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USING AN AUDIENCE RESPONSE SYSTEM (ARS) A.K.A. "CLICKER" TO DO ATTENTION RESEARCH

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by

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USING AN AUDIENCE RESPONSE SYSTEM (ARS) A.K.A. "CLICKER" TO DO ATTENTION RESEARCH

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This study makes an effort to examine whether a student's attention or engagement is increased by possession of an Audience Response System (ARS, or clicker). This experiment tested a difference in performance between students who possessed an ARS and those who did not. The experiment was conducted at a small state college in the Midwest where small class size is typical. Approximately half the students in each tested classroom were handed a clicker and then the entire class was taught a topic. After the topic presentation, students possessing clickers were assessed using a question based on that topic. The assessment was discussed. Further instruction was given on that topic. Then a second question was asked. Just before responding, however, students were surprised by an instruction to hand their clickers to students who were not expecting to be assessed. Barnard's exact test was used to analyze the 2x2 data from eight classes with $\alpha = 0.05$. The results indicated there were no significant differences between the two groups of students. The last-minute change in performance expectation did not appear to affect the assessment outcomes. This study utilized ARSs to collect data for the experiment. Advantages and disadvantages of using ARS devices to collect data were examined. ARSs were found to be effective in collecting research data.

Dedication

To my wife, Teena, and my children, Kasey, Nick, and Sam. Always pursue your goals with perseverance and huge amounts of effort. If you’ve learned anything from me may it be you have to work hard, sometimes fail, then get up and keep going to get where you want to be in life. On the journey, remember to be happy and stay in the present moment.

Acknowledgments

I want to thank my mentors in this pursuit – David Brooks and Lois Veath. Without someone “gently” encouraging me I know I wouldn’t have made it – you have given me hope when doubt was threatening my progress and have truly made a positive difference in my life.

To my Mother, Father, and Family - I want to thank you for helping shape who I am today. Without your contributions I wouldn’t have gotten this far – your encouragement and faith in me has always been appreciated.

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Chapter 1: Introduction

Audience response systems, also known as “clickers,” provide audience members a means for communicating information to a presenter. For this reason, they have begun to be widely used by teachers in classrooms. Up to this point in time much of the research on audience response systems (ARS) has examined students’ attitudes toward using the devices in class or for rudimentary uses such as daily attendance and low level knowledge assessments with multiple choice questions. Currently, “more detailed research is needed to determine why specific benefits and challenges influence the use of ARSs” (Kay & LeSage, 2009). Attitudes toward audience response systems have been measured often and have been found to be favorable as to their use in classrooms (Files & Marshall, 2006; Kay & LeSage, 2009; Roschelle, Penuel, & Abrahamson, 2004). How are such devices useful in learning?

Benefits of ARS

What are some of the benefits that accompany using an ARS in the classroom? According to many of the professionals who are studying and using ARS, an increase in attendance can be expected due to the speed and ease of use of clickers (Burnstein & Lederman, 2001; Cue, 1998; Greer & Heaney, 2004; Kay & LeSage, 2009; Trees & Jackson, 2007; Wit, 2003). An increase in time spent by the student preparing for class and taking this time seriously also can be expected (Burnstein & Lederman, 2001; Caldwell, 2007; Freeman et al., 2007; Graham, Tripp, Seawright, & Joeckel (III), 2007; Mazur, 1997). Last but not least, so long as ARSs are used to promote active discussion and learning, an increase in quiz and examination scores can be expected (Freeman, et al., 2007; Gier & Kreiner, 2009; Hake, 1998; Morling, McAuliffe, Cohen, & DiLorenzo, 2008; Poirier & Feldman, 2007). With benefits such as these, it is surprising that clickers are not more prevalent in education. Questions about the efficacy of clickers in the classroom remain to be answered such as “Is there a learning benefit to a student who possesses a clicker over one that doesn't?”

This study makes an effort to examine whether a student’s attention or engagement is increased by possession of an ARS. It also utilized ARSs to gather all research data. The research from which the idea for this investigation derived (Woelk, 2008) suggests that attention is increased by possession of a clicker (over those who do not possess a clicker) as possession of a clicker creates or sets up a situation where students will be anticipating interacting with the instructor through the ARS. This anticipation of being required to answer a question is what is assumed to increase the student’s attention and thus their performance in the classroom.

Origin of the problem

In *Optimizing the Use of Personal Response Devices (Clickers) in Large-Enrollment Introductory Courses*, Klaus Woelk’s (2008) related delivering a workshop describing the benefits of clickers:

> “…conducted a test addressing the engagement of an audience that consisted of faculty, staff, and graduate students. Exactly half the audience was handed a clicker for a live test. After exemplarily introducing some very simple chemical nomenclature, an “I learn”-type question resulted in 88% correct results. Pretending to strive for improving the learning experience, the author repeated explaining the nomenclature. Right before polling another question, (the question

chosen was almost identical to the first), the members of the audience holding on to a clicker were asked to pass it to those that did not have one. The result was a disappointing 56% of correct answers, although the subject matter had been explained twice. Because the audience members of the second poll did not anticipate the test, their engagement level was significantly lower. The test remarkably demonstrated the well-known effect that the expectation to be quizzed will lead to improved engagement" (Woelk, 2008).

