DISSERTATION

A MULTIPLE CASE STUDY OF INSTRUCTORS UTILIZING CLASSROOM RESPONSE SYSTEMS (CRS) TO ACHIEVE PEDAGOGICAL GOALS

Submitted by

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ABSTRACT

A MULTIPLE CASE STUDY OF INSTRUCTORS UTILIZING CLASSROOM RESPONSE SYSTEMS (CRS) TO ACHIEVE PEDAGOGICAL GOALS

This study examined five instructors who have employed Classroom Response Systems (CRS) for a minimum of five years. Instructors were asked their initial pedagogical goals when adopting CRS, and also to describe any changes in those goals or use of the technology since that time. Emerging themes were identified using a multiple case study methodology.

All instructors said their use of CRS evolved and changed from initial adoption to their current use of the technology today. Student engagement was the single ubiquitous reason provided for choosing to employ CRS. Other potential reason for using CRS include: peer instruction via group and cooperative learning, increasing student responsibility, reducing lecture while increasing interaction, employing deep learning pedagogy, redistributing classroom power back to students, increasing student achievement, and making classroom learning more enjoyable.

No single technique appeared to be required to benefit from the use of CRS. Instructors described an assortment of practices they found personally successful in a variety of classroom sizes. Some even chose to utilize the same pedagogical techniques as if they were using CRS, but purposefully eschewed the devices because they found them too constraining for the desired learning outcome. This indicates that the teaching methodology was more important that the technology. CRS seems to be suitable for performing a variety of pedagogical tasks, even if it is not the ideal way to achieve any single one. Based on this research, it appears the greatest

strength of CRS is that it can proficiently accomplish a multitude of learning goals in a relatively easy manner.

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DEDICATION

For all my students, past, present, and future:

They say that learning is a journey, so let's take a walk together.

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Chapter 1

INTRODUCTION

> "Today, at almost every university in the USA, somewhere a faculty member in at least one discipline is using a [Classroom Response System] in their teaching. Amazingly, these generally somewhat primitive tools are used in just about every discipline taught. Arguably, not since the overhead projector, has a piece of technology received such widespread acceptance as an aid to classroom teaching" (Abrahamson, 2006, p. 2)

From the abacus to the calculator to today's modern smart phones and tablet personal computers, technology has long been utilized in the classroom in an attempt to enhance student learning. George (2000) reported classroom technology can help promote inventive approaches to both teaching and learning, which in turn may lead to better student performance. However, adopting and utilizing classroom technology does not always lead to these scholastic benefits. Olgren (2000) indicates the usefulness of any educational tool lies in its ability to increase student learning.

> "Using technology for education and training offers many challenges, but perhaps the greatest is to focus not on the technology itself but on the learner and learning. Technology invites a tools-first emphasis, but technology is only as good as our knowledge of how to use it to enhance learning" (p. 7).

Research indicates learners appear to be well aware of how technology should be utilized to achieve pedagogical aims. Draper and Brown (2004), reported students gave an overall negative reaction to classroom technology when they believed it was being used primarily for its own sake. As one student in their study expressed, "[The] main focus of lecture seems to be on [technology] use and not on course content" (p. 86).

One such educational technology gaining widespread use in colleges and universities is the Classroom Response Systems (CRS). CSR technology allows students to anonymously

"vote" or provide answers to questions asked in a classroom. A CRS consists of handset response devices (similar in shape and size to a television remote control) that transmit signals to a receiver base. Each student in the classroom has a handset, with most schools requiring students to buy their own CRS devices. Instructors have access to a receiver base (often times purchased and provided by the school), which plugs into a computer. Utilizing proprietary CRS software, this base receives the transmitted signals from each handset, and is also capable of compiling and displaying student responses in real-time. In the classroom, each student response is anonymous and displayed as a single tally. Each handset has a unique code which students must "register" to link their names to an individual device. Additionally, the CRS software keeps a record of all responses and instructors can use this data to award points for either participation, for answering questions correctly, or a combination of both.

Extensive research into CRS use provides many reasons for the adoption of this technology, including: anonymous student responses (Caldwell, 2007; Wit, 2003; W. Wood, 2004), peer instruction (Boyle & Nicole, 2003; Caldwell, 2007; Cue, 1998; Wit, 2003), improved attendance (Burnstein & Lederman, 2001; Caldwell, 2007; Cue, 1998; Miller, Milholland, & Gould, 2012; Nelson & Hauck, 2008; Wit, 2003), increased student engagement (Beatty, Gerace, Leonard, & Dufresne, 2006; Caldwell, 2007; Cue, 1998; W. Wood, 2004), potential student achievement gains (Caldwell, 2007; Poulis, Massen, Robens, & Gilbert, 1998), and promoting active learning (Beekes, 2006; Caldwell, 2007; Cue, 1998; Nelson & Hauck, 2008).

While all of these potential benefits will be explored in further detail in the Literature Review for this study, perhaps the most important reason for utilizing CRS is the unique opportunity the technology provides for immediate feedback and contingent teaching. When utilizing CRS, instructors can ask a question in the classroom and within seconds gain feedback

regarding student comprehension. Additionally, as Keough (2012) writes, "Unlike traditional question/answer sessions where only one or two students have the opportunity to voice an answer, every student in the class can answer the question" (p. 3). If class responses indicate comprehension, the instructor moves on to the next topic with the knowledge their students understand what is being taught. However, if students indicate a lack of understanding, instructors can then take the time to addresses these issues. Thus, the pace and type of information presented in class is contingent upon student learning, which allows for a more specialized learning environment. There are times this leads to prolonged topic backtracking, which can extend the proposed teaching schedule. However, the opposite can also occur where less time is spent on topics that students already understand.

Problem Statement

To date, much of the research on CRS focused on two aspects. The first is the potential benefits of the technology, which include, but are not limited to, those topics listed above (Beatty, 2004; Beatty & Gerace, 2009; Beekes, 2006; Boyle & Nicole, 2003; Caldwell, 2007; Draper & Brown, 2004; Miller et al., 2012; Nelson & Hauck, 2008; Poulis et al., 1998; Wit, 2003; W. Wood, 2004). Researchers have attempted to demonstrate the effectiveness of CRS use, in essence promoting their worth as a pedagogical tool. The second research focal point has been on student opinions of the technology. In these studies, students self-reported that CRS helped them learn more, prepared them more thoroughly for exams, and helped them remember more lecture material (Nelson & Hauck, 2008). Bunce, VandenPlas, and Havanki (2006) reported over two-thirds of students responded they "enjoyed the [CRS] questions," and 71% said "The [CRS] questions helped me learn the material covered in class" (p. 491). My own thesis research investigated hospitality students' perceptions of the technology. In this study,

93% of respondents felt CRS questions helped to reinforce course concepts, 89% reported CRS encouraged them to participate in classroom discussions, 84% recommended using them in other courses in the program, and 77% reported they enjoyed using CRS in the class (Miller et al., 2012).

