one minor difference from the slide before or after it. Instructors might also have used a single slide to include a graphic or a website link. It may also be that these instructors included a plenty of slides they may never actually get through in the designated class period and then carry over to the following class period. Figure 4 indicates the graphical representation of the total number of slides per domain. It is obvious that most of clicker slides analyzed fell into the application domain with the second most being knowledge level slides.

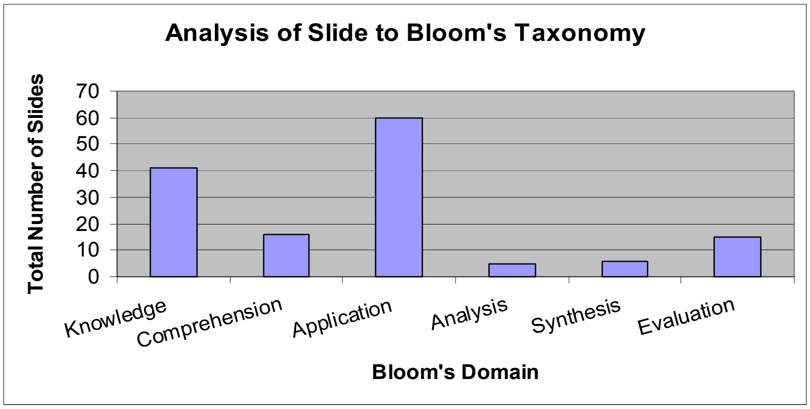

Figure 4. Analysis of the slides according to Bloom's Taxonomy

It was difficult to create higher-level thinking within multiple-choice questions; however it appeared with the thoughtfulness involved in asking clicker questions, these instructors have begun to foster higher-level of cognitive thinking. It was believed that this critical thinking was fostered not only in the manner in which the instructors posed the questions, but also in the discussion the instructors initiated after the question was posed. While knowledge, comprehension, and application type questions were most of the slides presented by clicker technologies, the level of cognition required increased as instructors forced students to make a decision, to stick to that decision, and to discuss that decision with peers.

The instructors also should pay attention while preparing the single question and question sequences according to Bloom's Taxonomy. The potential drawback of relating the different type of questions could be avoided by preparing a single question and question sequences. A single question usually fails to help students make context-dependent connections. Question sequences have three or four questions, each with a context that looks different to students, while the underlying concept looks equivalent to experts. By recognizing and applying a new concept in different contexts and conditions, students can obtain a better level of understanding according to a single question. By using question sequences, instructors can have a better understanding of where the students' difficulties are, and thus can provide corresponding feedback. Question sequences can also provide specific feedback to students themselves. A common difficulty when students learn science courses is that they cannot identify their mistakes. Question sequences can help students find specific difficulties. So, question sequences can create cognitive with less anxiety (Reay et al., 2005).

4. *Results of the interviews done with students*
The students had varying levels of experiences with clickers, from freshman to senior classes. Their opinions were thought-provoking, encouraging, and concerning. Four themes were emerged from the student interviews:

I) Students are able to identify benefits to their learning relating to the use of clickers in the classroom
As a part of the interviews, students were probed as to the methods used by their instructors, the benefits and limits of clickers, and the impact of clickers on learning. All students, whether they expressed a like or a dislike for clickers, were able to generate benefits from the use of clickers. Students liked the classroom and individual feedback that clickers provided. They liked being able to see potential exam questions before the exam as well as being able to know immediately if they were correct in their answer. Students also liked the interaction with other students that their instructors encouraged with regard to clicker questions. Finally, some students felt that clickers improved their learning and added to the level of cognitive thinking required in the classroom.

II) Students value technical competence in the instructors who use clickers.
Three students, all from one class where the instructor is a new clicker user, were frustrated with the level of technological competence exhibited by their instructor. Technical errors on the part of their instructor frustrated students, especially when the instructor used class time to try to resolve the errors. A senior student in geology engineering department recommended that instructors be required to take a clicker class to learn how to use the technology before implementing them in the classroom.

III) Students would like to see more instructors use clickers
Students expressed a desire for more use of clickers across campus and within their individual courses. This desire seemed to be expressed by both those students who felt their instructor was using clickers adequately, in

that they would like other instructors to use clickers, and also by those students who felt their instructor was not using clicker technology enough in their specific course to justify the cost.

IV) Students would like information on the use of clickers
Students mentioned the need for the campus or individual departments to list which courses are currently using clickers or are most likely to be using clickers in the future to allow students to know if they should keep their clickers or sell them. In addition, students noted that simply having an instructor tell them to keep their clicker for the remainder of their time on campus would be a benefit since they might need to use it in another class.

Besides, students wanted to know what content their clicker quizzes would cover in the event points are associated with correct and incorrect answers. Also students wanted to know what was expected of them regarding their use of clickers and what will be considered academic dishonesty as it relates to the use of clickers. Students mentioned abuse by students who are giving their clicker to another student to click in for them during class. When asked if they felt this was academic dishonesty, most of students mentioned that it would depend on whether the instructor had stated it as such in the beginning of the semester or in the syllabus.