Here Woelk assumes that the lack of expectation to be assessed, implied by not having a clicker, leads to a decreased level of engagement. Meanwhile, participants who have a clicker are assumed to have a higher level of engagement because they assume they will have to answer a question utilizing a clicker. Does the possession of a clicker increase student engagement relative to students who do not possess a clicker? What are the advantages and disadvantages of using ARS to collect research data? These questions were the focus of this research.

Research Hypotheses

H_o: There will be no difference in performance between students who possess an audience response system and expect to be tested from those who do not possess an ARS.

H_1: There will be a significant performance difference between students who possess an audience response system and expect to be tested from those who do not possess an ARS.

Research Question

What are the advantages and disadvantages of using ARS to collect research data?

Chapter 2: Review of the Literature

Historical Overview of ARS

The first audience response systems (ARSs) were developed in the 1950s when the United States Air Force used an electronic device to train personnel employing multiple choice questions which were integrated into training films (Judson & Sawada, 2006). In the 1960s, two more ARSs were built and installed in lecture halls at Stanford University (1966) and another at Cornell University (1968) (Abrahamson, 2006). According to Abrahamson (2006), "there are also descriptions of German and Japanese patents about the same time period, but it is not known if working versions of the systems were ever built.” The earlier ARSs didn't seem to be very effective as the "technological difficulty of implementing such systems in the pre-microprocessor, pre-network age can be inferred from verbal reports of early users of the Stanford system who said it either “never worked,” or “was a total pain to use” (Abrahamson, 2006). These devices appeared to be analog driven in design with various dials and gauges for recording student responses along with some form of wired box with buttons or dials for transmitting student responses to the instructors work platform as shown in Figures 2.1, 2.2, and 2.3 (Judson & Sawada, 2006).

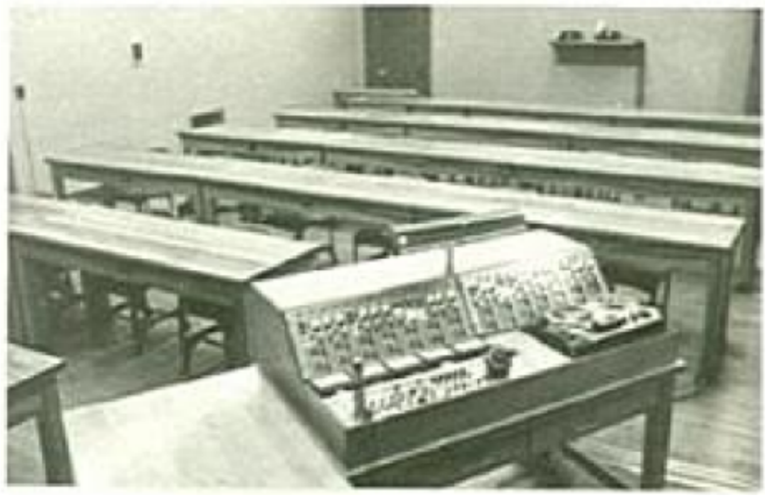

Figure 2. 1 - An ARS classroom from the instructors point of view with gauges and dials along with a reel to reel tape recorder and projectors in the back

Figure 2. 3 - Close-up of the instructor panel with gauges showing the percentage responding to each choice

Figure 2. 2 - A row of ARS stations for student input

The effectiveness of the systems seemed to depend upon how well the systems worked and how efficient the instructor was at interpreting the results from the instructor panels. The military's tests seemed to go well because they “state that in every one of these early test cases student attitudes towards use of response systems in university lectures was uniformly positive" (Bapst, 1971; Brown, 1972; Casanova, 1971; Garg, 1975; Littauer, 1972 as cited by Abrahamson, 2006). While both the teachers and students liked using the systems, early results from Bapst (1971), Bessler (1969), Bessler and Nisbet (1971), Brown (1972), and Casanova (1971) as cited by Abrahamson 2006, showed "no gains in student achievement from the use of response systems."

These lacks of gain can be traced back to their use which was largely to maintain a tailored pace by the instructor who would ask a multiple-choice question after lecturing on a subject or topic. If enough responses were positive, they would continue on to new material. If students did not understand the material, the instructor repeated the lecture material to the students (Judson & Sawada, 2006). Judson and Sawada (2006) equated this to an ineffectual use of technology and pedagogy as it is "not unlike a traveler being provided directions repeatedly in a foreign language by an overly helpful Samaritan: Eventually, the traveler will obligingly smile and be on his or her way without a clue of where to go, but the Samaritan will feel satisfied in having completed a good deed." Although the systems created in the 1950s and '60s were technically adequate, the expense of installing these systems (usually supported by grant money) coupled with the lack of pedagogical development associated with these new teaching tools led to a decline of their mention in literature until the 1990s. A few exceptions in education persisted who made unintended but important curricular discoveries in ARS use along with a few people in the business world who wished to utilize the benefits of audience response systems in their meetings.

An example of early ARSs associated with business uses can be relayed from Communications Technology International Incorporated which "has its roots in the very earliest days of the industry. In the late sixties, Bill Simmons retired from IBM where he had been a Director of Planning. At home, he reflected on how unproductive most meetings were and built a system to improve them. He named his brainchild the Consensor and in 1972 applied for a patent which was granted in 1974 (ComTec, 2009). Simmons (1974) described his work during an interview.