The question I have not yet seen answered in the literature is in regard to the effectiveness of the technology as it relates to an instructor's personal pedagogical goals. After all, using CRS does not guarantee success, especially when the technology is not aligned with specific educational goals. Some students reported a negative reaction to the devices when they felt the technology was simply being used for its own sake and not for the betterment of the class (Draper & Brown, 2004). Van Dijk, Van Der Berg, and Van Keulen (2001) failed to see an increase in student interaction when utilizing the devices. Other research indicates no improvement in student achievement when using CRS (Bunce et al., 2006; Nelson & Hauck, 2008). On the whole, these studies suggest it is critical to align CRS use with desired instructional outcomes, regardless of what that may be. As Draper and Brown (2004) wrote, "The benefit [for CRS] does not depend simply on the technology but on how well it is used on each occasion to promote, through learner interactivity or contingent teaching or both, thought and reflection in the learners" (p. 93).

Investigating how CRS has been utilized to achieve instructor's pedagogical goals is not a simple task because no single response can accurately and succinctly answer this question. This is because each instructor's perception of CRS effectiveness is largely based upon their expectations for the technology. Furthermore, each instructor has his or her own goals for using the technology, and they alone can answer to the effectiveness of CRS in achieving those goals.

It is the aim of this study to investigate each experienced instructor's goals and also understand the unique way teachers use CRS technology to those ends.

Background of the Study

This proposed study stems from prior research investigating student perceptions of CRS use in the Hospitality Management program at Colorado State University (Milholland, 2010). In this research, study questions were primarily based on student perceptions of how CRS reinforced course concepts and encouraged classroom discussion. Students were also asked if they would recommend using the technology in other classes both in the program and at the university. CRS was initially adopted in this setting with the intent of engendering discussion and facilitating contingent instruction. Based on our observations and also the data from student responses, the technology did indeed lead to achieving these goals.

However, when given the chance to write free-response statements regarding CRS, a number students self-reported that using the devices motivated them to attend class, and the technology also helped make the course fun. Through much discussion over the next few years, the question eventually emerged of instructor perceptions of the technology. While we did see our pedagogical goals of CRS use come to fruition, the student's written free-responses regarding increased motivation to attend and enjoyment of use were unintended benefits. As an instructor, I used this information to shape my decisions regarding CRS in the same class, and also others I have taught. When offered the opportunity to teach additional courses, my decision to incorporate CRS into the teaching material was based, in part, on both these intended and unintended benefits. Through personal reflection, and while pursuing my PhD in education, this eventually led to a desire to conduct further research into the technology. However, this inquiry shifts the focus of the study from students toward instructors.

Research Questions

Two primary questions will guide this inquiry:

1. Did using CRS provide the desired benefits you sought when choosing to adapt the technology?

2. How has CRS impacted your classroom preparation or teaching style since you adopted the technology?

Definition of Terms

Classroom Response System: Abbreviated as CRS. Handheld devices used to answer instructor questions. They send electronic signals to a hardware receiver which is connected to a computer. Other interchangeable terms for this type of technology are Student Response System (SRS), Audience Response System (ARS), and Clickers.

Receiver Base: Hardware capable of receiving signals from individual CRS devices. This plugs into a Universal Serial Bus (USB) port of a computer, and each receive base has a unique identifier so it can only receive specific signals. These unique signals are usually in the form or a multi-letter code that students enter into their handheld devices when first powered on. The unique identifier allows for multiple receivers in the same general area to only accept signals from specific handsets, meaning instructors in neighboring room can use the technology without receiving signals from devices outside of their classroom.

CRS Software: Computer program developed by the CRS manufacturer that allows the receiver base to communicate with the computer. Each handset has a specific code that it transmits to the receiver base. This software help to link these codes with the students enrolled in the course, which allows the instructor to award points for using the technology. The software also allows the students to see the result of classroom voting while still keeping individual votes anonymous.

Researcher Perspective and Ethics

My interest in CRS is rooted in my personal experience as an instructor

Having adopted the technology in nearly all the classes I taught, it is critical that I am forthright with my opinions of the technology

I am a Proponent of Using CRS

I freely admit I have a personal bias toward CRS, and have even earned a reputation as "the clicker guy" in many of my Ph.D. classes since I often used them as the basis for research assignments. I have advocated their use in many conversations with both faculty and students. During these conversations, most people expressed they were either *for* or *against* the technology. When I heard a person express their dislike for CRS, I was compelled to ask why they felt this way. For instance, one graduate student told me she "hated" CRS because her instructor only utilized them for attendance by asking a single question at both the beginning and end of class. As a graduate student, she resented being "babysat" and felt this was far below the respect she earned by being accepted into a masters-level university program. In talking to instructors who implemented CRS into their curriculum, I heard from multiple sources that using the technology was "a pain" because they found themselves behind schedule compared to prior semesters.

Over time, my interpretation of these negative reactions toward CRS led me to conclude the majority of my conversations with people who disliked the devices were opposed to the methodology as opposed to the specific technology. In both examples above, I understood why these people expressed their dislike. I completely agreed with the angry reaction of the graduate student, because I would feel personally insulted if I had my attendance monitored anytime during my last seven years of graduate classes. I also understood the frustration of the

instructors who were teaching their classes for a number of semesters and had the timing of the course exactly the way they wanted. It must have been frustrating to introduce a device that would interrupt the normal flow of lecture, leading to a disruption of their well-established rhythm. Additionally, when students answer a question incorrectly, they immediately want to know why the answer is wrong. This typically leads to more explanation and discussion, which further slows the pace of the instruction.

Chapter 2

REVIEW OF THE LITERATURE

To better understand the origins of this study, it is critical to review the literature regarding CRS. This review includes benefits of CRS use, learning theories linked to the device, and teaching methodologies that can enhance using this technology.