5. Results of the SRS attitude survey according to gender
With respect to total the SRS attitude score, male students (M=56.5, SD=9.2) had significantly more positive attitudes towards the SRS than female students (M=52.1, SD=10.1) (t=5.2, df=521, p<.001). The effect size of 0.45 is considered to be in the medium range by Cohen (1988). Since overall attitudes toward the SRS were significantly different, a MANOVA was run to compare male and female students on each of the nine-Likert scale survey items examining attitudes toward using the SRS. Hotelling's T was significant (p<.001), so individual comparisons were done on each survey question. Male and female students differed significantly on all items (Table 4).

Table 4: Gender differences in attitudes toward the SRS based on survey results

Measure	Males		Females		F
	M	SD	M	SD	
Overall Attitude					
When a SRS was used, the class was better	5.07	1.22	4.41	1.35	28.01*
Student Involvement					
I was more engaged in the lesson when a SRS was used	5.44	1.32	5.12	1.52	9.31**
I was more motivated when a SRS was used	5.43	1.41	4.99	1.52	19.28*
I participated more than I normally would when a SRS was used	5.61	1.33	4.97	1.47	7.55***
Using a SRS generated more class discussion	4.98	1.46	4.34	1.53	18.92*
Learning					
I learned more when a SRS was used	5.02	1.48	4.65	1.69	12.75*
Assessment					
Using a SRS was a good way to test my knowledge	5.67	1.35	5.19	1.48	7.81***
I liked seeing what other students in the class selected for answers	5.12	1.42	4.77	1.46	6.68**
I liked using a SRS for tests	5.23	1.54	4.83	1.62	29.63*

*p<.001; **p<.005; ***p<.05.

CONCLUSION
The results obtained from research questions can be reduced as follows.

1. It would seem from the comments of six instructors that incorporating student response system into their university level classrooms was both beneficial and enjoyable. Learning clicker technology and deciding on ways to incorporate technology has challenged the instructors to think about their lectures as a whole with respect to pacing, student interaction, and classroom engagement.

Instructor's perceived outcomes of the use of student response systems include increased student participation, increased student attendance, improved instructor-student interaction, active and collaborative learning activities, and an enriching educational environment.

Subtle benefits to clickers emerged and included a decrease in the amount of time spent grading and writing down answers, greater understanding behind pointing out wrong answers, an increase in student generated verbal questions, and a new thoughtfulness behind preparing class sessions.

2. While instructors generally answered by saying that they did not consider the cognitive level of the their students when designing clicker questions, the actual slides representing clicker questions and the interview and observation results represent a mix of cognitive learning domains according to Bloom's taxonomy. Many questions posed through the use of clickers are simply knowledge and application level questions. However, higher-level, synthesis and evaluation questions were represented.

It is also obvious that a higher-level of thinking can occur as an instructor fosters discussion with the use of clicker questions. A question is posed, students are required to make a decision, they have to choose an answer, and the instructor then encourages the students to talk among themselves, generating peer discussion or peer learning. The student now either has support for the answer s/he chose or must defend the answer to a peer. Further discussion as a large group might also be generated. As the instructor guides the students through the process of describing why they chose the response they chose and why that response is right, wrong, or indifferent, this higher-level thinking can emerge. In addition, students become more likely to ask questions when they are able to see that they are not alone in their thinking and when they feel the instructor cares about their opinions and learning. Instructors can clear up misconceptions and generate class discussions about course content immediately on seeing student responses.

3. While there were slightly mixed thoughts on student experiences with clickers, most of the twelve students interviewed in this study held a favorable regard for the use of clickers in the university classroom. Students noted the use of clickers associated with class credit points increased their likelihood of attending class and noted the improved learning that occurs on attending class.

Students felt that being able to make peer comparisons and being able to validate their understanding of the course content were also benefits of the use of clickers. They enjoyed the peer discussions that instructors facilitated with regard to the use of clickers. Some students felt frustration over the competence level of instructors with clicker technology while other students were forgiving about the learning curve associated with the technology.

The most beneficial activities cited by the students in this study related to clicker use were content comprehensions review, generation of classroom discussion, application questioning, and attendance checks. Students did desire that instructors use clickers daily and in various ways mainly to justify their purchase of clicker. The students also requested this increase in use because they felt the use of clickers did supported or improved their classroom learning.

Most students in this sample were not able to make the connection between the use of clickers and the enhancement of higher-level thinking, but they did desire more information from their instructors as to why clickers were used in their classrooms. Several students were able to formulate a connection between the use of clickers and the improvement of higher level cognitive thinking.

4. Student involvement, assessment, and perceived learning were examined with the help of the SRS attitude survey. A simple comparison indicated that male students were significantly more positive than female students in all three categories. Male students were more motivated and engaged when using the SRS, participated more in the SRS-based classrooms, liked using the SRS to test their knowledge, especially in summative evaluation, thought the SRS generated more class discussion, felt the SRS helped improve their learning, and overall, thought the SRS-based classes were better. Female students on the other hand, would seem more stressed when using the SRS.

The benefits and drawbacks of the SRS were clearly reported in the literature. The research supports those outcomes obtained from the literature. However, the author could not find any statistical (qualitative and quantitative) analysis applied in any researches. It was believed that this research will elucidate the details about SRS and encourage other researchers to investigate various parameters affecting the success of the learning system.

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