The following is a description of the early product along with the history of the company (ComTec, 2009): The Consensor was a system of dials, wires, and three lights (red, yellow, and green). A question was asked verbally, and people would turn their dial anywhere from 0 to 10. If the majority agreed, the green lamp would light. If not, either the yellow or red would. Simmons teamed with a couple of others to form Applied Futures, one of the very first audience response companies. Although business was strong for this fledgling company, the Command and Control management style of the day proved a formidable opponent. Brooks International, a management consulting firm headquartered in northern New Jersey, purchased Applied Futures in 1986. Brooks found the Consensor to be an invaluable tool in getting a quick, accurate "finger on the pulse" of a client organization. In 1988, Mike Lull (then a vice president with Brooks) purchased the Consensor business from Brooks and renamed the company Communications Technology. In 1992, Tom Campione joined ComTec and helped build an industry leading company that has focused on software development for Fleetwood Wireless Audience Response Systems. In 2005, Campione purchased a majority stake in ComTec and along with the rest of today's management team remains committed to providing quality products while retaining an industry leadership role (Simmons, 1974). This suggests uses other than education for which ARS systems can be employed successfully.

According to Abrahamson (2006), in 1985 he along with Fred Hartline and Milton Fabert built a series of wired prototypes they named Classtalk from surplus materials (Atari keypad's, LED displays, etc.) that all culminated in being connected to a teacher's Apple computer. They set up their system in a 200-seat lecture hall at Christopher Newport University where it was to be used to teach. He said they benefited from two lucky accidents. Because they could only afford 64 keypads in the lecture hall, students were forced to use keypads in small groups, a structure that promoted sharing of information within each group. Professor George Webb, Dean at the University, who despite his other duties had been teaching university physics for over 15 years, had an especially strong pedagogical orientation.

Professor Webb had been teaching university physics for so long he enjoyed a sense of security with the subject matter which, along with the new Classtalk system, gave him an opportunity to try out different pedagogical ideas. Although students' talking in classes was generally unacceptable, Professor Webb started to encourage these group discussions and found the students not only seemed to learn more but stayed together in these small groups after class to study. He would also start class or a new subject by, "very carefully choose[ing] a question that had an obvious answer based on everyday non-physicist thinking, but which was invalid. When over 90% of the class chose this answer and found out that they were all wrong, they suddenly became interested and were more than ready to listen" (Abrahamson, 2006). Some of the other commercially available systems, before a resurgence in popularity in the 1990's, were the Spitz Student Response System, the Anonymous Audience Response System, and the Instructoscope which went a little further in providing individual student feedback by lighting a green or red light (Judson & Sawada, 2006).

Resistance to Using ARS

In the late 1980s and very early in the 1990s, there was still much resistance to using audience response systems beyond the expense involved in installing an ARS. Some people said they could get the same response from students allowing them to raise their hand in response to questions (Lasry, 2008). The lack of anonymity due to students looking around (or cheating) is such that only the bravest of students volunteer (Judson & Sawada, 2006; Mazur, 1997; Penuel, Abrahamson, & Roschelle, 2006). Another issue is the students' lack of anonymity called response set (a.k.a., response style or bias) which is the "tendency of some people to answer a large number of items in the same way (usually agreeing) out of laziness or a psychological predisposition" (Neuman, 2003).

Another form of resistance that came around the mid-1980s and was named the "George Orwellian," "1984," or "big brother" effect where teachers would use their power to constantly watch over and intimidate students (Abrahamson, 2006). This idea, it turns out, is self-correcting and tends not to happen since, "in most educational situations, aggressive surveillance poses penalties for the instructor in terms of student attitude, reduced student motivation, and unpleasant classroom atmosphere" (Abrahamson, 2006). It was found that professors who tend to be overly controlling and/or overbearing have low enrollments or large drop rates at the beginning of their classes, and low evaluations at the end of the semester. Researchers at Ohio State University working with high school teachers uncovered a more powerful explanation: "the data itself coming from the system appears to lead teachers to question their pedagogical strategies, and to discover better ways to teach" (Abrahamson, 2006).

Resurgence of ARS

A few more studies examined the effect audience response systems had on academic achievement (Abrahamson, 1998, 2006; Cue, 1998; Hake, 2002; Judson & Sawada, 2006; Mazur, 1997; Penuel, et al., 2006). Specifically, these studies began to examine the effects on student achievement when the ARSs were used to display anonymously student responses, allow and encourage discussion among students, and to share thought processes aloud. In short, these focus on the processes of interactive engagement (IE) and/or active learning utilizing the ARS as a bridge between the instructor and students. Excitement began to build from the positive results they were obtaining and the broad scope of possibilities ARS offered to improve upon educational pedagogy.

According to Abrahamson (2006), after developing the Classtalk II and selling four systems to the new Hong Kong University of Science and Technology, Professor Nelson Cue (a former U.S.A. physics professor) saw the power and limitations of the systems. This prompted Cue to obtain funding from the Hong Kong government to produce a commercially viable form of technology for ARSs. Cue and a colleague paired back the technology by using low-cost wireless television remote control technology and the power of computer projection technology to produce a robust but practical ARS (Judson & Sawada, 2006).