Potential Benefits of Using CRS

A multitude of research has been conducted regarding CRS and the benefits of its adoption in the classroom. There are many reasons why researchers and instructors alike have promoted adoption of this technology, including: increasing active engagement to promote learning, encouraging classroom discussion, utilizing peer instruction techniques, students can respond to questions anonymously, increased student attendance, and potential student achievement gains.

Increasing Active Engagement to Promote Learning

Research indicates CRS can promote active learning when it is utilized with specific instructional methodologies designed to engender engagement. Instructors reported a substantial increase in student participation with the introduction of CRS, especially compared to prior years (Beekes, 2006; Burnstein & Lederman, 2001). Another instructor was quoted as saying, "In my experience there is nothing that engenders discussion in a large class to the same extent" (Lindenfeld, 2001, p. 82). Furthermore, a comparison of CRS implementation studies showed that one of the most prevalent findings reported by instructors adopting the technology was "increased student engagement and participation" (Fies & Marshall, 2006). This increase in engagement is probably due to students actively participating in the course by using their CRS

devices. But, this change might also be attributed to a change in student attitudes brought about by using the technology. Trees and Jackson (2007) found that a majority of students agreed with the statements, "The use of clickers in this class has made me feel less anonymous" and "Clicker questions encouraged me to be more engaged in the classroom process." Perhaps their increase in active participation is correlated to this decreased feeling of anonymity. As Trees and Jackson (2007) wrote, this aspect of their research, "may have tapped into an internal motivation to come to class created by interesting and engaging active learning practices" (p. 36).

It should be noted the use of CRS technology does not inherently guarantee these benefits in the classroom. In fact, promoting active learning involves very deliberate pedagogical choices by the instructor. "[The] activities must be designed around important learning outcomes and promote thoughtful engagement on the part of the student. Adopting instructional practices that engage students in the learning process is the defining feature of active learning" (Prince, 2004, p. 226). To that end, Hake (1998) showed interactive engagement was twice as effective in promoting learning and understanding of course concepts when compared to traditional teaching method. Laws, Sokoloff, and Thornton (1999) indicated active learning techniques led to a three-fold increase in the number of students understanding a concept compared to traditional instruction. When compared to lecture-based instruction, students who learned concepts while interacting with faculty and peers were more likely to retain and then apply that information in other contexts (Handelsman et al., 2004).

Anonymous Responses

CRS works by recording individual student answers, but only the instructor can see each particular response. In the classroom, each individual answer is displayed as a single, unidentifiable vote which can then be displayed to the students as a histogram (Figure 1).

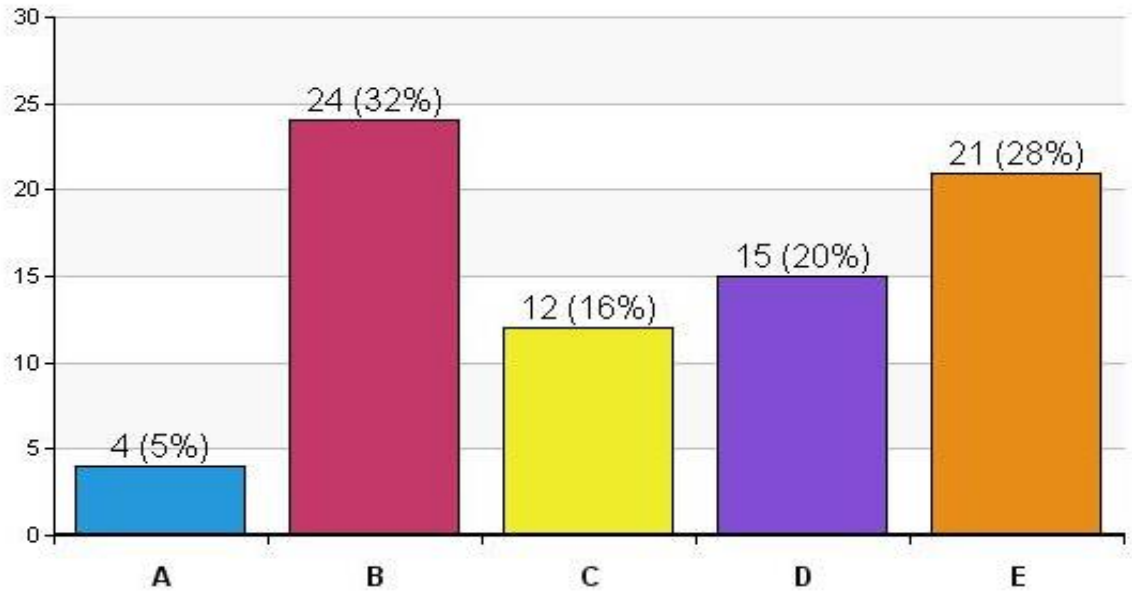

Figure 1: Example of Student CRS Responses as Displayed in the Classroom

The ability of students to respond anonymously helps address the issue of those learners who are hesitant to answer questions verbally or by show of hand for fear of social reprisal for an incorrect response (Beekes, 2006; Poulis et al., 1998; W. Wood, 2004). Many researchers reported one of the critical components of the technology was the ability to record student responses while still protecting individual anonymity (Davis, 2003; Fies & Marshall, 2006; Nicol & Boyle, 2003). CRS can also serve as a pedagogical "enabler" by both providing a voice for those hesitant to respond in lecture (Draper & Brown, 2004), and also helping to limit the impact of vocal students who tend to dominate classroom conversations (Davis, 2003; Fies & Marshall, 2006). In multiple studies, students reported personal anonymity as a key reason they liked the technology (Draper & Brown, 2004; Keough, 2012; Nelson & Hauck, 2008; Trees & Jackson, 2007). In another study, students responded they were 76% more likely to respond to a question with CRS than by raising their hand (Robinson & Ritzko, 2006).

Furthermore, Draper and Brown (2004) propose that because individual CRS answers are anonymous, this actually *encourages* students to pick an answer, even when they were unsure their selection is correct. Additionally, once students select an answer they tend to become emotionally invested in the question. Because the chosen answer is now 'theirs' the learner is more likely to pay attention to the solution and any discussion or explanation that follows (Beatty, 2004; Beatty & Gerace, 2009; Wit, 2003).