Later, in 1998, Abrahamson and Professor Cue agreed to work together to create "PRS" or the Personal Response System. This system allowed "students [to] check visually, on the overhead screen, to see if their response had been received by the teacher's computer" (Abrahamson, 2006). Additionally, "they decided further to cut the cost of student handheld units by eliminating the handheld screen (which would have been required for login), and building in a unique identifier into each handheld. In this way, each student would automatically be uniquely identified no matter where she or he was located in any classroom. This approach also mandated limiting question types to multiple-choice only" (Abrahamson, 2006). This last decision, while restricting pedagogy, meant that a student need only press a single button to respond to a question in class. These changes allowed a student to buy, own, and carry his or her unit to any classroom where a system was in use and the system would recognize it, and by inference, the student him or herself. Almost all new systems emulate some or all of the groundbreaking changes Professor Cue introduced to ARSs. These changes also resulted in the increased use of ARSs after 2003 (Kay & LeSage, 2009).

Clickers

Contemporary audience response systems go by many names including: audience response system (ARS, most used term), personal response systems (or stations– PRS), classroom response systems (CRS), interactive voting systems (IVS), electronic voting systems (EVS), student response systems (SRS), interactive student response systems (ISRS), group response systems (GRS), group process support systems (GPRS), and the more colloquial term clickers (Cain & Robinson, 2008; Kay & LeSage, 2009). Kay and LeSage's (2009) review of literature referenced no less than 26 different labels and stressed that inconsistent labeling creates a difficulty in staying current with the latest research. The modern ARS generally consist of three elements: a wireless transmitter/receiver or handheld system for the audience (the clicker); a transmitter/receiver system for the lecturer hardwired to a computer (USB or plug-and-play); and software to collect, analyze, and project the responses. The proprietary software may be one package or may consist of many different programs allowing for selection for particular curricular needs. On account of the popularity of Microsoft PowerPoint presentation software, most companies have a plug-in so that questions can be included with PowerPoint presentations.

Due to the limits of line of sight infrared (IR) transmission in large lecture halls, IR technology has been largely replaced with radio frequency (RF) technology. Contemporary wireless ARS devices vary in features. Some have only a few (usually five) buttons/keys for multiple choices with no display screen. Other devices have multiple lines of display and keys capable of answering true false, multiple-choice, numerical answers, and short one word or sentence answers along with storage space for homework assignments (eInstruction, 2009a). Testing is currently being undertaken for an ARS with a full qwerty keyboard which will open up even more avenues when it comes to delivering answers to instructors (SMART, 2010).

Devices equipped with Bluetooth technology allow companies to create software for virtual emulation of clickers (eInstruction, 2009b; SMART, 2010). Thus, a laptop computer, PDA, or mobile smartphone can replace the clicker by using a virtual ARS application (eInstruction, 2009b; SMART, 2010).

Finally, one noteworthy advance is the wireless networking of scientific calculators by Texas Instruments (TI). TI has made it possible for a scientific calculator to take the place of the clicker. The wireless networking device that connects the calculators is called TI-Navigator (TI, 2009a) and allows four calculators to be connected together for graph, equation, or answer receiving/transmission from teachers and students. The latest incarnation (Spring 2010) will remove the four calculator "hub" and allow each calculator to wirelessly connect to the teacher's computer (TI, 2009b) using Bluetooth® technology. In this way a teacher can share student solutions with the class or send equations, questions, or solutions to student calculators. The only drawback is that there appears to be an upper limit of 40 calculators connected at one time.

Clickers as a Tool in Education – What has been done?

Over the past 40 years, ARSs have garnered a positive response from audiences and teachers (Caldwell, 2007; Kay & LeSage, 2009; Lantz, 2010). Due to their transformational qualities (teachers realizing the inadequacy of passive lectures) coupled with the seeming unending lowering of the price of technology, ARS installation has taken place in an ever increasing number of classrooms at all levels of education (Burnstein & Lederman, 2006).

With respect to research, a lack of formal studies regarding clickers along with associated reliability estimates and validity information makes meta-analysis of studies unlikely and restricts meaningful comparisons of studies (Kay & LeSage, 2009). With this type of growing implementation, it is time for researchers to start adding the rigor necessary to show how and why these systems benefit instructors, students and researchers.

Studies are beginning to chart new paths to the potential that ARSs offer in improving both student learning and instructor delivery of pedagogy. With respect to some of the prior work by Roschelle, Penuel, and Abrahamson they have (Abrahamson, 2006),

> "… identified 26 studies in mathematics, chemistry, and the humanities reporting positive outcomes. These range from promoting greater student engagement (16 studies), increasing understanding of complex subject matter (11 studies), increasing interest and enjoyment of class (7 studies), promoting discussion and interactivity (6 studies), helping students gauge their own level of understanding (5 studies), teachers having better awareness of student difficulties (4 studies), extending material to be covered beyond class time (2 studies), improving quality of questions asked (1 study), and overcoming shyness (1 study)."

They also mentioned that, although outcomes were positive, these studies lacked rigor or strong conclusions making it "impossible to draw strong conclusions about the technology's effectiveness" (Abrahamson, 2006).

Files and Marshall's (2006) literature review on ARSs indicates that they are most often used to take attendance, obtain summative assessment data, or collect survey data. Reports generally: (1) address individual rather than small group use of CRS; (2) compare non-CRS supported traditional practice with CRS supported interactive methodologies; (3) rarely describe conditions of use such as purely formative assessment that serves to scaffold instruction; and (4) rarely report on classroom interactions where a CRS is consistently used in complete anonymity (Files & Marshall, 2006). They additionally categorized 24 reports some of which were included in Roschelle, Penuel, and Abrahamson (2004), but took a different approach by categorizing reports by either pedagogical theory or implementation into different areas of undergraduate study.