Classroom Discussion

There are many learning theories which postulate that social interactions are a key component in learning. These include: Vygotsky's (1978, 1986) social development theory, Bandura's (2012a, 2012b) social cognitive theory , Mezirow's (2000) transformational learning and Boyatzis' (2006) intentional change theory. In reflecting on the commonalities of these theories, Slavich and Zimbardo (2012) wrote:

> Students must engage in collaborative, interdependent problem solving and discussion to achieve meaningful, sustainable changes in their attitudes and behaviors. Therefore, the overall vision for the classroom is not one of a competitive playing field, but rather of a collaborative idea lab, filled with questions such as: What do we know? What do we wish we knew? How do we work together to acquire that knowledge? And, how will that knowledge move us forward? (p. 586)

To that end, Duschl (2003) believes that one of the teaching strategies that is critical to engaging learners is to compare and contrast students' responses by both recognizing and then conversing about differing ideas. CRS has long been utilized to promote exactly this type of discourse. In a review of 26 research articles on CRS, 7 mentioned heightened discussion and class interactivity when using the technology (Roschelle, Abrahamson, & Penuel, 2004; Roschelle, Penuel, & Abrahamson, 2004).

In our previous research (Miller et al., 2012), nearly 89% of students agreed with the statement "Using the [CRS] encouraged me to participate in classroom discussions."

Additionally, 89% said class discussions reinforced course concepts. This led us to conclude that a vast majority of students in our study felt that using CRS fostered classroom discussion, and this discourse was helpful in strengthening their understanding of course concepts. The student's written comments regarding the technology further these ideas.

- "I feel that [CRS] in the class increase vocal class participation."
- "[CRS] questions were great! It thoroughly helped my understanding of subjects and encouraged me to engage in discussion."
- "The [CRS] helped me participate."
- "I loved having the [CRS]. It was a great way to stay involved in the learning."
- "The [CRS} was helpful because we figured out the answers on our own and it maintained focus."

In a similar vein, students in one study ranked discussion as the most important aspect of the CRS interaction (Reay, Bao, Pengfei, Warnakulasooriya, & Baugh, 2005). In another study, Wood (2004) realized that just by adding the technology to a traditional lecture, the tenor of the class changed. Wood wrote that using CRS "[made] the students more responsive in general, so that questions posed to the class as a whole during lecture are much more likely to elicit responses and discussion" (p. 798). Another study found that even without an instructor promoting discussion through CRS use, simply displaying the histogram generated by the software (see Figure 1) led to increased student discussion (Mestre, Gerace, Dufresne, & Leonard, 1997).

Peer Instruction

Within some learning theories, there has long been a belief that students gain valuable knowledge from working with their peers (Piaget, 1955; Vygotsky, 1978, 1986). Research seems to bear this out as peer learning methods have been linked to higher exam score and/or

learning gains compared to traditional teaching methods like lecture (Hake, 1998; MacManaway, 1970; Pollock, 2006). While there are many pedagogical methods to encourage peer learning and instruction, Slavich and Zimbardo (2012) believe it is the *process* which is critical for student learning. "Collaborative interdependence is very important for maximizing the likelihood that students will gain valuable skills from each other, including those that are involved in analysis, synthesis, evaluation, reasoning, problem-solving, and communication" (p. 583).

One of the pioneers of peer instruction and peer learning is Dr. Eric Mazur, a physics instructor at Harvard University. In his formative 10-year research on peer instruction, he created a pedagogical technique called *think-pair-share.* In this technique, a course concept is presented and immediately afterwards the students are given a multiple choice question. They are asked to *think* about the question and formulate an answer. Students are then asked to *pair* up and attempt to convince each other of their individual answer. After this dyadic conversation, students are then asked to *share* their answer via CRS (Crouch & Mazur, 2001).

In evaluating the impact of this learning technique, Crouch and Mazur (2001) found that roughly 40% of the class initially had the correct answer and their peer conversation bolstered that response. They also found an average of 32% of students changed their response to the correct answer, while 6% were convinced to change from the correct solution to an incorrect answer. This means that the act of conversing with a classmate lead to nearly double the number of students answering the question correctly (Crouch & Mazur, 2001).

Crouch and Mazur (2001) also saw an increase in test scores correlated to peer instruction. Every student in the physics program took a pre- and post-test to measure learning of important concepts. In the traditional teaching methods courses, the average was an 8% gain.

However, in the peer instruction techniques courses, the gains ranged from 14 – 25%, with an average gain of 19.3% (Crouch & Mazur, 2001). Of note is that these scores increased in each year the tests were administered over a six year span, and five different instructors taught courses in the department using peer instruction techniques. This led the researchers to speculate that the peer instruction techniques most likely had an impact on these results since they could not be attributed to instructor difference alone (Crouch & Mazur, 2001).

Wood (2004) describes a personal classroom experience that illustrates the potential to utilize CRS in conjunction with peer instruction. He had presented a topic in lecture which he believed the students understood. He then asked a CRS question to gauge their subject knowledge, and found approximately 50% had answered the question incorrectly.

> For me, this was a moment of revelation. I was not so much disappointed by the result as elated by the realization that for the first time in over 20 years of lecturing I knew, on the spot (rather than after the next mid-term examination), that over half the class didn't 'get it:' had not understood either the question or my presentation of the phenomenon. Because I had already explained the phenomenon as clearly as I could, I simply asked the students to debate briefly with their neighbors and see who could convince whom about which answer was correct. The class erupted into animated conversation. After a few minutes, I asked for a revote, and now over 90% gave the correct answer. (p. 797)

Even without explicitly using peer instruction techniques, student reported many benefits to using CRS in the classroom setting. Some learners enjoyed being able to compare their chosen answer to that of their classmates (Bunce et al., 2006; Draper & Brown, 2004; Nelson & Hauck, 2008). Several found it reassuring to see other students had also answered a question incorrectly because they now understood they weren't the only person who didn't yet grasp a course concept (Beatty, 2004; Draper & Brown, 2004). Students reported CRS use presented a chance to discuss answers and course topics with classmates (Beatty, 2004; Boyle & Nicole, 2003; Bunce et al., 2006; Caldwell, 2007; Draper & Brown, 2004; Wit, 2003), and sometimes

simply hearing the rational of other learners helped clarify their own reasoning (Beatty, 2004). When asked why this may occur, students indicated their peers can help clear up misconceptions because they "speak the same language" and "can explain it in sort of easier terms than the lecturer" (Boyle & Nicole, 2003, p. 8).

Cooperative Learning

Another potential benefit of using the technology is cooperative learning in the classroom. The objective of cooperative learning is "students working together, for one class period or several weeks, to accomplish shared learning goals" (Johnson & Johnson, 1999). In their pedagogy-defining work on the subject, Johnson, Johnson, and Smith (1991) describe five basic elements to cooperative learning: (1) positive interdependence, (2) face-to-face promotive interaction, (3) individual accountability and personal responsibility, (4) social skills, and (5) group processing.

Two studies specifically investigated using CRS to promote cooperative learning. Morrison, Caughran, and Sauers (2014) integrated the technology into a 300-seat organic chemistry classes with the hopes of promoting this specific pedagogical technique. Their findings indicated CRS could be effective as a teaching tool if it helped pinpoint student misconceptions in real time. They acknowledged that the large class size and the challenging nature of the course material often made it difficult to identify and address student confusion. However, these instructors concluded that purposeful use of the technology helped achieve their goals. Specifically, "creative development and implementation of CRSs to engage and actively involve students in the learning process successfully transforms the large lecture classroom into a smaller more intimate and responsive learning environment" (Morrison et al., 2014, p. 1843).

A second study investigated student perceptions of three potential cooperative learning techniques: paper-based response, CRS, and Computer-Based Testing. In this research, 73% of students said CRS was their first choice for cooperative learning, citing the technology was "fun," it provided immediate feedback, and it helped learners compare if they shared misconceptions or made similar mistakes as their classmates (Antoun, Nasr, & Zgheib, 2015). It should also be noted that student perceptions of CRS usefulness to achieve cooperative learning can vary. Fujikura et al. (2013) found these perceptions varied throughout the duration of the course, and "the quality of materials in the application phase was key to activating learner motivation" (p. 67).

Improved Attendance

Numerous studies indicated CRS use may increase student attendance (Caldwell, 2007; Cue, 1998; Paschal, 2002; Wit, 2003). In some cases where CRS was also tied with as little as 10% of a student's grade, instructors reported significant increases in student turnout (Burnstein & Lederman, 2001; Caldwell, 2007; Nelson & Hauck, 2008). My own research into student perceptions of CRS revealed similar outcomes. Students reported the use of CRS motivated them to attend, and some even felt rewarded for showing up to class (Miller et al., 2012). In this study, student responses to an open-ended question regarding the technology reflected these findings.

- "The [CRS} motivated me to come to class."
- "I love classes where you are rewarded for coming."
- "[I] really liked the [CRS] because we got points for going to class."
- "I liked earning points for coming to class. It makes it fairer [*sic*]."

Keough's (2012) review of literature related to CRS provides even more insight into student attendance and the technology. After removing the studies where (a) students self-reported attendance and (b) where grades were linked to using the technology, he found that 77.8% of the remaining studies saw a significant increase in student attendance in CRS classrooms compared to their traditional counterparts. This indicates that the technology itself may contribute to an increase in attendance, and not just because CRS use has so frequently been tied to student grades.

Wit (2003) found a somewhat similar result. In this study, the researcher chose to replace one lecture period every other week with an interactive tutorial session utilizing CRS. The course normally met four times per week for one hour each, and the students did not receive any course credit for attending the tutorial sessions. In previous years before using CRS to lead these tutorial sessions, the historical pattern was that 60% of students attended the first tutorial, but fewer and fewer would attend each subsequent meeting, with the final session usually averaging about 10%. When comparing approximate attendance between their current CRS-led tutorials and the previous years without the technology, the instructors found a significant increase for each tutorial session, include a 4-fold attendance increase near the end of the semester (Wit, 2003). While it may be impossible to pinpoint exactly why these increases transpired in this study, the correlation between CRS use and increased attendance is certainly noteworthy.

Potential Achievement Gains

Research has also tried to evaluate the impact of CRS use on student achievement. Caldwell (2007) linked CRS use with an almost two-fold increase in the number of 'A' letter grades achieved in a course. Poulis et al. (1998) attempted to measure the impact of the technology on a pass-fail exam. In their study of nearly 4,400 students, after CRS was

implemented in the course, the number of students passing the exam increased from approximately 54% to 84%. Along with this 30% increase in passing results, Poulis et al. (1998) also reported a much more consistent student achievement level throughout the courses that were studied. Caldwell (2007) also found CRS use correlated with an increase in exam scores in the upper quartile of the course. There were also multiple studies linking CRS to fewer failing grades on either exams or for the overall course. Paschal (2002) reported 1/3 as many students earned 50% or less on exams in CRS classes, and Caldwell (2007) saw 4.7% fewer students fail her courses that utilized the technology.

In Keough's (2012) review of published literature, 34 samples were evaluated investigating CRS and objective performance outcomes, including: quiz and exam scores, final grades, standardizing test results, mean pass rates, and pre- and posttest scores. In 22 of the 34 samples, CRS use was linked to significant achievement in student performance (Keough, 2012). Ten of the 12 remaining samples also saw increases in student achievement, but these were not statistically significant changes. Another study comparing a traditional classroom to low and high CRS use courses (based on frequency of questions) also failed to see a significant difference in mean student course grade across the three conditions (Nelson & Hauck, 2008). However, this study did find a correlation between high CRS use and increased attendance, and an additional correlation between attendance and student course grade. Thus, students in the high use CRS course were more likely to attend, and those who attended did earn significantly higher overall course grades.

Regardless of the study, it is virtually impossible to isolate the exact mechanisms behind these increases in student achievement because CRS utilizes a variety of methodologies concurrently (contingent instruction, peer learning, active engagement, increased attendance).

Rather, researchers of the technology attribute increases in student performance to any and all combinations of using these pedagogical techniques simultaneously (Nelson & Hauck, 2008; Poulis et al., 1998).

Surface and Deep Learning

The idea that CRS can lead to both increased attendance and potential achievement gains raises the question of both why and how they take place. Notwithstanding the exact mechanism behind these findings, it seems the more important question to ask is what is the true benefit to learners? Since nearly every instructor that employs CRS offers a point-based incentive for using the technology, it follows that those who attend more classes will earn more points, which subsequently leads to increased overall course grades. There is also the thought that increased attendance can lead to learning gains, which benefits exam scores, and consequently better course performance. Based on either of these things occurring, a key notion that should be touched upon is surface versus deep learning.