The pedagogical theories examined were: Peer Instruction (PI) by Mazur, Dufresene et al. (1996), which supported sequence based on Kolb's Experimental Learning Cycle; Stroup et al. who focused on "next generation" functionalities from a socioconstructivist sense and included using new TI-Navigator and PDA technology; and the inclusively defined Classroom Aggregation Technology for Activating and Assessing Learning and Your Students' Thinking" (CATAALYST) by Roschelle et al., (2004). All of these pedagogical strategies benefited from the immediate feedback ARSs generate in the form of a histogram except in the case of the TI-Navigator system where student equations and graphs are additionally collected, displayed, and discussed. Implementations were mainly in the area of physics. Two involved engineering programs and medical groups, and one involved high school mathematics and physical and life science (Files & Marshall, 2006).

Kay and LeSage (2009) undertook a review of 67 peer-reviewed journals "in order to present a more current and representative summary of benefits and challenges experienced when using this new technology." To summarize studies: 64 were performed between 2000 and 2007, with 49 articles published since 2004. Thirty-six studies described data about attitudes while 24 focused on learning. Regarding methodology, 20 of the studies were survey-based, 12 were case studies, 13 offered theoretical analyses**,** 8 presented qualitative data, and the remaining articles provided specific or general reviews of ARSs. The predominant population was undergraduate students (n = 49) in science- or mathematics-based subject areas in relatively large classes (Mean = 308).

Kay and LeSage (2009) also included a useful table (their table 1) regarding three categories of benefits including classroom environment, learning, and assessment. The table is broken into three columns of benefits, descriptions, and evidence. It is reproduced in Appendix A. The classroom environment benefits examined are attendance, attention, anonymity, participation, and engagement. The learning benefits are interaction, discussion, contingent teaching, learning performance, and quality of learning. The assessment benefits are feedback, formative, and comparison. Key outcomes from Kay and LeSage (2009) come mainly in the form of direction for future research in at least four areas.

First, “more detailed research is needed to determine why specific benefits and challenges influence the use of ARS.” Second, “more research is needed on analyzing the impact of specific types of questions on creating student-centered, knowledge-rich learning that builds classroom community.” Third, “the context of ARS use needs to be expanded to include social science subject areas and K-12 classrooms.” Finally, “more research is needed on individual differences in the use of ARSs. Focusing on gender, grade level, age, and learning style would be a viable starting point.”

This literature review along with the others helps to emphasize the use of ARS technology in the physical sciences and in particular physics. These reviews also stress that more in-depth research needs to be done into how and when ARS can add to a learning environment (Abrahamson, 2006; Files & Marshall, 2006; Kay & LeSage, 2009; Penuel, et al., 2006; Simpson & Oliver, 2002). It appears that research in the area of clickers will offer an abundance of opportunities in the future.

Clickers – What needs to be examined

According to Roschelle et al., (2004), there are gaps "in systematically measuring and understanding how teaching and learning unfolds in these kinds of networked classrooms." The authors go on to say the contribution of specific pedagogical elements have not been systematically measured and that some of the more dominant theories and ideas about how instruction in higher education with audience response systems unfolds does not adequately capture the range of experiences reported by practitioners. According to Files and Marshall (2006), missing from current research are:

1. Tightly controlled comparisons in which the only difference is the use, or lack of use, of a CRS.
2. CRS use in connection with diverse pedagogical approaches:
    a. Group-based methodologies that are combined with group-based CRS use.
    b. Varying degrees of anonymity in response collection.
    c. CRS use for purely formative assessment modalities that scaffold learning.
3. CRS use in connection with diverse populations and content areas:
    a. Same content area, but different populations.
    b. Same population, but different content areas.
4. Finally, it is of particular note that the current literature base contains conflicting reports of the efficacy of using CRSs in individual mode versus group mode. Given the emphasis on collaborative work in the National Science Education Standards and elsewhere, the effects of group mode use merit further study.

Chapter 3 – Methods and Procedures

The result reported by Woelk (2008) implied that having a clicker might affect the attention one paid to instruction based upon whether the same assessment was likely to be made. In other words, having a clicker impacted the attention paid to instruction. This series of replicated experiments sought to determine whether the outcome reported from a training workshop would be similar for actual college classrooms.

Population and Samples

This study was undertaken at a rural Nebraska liberal arts state college in the Midwest with testing limited to undergraduate baccalaureate students. Average student demographics for the college (full-time and part-time) for years 2004-2006 are as follows:

Table 3. 1

Average Undergraduate Population	2245
Gender	%
Percentage Male	42
Percentage Female	58
Age	%
Percentage Age, 24 and under	72
Percentage Age, 25 and older	28
Race	%
Nonresident Alien	1
Black, non-Hispanic	1
American Indian/Alaska Native	2
Asian/Pacific Islander	1
Hispanic	3
White, non-Hispanic	84
Race/ethnicity unknown	8

Undergraduate classes in science, mathematics, arts and humanities were studied.

Institutional Review Board Procedures

The author had approval from the Institutional Review Board (IRB) at Chadron State College. Due to the responses of the students never being associated with the name of the student, minimal risk to participants, and the research being carried out in a normal educational setting a waiver for need of consent by individuals was granted by the IRB (see Appendix C).