Gordon and Debus (2002) describe surface learning as students doing the least amount of work necessary to achieve minimum requirements. This differs greatly from deep learning, which they describe as a student's desire to comprehend new material through active integration into their existing knowledge base. Put another way, the surface approach is about rote learning, while the deeper approach focuses on understanding (Biggs & Tang, 2011).

These two motivations are vastly different, as is their long-term benefit to the learner. Surface learning is commonly entrenched in many institutions because the standard curriculum tends to lend itself to conformity rather than exploration (Howard, Mitchell, Spennemann, & Webster-Mannison, 2000). Attempting to encourage students to engage in deeper learning can also be problematic because deeper learning is intrinsically motivated, while surface learning

accomplishes what is expected of many students: simply passing an assessment (Marton & Saljo, 1997). However, deeper learning pedagogy was proposed as a method to enhance educational sustainability (Warburton, 2003), and this type of learning would benefit students well beyond the walls of their learning institutions.

CRS and Recommended Pedagogy

There are also a number of publications that recommend certain pedagogical techniques to maximize the effectiveness of CRS. Many authors have postulated the importance on effective question writing as key to successful use of the technology (Beatty, 2004; Beatty & Gerace, 2009; Beatty et al., 2006; Caldwell, 2007; Gier & Kreiner, 2009; Wit, 2003). Others have promoted the use of previously mentioned peer instruction techniques (Boyle & Nicole, 2003; Crouch & Mazur, 2001).

Using CRS does not Guarantee Desired Outcomes

Despite the touted benefits of CRS, their employment does not guarantee desired results in either learning or student achievement. One study found no evidence that utilizing CRS was a predictor of success in university level science classes (Sutherlin, Sutherlin, & Akpanudo, 2013). Instead, student GPA and prior performance were statistically correlated with student achievement. The same research found students could report a favorable attitude toward CRS, but this was not an indicator of improved student achievement (Sutherlin et al., 2013). In a similar vein, Cummings and Hsu (2011) investigated how the technology might impact exam performance. They discovered a positive correlation between increased student scores and CRS use, but only on certain examinations. They were left to wonder whether some course topics might not lend themselves favorably to using the devices. That study also found that over 60% of students believed CRS was beneficial to their learning, but just 38% believed the devices

would help them earn better course grades. For some students, this seems to indicate a disconnect between those two concepts.

Another study indicated that low performing students (with a grade of <70% in the class) did not believe CRS helped their learning or gave them any advantage when it came time for examinations (Addison, Wright, & Milner, 2009). This study also investigated identical courses where the technology was used in just one of the classrooms. The only statistically significant difference in the CRS course was an increase in student achievement limited to those earning exam grades of 91-100%. The remainder of students in the CRS section did not outperform exam scores of the non-adapting course (Addison et al., 2009).

The results of one study seem to fly in the face of the majority of CRS research. Christopherson (2011) attempted to evaluate the true utility of CRS in the classroom. Teaching two different sections of the same course, she chose to utilize the devices in one section, while in the other section she asked identical questions, but relied on students raising their hands or vocally providing answers. In her experiment, she found no statistically significant difference between the mean scores on five separate examinations, or for the final overall grade in the course. She also asked students in both sections to self-report their engagement level, and again there was no statistically significant difference in results. Christopherson (2011) further describes herself as a "prodigious user of CRS," but believes the devices serve a limited pedagogical role in the classroom. "I do see the benefits of using this tool within the classroom. However, I do see the technology as just that, a tool" (p. 290)

Learning Theories Tied to CRS

Two learning theories are readily applicable to using CRS. David Kolb (1984) proposed his experiential learning theory when writing "learning is the process whereby knowledge is

created through the transformation of experience" (p. 38). His four-stage experiential learning cycle (Figure 2) illustrates that learning occurs through a series of events.

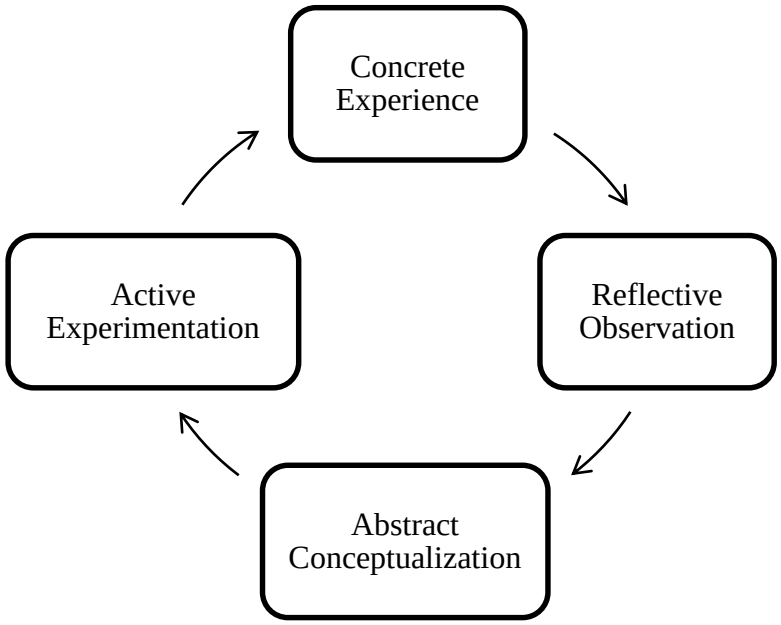

Figure 2: Kolb's (1984) Learning Cycle

The theory proposes an individual must experience all stages of the cycle to effectively learn a concept. However, the point of entry into the cycle may vary according to each individual's personal experience (Kolb & Fry, 1975).

When using CRS, the experiential learning cycle can occur as follows: the instructor presents new information in the classroom and then asks a CRS question relating to that concept. Students then anonymously respond to the question by using their CRS devices. When the voting ends, their answer (and those of their classmates) is revealed and discussed. In this hypothetical situation, the student may enter the cycle at "Concrete Experience" as the information being taught challenges their previously 'known' beliefs. As the student provides an answer and the voting results are shown, they further move to "Reflective Observation" if their response differs from the correct answer, or even if it falls outside of the class majority vote. As

the student learns a new idea or modifies their existing understanding of a concept, they move to the "Abstract Conceptualization" phase. If the student can further take this new information forward and apply it to their world, they complete the cycle by moving to the "Active Experimentation" stage of the learning cycle.