Classes Utilized and Experiment Procedure

Initially an e-mail was sent out campus wide to recruit volunteer classes for the experiment. A copy of the e-mail message used for this purpose is supplied in Appendix B. Generally an extra e-mail, or two, was necessary for simple clarification of what was needed from each instructor along with communicating a time for the experiment to be scheduled. Classes in the sciences, mathematics, humanities and arts were included.

The participants were regularly enrolled students in classes who happened to attend on the day of this unannounced experiment. Each instructor developed a brief instructional topic of their choice with two similar topic questions. ARSs were distributed randomly to fewer than half of the students attending before the instruction. The instructor announced, "We are making a quick test of these clickers. I'm going to teach xyz, and then ask a question about that." The instruction was presented, after which students with clickers were asked to respond. The instructor presented the question, announced the accepted answer, and then presented the instruction again with a slightly different twist. The instructor then asked a new but very similar topic question. Immediately before asking students to respond, however, the instructor directed students to pass their clickers to students who did not previously have a clicker. The data gathered included responses to the first and then to the second question. After discussion of the second question, the clickers were collected. Individual responses were never connected to a particular student.

There are two groups of data for each class involved in the study. The responses from participants possessing clickers who expected to be tested (before the switch was applied – BS) and responses from participants who did not originally possess a clicker and were not expecting to be tested (after the treatment is applied – AS). Data collected from the first and second questions was in the form of the number of correct answers and number of incorrect answers for both before and after the treatment.

Design Analysis

A primary strength of this rural state college is small class size. Since class sizes N >= 30 are not common at the college, the sample was drawn from approximately eight college courses with class sizes as close to 30 as possible to add validity (strength) to the results. The data gathered include responses to two similar topic questions, one before and one after the desired treatment with responses never connected to a particular individual. Normally a chi-squared goodness of fit test would be used to compare the frequencies of correct to incorrect answers before and after the treatment. Due to small class size and a high probability that frequencies in a cell will be less than or equal to five (a violation of the chi-squared test) Barnard's exact test with $\alpha = 0.05$ was used. Barnard's exact test was chosen because it is more powerful than Fisher's exact test which assumes equal marginal quantities for both rows and columns and is considered too conservative by today's standards (Lydersen, Fagerland, & Laake, 2009; Upton, 1982).

Equipment

The transmitter/receiver and clickers (30) are from eInstruction with the clicker brand being InterwritePRS (eInstruction, 2009a). Each clicker was identifiable by a unique number (hardware) and a student input ID which was filled in with a lettering of A1 to A30 to allow for anonymous collection of data by Interwrite Response software (eInstruction, 2009a). The equipment was easily carried in two suitcases: one for the laptop and the other for clickers. The transmitter/receiver and laptop set up time was approximately five minutes. Data from clickers was gathered using a laptop prepared prior to the experiment and operated by the primary investigator.

Chapter 4 - Data Analysis and Results

The software package used to calculate Barnard's exact test was StatXact 9 (Cytel, 2010). The 2x2 data collected for each class in the experiment appears in Table 3.2. Each grouping of frequencies has been named by class starting at class1 and ending at class8. Class0 represents frequencies from Woelk's original experiment (Woelk, 2010) while class1 through class8 represents this experimental data and statistical results. Data were obtained form one other class, but there was a clear violation of the protocol such that the data from that class were not included in the analysis.

According to Woelk's experiment that inspired this study, before having the participants exchange clickers (the treatment) he had explained a topic and asked a question to which 88% of the participants had answered correctly and 12% incorrectly. This translates to 28 correct and four incorrect answers out of 32 participants. Then Woelk gave further instructions on the same topic and asked another question but before having the students reply he asked participants to hand their clickers to someone who had not answered a question to determine if the other half of the class understood the topic. Results showed only 56% correct to 44% incorrect which translates to 18 correct and 14 incorrect answers out of 32 participants. As can be seen from table 3.2 below, class0 from Woelk's workshop provided a significant result of $p = 0.0118$; there is evidence that the switch created an effect.

Table 3. 2 Results		Observed Values		Percentages		Barnard's
Classes		Correct	Incorrect	Correct	Incorrect	2 tail
0 Woelk	BS	28	4	88	12	0.0118
	AS	18	14	56	44	
1	BS	4	8	33	67	0.2789
	AS	7	5	58	42	
2	BS	3	5	38	63	0.8036
	AS	4	4	50	50	
3	BS	6	4	60	40	0.7766
	AS	7	3	70	30	
4	BS	4	1	80	20	0.5156
	AS	5	0	100	0	
5	BS	9	3	75	25	1.0000
	AS	9	3	75	25	
6	BS	4	7	36	64	0.7785
	AS	3	8	27	73	
7	BS	9	3	75	25	0.1259
	AS	5	7	42	58	
8	BS	12	2	86	14	0.7442
	AS	11	3	79	21	
	BS = Before Switch AS = After Switch					

Results show (see Table 3.2) that all eight classes that participated in the experiment had non-significant results.