Another learning theory related to CRS is Robert Gagné's Theory of Instruction (1985). This theory of instructional design proposed that effective teaching must be constructed with three goals in mind: having a taxonomy of learning outcomes, creating the most effective conditions for students to learn, and following a series of learning events. This last area of instructional design, which he called "The Nine Events of Instruction," is most closely related to CRS use. According to Gagné (1985), the process of learning follows a distinct series of events, all of which must happen in a specific order. Thus, to foster an optimal learning environment, effective instructional design should also follow that specific order. The theory states that a learning experience must follow these sequential steps to impact students (Gagné, 1985):

1. Gaining attention (of the learner)
2. Informing learners of objectives
3. Stimulating recall of prior learning
4. Presenting the new information
5. Providing learning guidance
6. Eliciting performance
7. Providing feedback
8. Assessing performance
9. Enhancing retention and transfer

When this instructional design and learning theory is applied to CRS, the outcome may be as follows: As noted in the previous example, the instructor presents new information and asks a question on the topic. The learner responds with their CRS, the responses are revealed, and a discussion ensues. Utilizing the design of Gagné's (1985) theory, we would assume the instructor has already gained the learner's attention and has informed them of the learning

objectives. Before or during the presentation of new information, the student is asked to recall what they already know or what they recently learned on the subject. The new information is presented and the instructor asks a question on the topic. This step involves both providing learning guidance and also asks students to elicit a performance by answering a question. As the results of polling are revealed to the class, the instructor should provide feedback as students are now able to assess their performance on the question. The instructor can further facilitate this step by helping students understand why a chosen answer is incorrect (which further illustrates the need to create answers which seem "equally likely" to students). In the last step, the instructor should bring this newly acquired knowledge forward into any other applicable areas of the course, enhancing retention and further transfer of the learning into new situations. The students are also involved in this process when they bring this new information with them into the world outside of the classroom.

Linking Instructional Methodology and CRS

Like any other tool utilized in a classroom, the effectiveness of the technology is contingent upon using this technology to achieve specific goals. As one study evaluating CRS and student grades put it, "It is therefore not whether you use [CRS], but how you use [CRS] that make them effective" (White, Syncox, & Alters, 2011, p. 558). By linking CRS to specific teaching methodologies, these devices can help instructors achieve critical pedagogical goals.

Contingent Teaching

One of the goals of CRS use is contingent instruction. When teachers have the ability to understand what their students know and what they are actively learning in the classroom, it allows them to modify their instruction to best fit those learners' needs. As Pol, Volman, and

Beishuizen (2011) wrote, "When teaching contingently teachers are, thus, seen to act less directive and not pursue only their own agenda but, instead, respond adaptively to the needs of students" (p. 55). Research indicates instructors employing contingent teaching will see their students outperform learners from classrooms where teachers do not emphasize contingent methodologies (Murphy & Messer, 2000; Pratt & Savoy-Levine, 1998; D. Wood, Wood, & Middleton, 1978).

Many studies on contingent teaching have focused on one-on-one instruction (Murphy & Messer, 2000; Pratt & Savoy-Levine, 1998; D. Wood et al., 1978). This logically stands to reason as it should be easier for an instructor to gauge one learner's understanding of a topic compared to a classroom full of students. However, most traditional classrooms rely on a single instructor to teach multiple students simultaneously. In this setting, it can be very difficult to determine the knowledge level of the classroom as a whole, much less of individual students. In this instance, using a CRS is just one of many different ways to attempt to gain a more complete picture of student understanding.

Researchers agree that effective contingent teaching is a cycle by which the teacher first determines the learner's knowledge level and then adapts instruction to fit that need. Pol et al. (2011) indicate that each component is critical, stating "both diagnostic and intervention strategies are necessary for contingent teaching" (p. 47). Ruiz-Primo and Furtak (2007) explored this relationship even further, describing contingent teaching as a six-stage interactive process between instructor and learner (Figure 3).

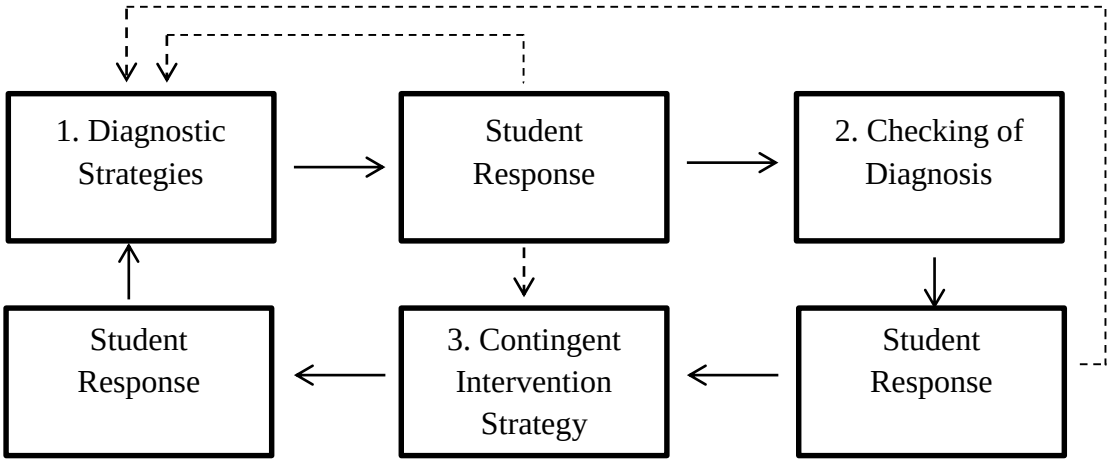

Figure 3: Ruiz-Primo & Furtak's (2007) Contingent Teaching Cycle

Their research indicated most instructors did not complete the entire cycle, but the closer a teacher came to completing the cycle, the better their students performed on a given task (Ruiz-Primo & Furtak, 2007). Multiple studies found that many teachers failed to even achieve the diagnostic stage, making further pursuit of contingent methods highly unlikely (Deen, Hajer, & Koole, 2008; Lockhorst, van Oers, & Wubbels, 2006).

Active Learning

Another goal of CRS use is active learning. F. Vella (1989) indicates the average student attention span is about 20 minutes, which is far shorter than the vast majority of college-level courses. If an instructor does not have their student's attention, it stands to reason they may have a difficult time helping them learn information being taught that day. Thus, the goal becomes how to extend the student's attention span to match the duration of the session. One potential way to keep students engaged throughout the entire class period is through active learning techniques.