Results Using ARS to Collect Data

Advantages

Overall, using ARSs to collect research data was a success. The small learning curve to understand and master the software along with the ease of operating the clicker and the large array of data that can be collected from the Interwrite PRS clickers (true/false, multiple choice, matching, numerical and short answer along with the ability to collect homework assignments) makes this device very dynamic when it comes to collecting data. The near instantaneous results and the different formats offered by this software to organize what has been collected, termed "reports" by the software, (includes raw data, percentages right/wrong, breakdown of multiple-choice questions), and a graph of the normal distribution of responses is impressive. In addition, the software offers the ability to export data in spreadsheet format that is compatible with today's typical spreadsheet software packages or as text/comma separated values. Overall, starting with digital data made the process of storage, analyzing, and archiving convenient (data already in the computer), powerful (analyze using clicker software or export to familiar software), and secure (password protected).

Disadvantages

The largest disadvantage to using ARS was carrying the cases around to the different rooms. Another disadvantage came from set up which was short (approximately 5 minutes) and could be compensated for by showing up a little earlier for each class. Although this did not occur in the experiment, the possibility of theft of one of the ARS units is also a possible disadvantage.

Chapter 5 - Conclusions and Implications

Limitations and Recommendations of the Study

It is hard to argue that students weren't paying attention (even though they had no stake in the testing) due to correct answers generally outweighed incorrect answers and proportions of correct and incorrect answers never being significantly different before and after the ARS transfer.

This study examined students at the beginning of class periods (approximately the first 10 to 15 minutes) when their attention level might be highest. Students who had been in class for more than 15 minutes were not studied. It is possible that differences in student engagement might have been detected had they been measured later in the class periods.

It also is possible that the presence of the experimenter had an effect. In these small classrooms, the presence of a visitor is always noticed, and this may have led to atypically high levels of attention

Since the experiment conducted was limited to approximately the first 10 to 15 minutes of class time a good follow-up to the experiment would be to repeat this process at the end of a class to see if a significant difference occurs at that time. This would suggest that clickers have the ability to maintain student attention due to the expectation of being tested at any time throughout a class. Since Woelk's impromptu results were not reproduced here, this may be a better explanation for what occurred in his workshop.

Conclusion

This study sought to determine if there is a significant difference in the attention of students who possess an ARS and expect to be tested from those who do not possess an ARS and do not expect to be tested. To test if the expectation to be tested is responsible for the significant result Woelk's original experiment was recreated with testing taking place at the beginning of class when attention levels are at their highest. Once the treatment was applied to students who were not expecting to be polled an examination of the data using Bernard's exact test resulted in no significant difference in all eight of the classes examined (excluding the one class that violated test protocol). According to the original experiment, since the second group of students didn't expect to be tested their results should be significantly different from the first group. This effect was not evident at any point throughout the experiment. What was found is that both the expectation to be tested and attention level of the second group was typically on par with results from the first group. These results speak very clearly and singly by showing that generally all students at the beginning of a class are paying attention whether or not they expect to be tested over the topic being discussed.

Further Study

The class sizes at the study institution were small. Large classes, especially ones where students are more likely to perceive themselves as anonymous, might yield different results with respect to attention. Also, large classes in first-year subjects might also be different.

The Woelk report dealt with a workshop environment where the participants had nothing at stake in learning the content. Repeating this experiment in workshop settings might reveal that inattention was the result of the learner's goals. A different way to test this might involve conducting some workshops in which the tested content was discipline related (more likely to duplicate Woelk's outcome) versus ones in which the tested content related to research on clickers (less likely to duplicate Woelk's outcome because of workshop participant interest).

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Appendix A: Benefits of using ARS from Kay and LeSage (2009)

Benefit	Description	Evidence
Classroom Environment Benefits		
Attendance	Students go to class more	Burnstein and Lederman (2001), Caldwell (2007), and Greer and Heaney (2004)
Attention	Students are more focused in class	Bergtrom (2006), Burnstein and Lederman (2001), Caldwell (2007), d'lnverno et al. (2003), Draper and Brown (2004), Elliott (2003), Jackson et al. (2005), Jones et al. (2001), Latessa and Mouw (2005), Siau et al. (2006), and Slain et al. (2004)
Anonymity	All students participate anonymously	Caldwell (2007), Draper and Brown (2004), Jones et al. (2001), Siau et al. (2006), Simpson and Oliver (2007), and Stuart et al. (2004)
Participation	Students participate with peers more in class to solve problems	Bullock et al. (2002), Caldwell (2007), Draper and Brown (2004), Greer and Heaney (2004), Jones et al. (2001), Siau et al. (2006), Stuart et al. (2004), Uhari et al. (2003), and Van Dijk et al. (2001)
Engagement	Students are more engaged in class	Bergtrom (2006), Caldwell (2007), Draper and Brown (2004), Latessa and Mouw (2005), Preszler et al. (2007), Siau et al. (2006), and Simpson and Oliver (2007)
Learning benefits		
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, Khachan, Chan, and O'Byrne (2005), Siau et al. (2006), Slain et al. (2004), Stuart et al. (2004), Trees and Jackson (2007), and Van Dijk et al. (2001)
Discussion	Students actively discuss misconceptions to build knowledge	Beatty (2004), Brewer (2004), Draper and Brown (2004), Jones et al. (2001), and Nicol and Boyle (2003)
Contingent teaching	Instruction can be modified based on feedback from students	Brewer (2004), Caldwell (2007), Cutts (2006), Draper and Brown (2004), Elliott (2003), Greer and Heaney (2004), Hinde and Hunt (2006), Jackson et al. (2005), Kennedy and Cutts (2005), Poulis et al. (1998) and Stuart et al. (2004)
Learning performance	Learning performance increases as a results of using ARS	Bullock et al. (2002), El-Rady (2006), Fagan et al. (2002), Kaleta and Joosten (2007), Kennedy and Cutts

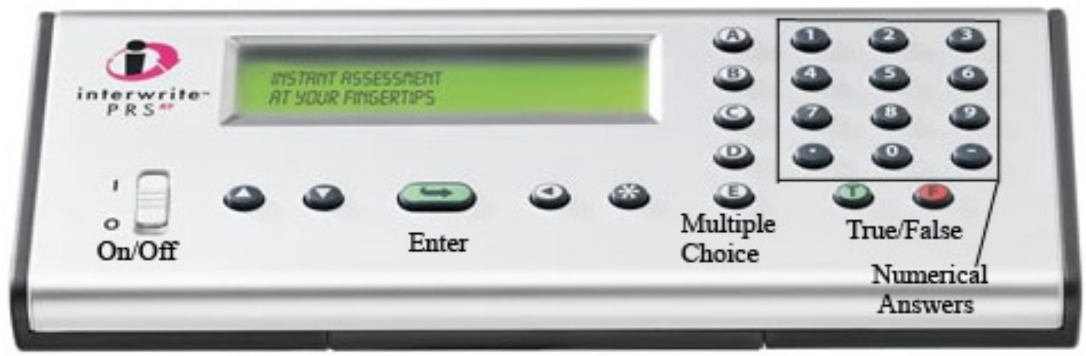
		(2005), Pradhan et al. (2005), Preszler et al. (2007), Schackow et al. (2004), and Slain et al. (2004)
Quality of learning	Qualitative difference when learning with ARS (e.g., better explanations, thinking about important concepts, resolving misconceptions)	Caldwell (2007), d'lnverno et al. (2003), Draper and Brown (2004), Elliott (2003), Greer and Heaney (2004), and Nicol and Boyle (2003)
Assessment benefits		
Feedback	Students and teacher like getting regular feedback on understanding	Abrahamson (2006), Cline (2006), Draper et al. (2002), McCabe (2006), and Pelton and 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 and Brown (2004), Dufresne and Gerace (2004), Elliott (2003), Greer and Heaney (2004), Hatch et al. (2005), Jackson et al. (2005), Siau et al. (2006), Simpson and Oliver (2007), and Stuart et al. (2004)
Compare	Students compare their ARS responses to class responses	Burton (2006), Caldwell (2007), Draper and Brown (2004), Hinde and Hunt (2006), and Simpson and Oliver (2007)

Appendix B: Email sent to faculty requesting study participation

To: Campus Faculty
Subject: Hi Guys - I need help please

I believe my first email was a bit too long and possibly confusing so I'm going to simplify.

I'm doing my dissertation research on Personal Response Systems (PRS - Clickers)



I would like to come to **your CLASSROOM** and gather some data for my dissertation using these devices – your benefit would be seeing them in action.

The Study:

I hand out clickers to a random group of students at beginning of class and give a short how-to on using the PRS (Turn it on, join class by pressing enter, then enter your answers when asked – very simple)

1. **Whatever you are lecturing on** I would like you to make **TWO QUESTIONS TOTAL** on that topic. Multiple choice or numerical answers preferred.
2. You lecture for a few minutes – ask them a question to see if they have absorbed what you've said.
3. I collect the answers and show you how many got it right vs. other answers.
4. You lecture for a few more minutes on your topic – ask them another question on your topic. **Right before they answer I will apply the treatment**.
5. I collect the answers and show you how many got it right vs. other answers.

<u>Done in about 10 minutes</u> – real time feedback with your students.

Let me know a day and time and I'll fit my schedule to suite your needs.

You can either send me the two questions prior to class so I can place them into a PowerPoint/PRS format to be projected (a mediated room will be necessary) or they can be sequentially displayed in class on paper, an Elmo, or chalkboard – whichever is easiest for you.

PS: If you would like I can show up a bit early and show you some of its other features – of course it does quizzes/examinations only there is no Scantron to pay for and the software gives wonderful reports by class/student/etc. for assessment. It also can store up to 3 homework assignments of 30 questions each to be handed in at your convenience. For example they can hand in an assignment and the software instantly grades it – you go over the assignment instantly with your class – more fast feedback. This PRS accepts multiple choice, T/F, numerical answers, and short word answers – the limit is 11 characters.

Please, if you can help me I would greatly appreciate it – the bigger the classes the better starting at 20 students.

Thank You Very Much,

Roger Kendrick
Chadron State College
1000 Main Street
Chadron, NE 69337
kendrickcsc@msn.com or rkendrick@csc.edu

Appendix C: IRB Approval

CHADRON STATE COLLEGE

January 21, 2008

Mr. Roger Kendrick
Instructor of Physics
Chadron State College

Dear Mr. Kendrick:

Based upon your original application to the Institutional Review Board entitled "Lectures and Student Engagement," it is my judgment that your research protocol satisfies the requirements of the Board's exempt review. I understand that this research will be used as part of your doctoral dissertation. In that regard, please use 261611 for your assigned IRB number.

Sincerely,

Lois Veath
Vice President for Academic Affairs

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