Slavich and Zimbardo (2012) describe active learning as "the notion that students must read, write, discuss, and engage in problem solving to maximize their potential for intellectual

growth. These activities are important because they engage higher-order cognitive strategies such as analysis, synthesis, and evaluation" (p. 571). The key to active learning seems to lie in student engagement. Brown (2008) indicates that when learners become more engaged they begin taking more responsibility for their education, which can ultimately lead these students to shape their own learning experiences.

Research indicates there may be a correlation between student performance and active learning. (Stewart, Houghton, & Rogers, 2012) saw an increase in student learning outcomes associated with instructors using active learning techniques. Gardner and Belland (2012) concluded that "by creating courses that implement multiple active learning strategies, student learning can potentially be improved" (p. 473). Minhas, Ghosh, and Swanzy (2012) reported active learning techniques linked to statistically significant higher exam scores. Additionally, almost 70% of respondents in this study indicated a preference for instructional methods containing active learning. Reinhardt and Rosen (2012) compared structural differences in teaching with active learning techniques. They found learners achieved higher exam scores when 15 minutes of each lecture period was reserved for active lecture methods (think-pair-share, concept tests, minute papers, etc.) compared to teaching with collaborative or cooperative methods where teamwork and communication were emphasized.

Providing Immediate Feedback to Students

As Beatty (2004) indicates, traditional teaching follows a "ballistic" pattern. Teachers "deploy" instruction and hope for as many "hits" (student learning) as possible. In the traditional instructional model, instructional effectiveness is not generally understood until students are assessed, usually by exam, quiz, or written response. Often times, these types of assessment occur days or weeks after concepts are taught. Once assessment occurs, however, it is often too

late to do anything but review common misconceptions gleaned from evaluating incorrect student answers. Also, scores in the traditional classroom are often tied to incorrect answers on these *initial* assessment activities. Therefore, students may lack motivation to learn from incorrect answers when there is no potential benefit to their course grade. Epstein et al. (2002) describes the shortcomings of this process as follows:

> The typical multiple-choice test may be an effective and practical assessment tool but it does not convert mistakes into new learning. Indeed, without corrective feedback, the learner likely exits an examination assuming that an incorrect response was actually correct; thus, an examination that does not employ feedback may promote misconceptions. (p. 188)

Teaching methods employing delayed feedback may contribute to students potentially losing the meaning of a question between when it is asked and when the instructor has time to grade and return the assessment (Yourstone, Kraye, & Albaum, 2008). There is also the potential that delayed feedback can impact the significance a question initially held for the learner.

> A question posed today but with feedback given some days later seems to lose some relevancy in the student's mind. With traditional time-delayed methods of feedback, the thoughts that the student had at the time that the question was first posed may not be as clear or even remembered when the student receives delayed feedback on that same question. (Yourstone et al., 2008, p. 80)

Research indicates using immediate feedback may lead to improved student gains. When comparing immediate and delayed feedback techniques, Yourstone et al. (2008) reported that students in a classroom utilizing immediate feedback scored higher on exam scores than those in traditional classrooms. The same study found students in immediate feedback courses seemed much more involved during class time, and "the ability of the students and the instructor to engage in a dialogue around each question seems to be very beneficial" (p. 86).

Another study compared immediate feedback assessment with other traditional assessment methods (Epstein et al., 2002). In this study, subjects were presented with new information to learn, and a short time later given a multiple choice exam on the topic. Half the participants were provided with immediate feedback on each question, while the other half took the test in the traditional format using either a scantron or computer. The initial comparison between groups showed no statistical difference, indicating all students scored essentially the same regardless of testing methods. Within each group, half the students were asked to return in 24 hours while the other half returned seven days later. Upon returning, students were given another examination over the same material, this time solely utilizing multiple choice scantron testing. Regardless of the conditions of the study (immediate feedback vs. scantron or immediate feedback vs. computer testing), the immediate feedback groups scored statistically significantly higher after both one day and seven days (Epstein et al., 2002).

Epstein et al. (2002) explained these results by saying immediate feedback techniques engage students in an exploratory process of "learning during the testing process" (p. 198). The researchers go on to say immediate feedback is "an engaging medium that supports learning by providing reinforcing feedback for correct responses and corrective feedback for incorrect responses while involving the participant in a discovery process" (Epstein et al., 2002, p. 199). This study further espouses that immediate feedback is much more effective than traditional testing, primarily because this type of assessment is more likely to reinforce misconceptions since there is no emphasis on learning. "A more optimal multiple-choice testing format would not only assess the learner's current level of understanding, but would also correct misunderstandings. That is, the test would teach as well as assess" (Epstein et al., 2002, p. 188).

Providing students with immediate feedback may also reduce the "house-of-cards" effect, occurring when students do not understand the basic concepts of a subject (Poulis et al., 1998). Without a fundamental foundation of the building blocks of a subject, further instruction may only lead to student frustration, poor achievement, and potential failure. Bransford, Brown, and Cocking (1999) indicate that addressing student misconceptions during the teaching process is now acknowledged as a fundamental aspect of effective instruction.

Why Conduct this Research?

For each possible goal of CRS adoption, multiple studies have been conducted to provide evidence of using the technology to achieve those ends. These include: student engagement (Beekes, 2006; Burnstein & Lederman, 2001; Fies & Marshall, 2006), anonymity of student responses (Draper & Brown, 2004; Nelson & Hauck, 2008; Trees & Jackson, 2007), increasing classroom discussion (Blake, 2006; Mestre et al., 1997; Miller et al., 2012; Reay et al., 2005; W. Wood, 2004), peer instruction (Beatty, 2004; Boyle & Nicole, 2003; Bunce et al., 2006), increased attendance (Caldwell, 2007; Cue, 1998; Wit, 2003), and potential student achievement gains (Keough, 2012; Paschal, 2002; Poulis et al., 1998). There have also been multiple studies describing instructor best practices (Beatty et al., 2006; Caldwell, 2007; Keller et al., 2007; Reay et al., 2005; Robertson, 2000; Wit, 2003). These studies, and similar research, cover CRS-based pedagogy topics such as: setting goals for using the technology, communicating expectations to students, writing effective questions, how frequently to ask questions, ways to discourage cheating, and how to avoid common mistakes, just to name a few. However, at the time of this research, there appear to be very few case studies regarding use of the devices. Those case studies that were discovered focused on student attitudes and perceptions of the technology.

Therefore, I postulated that a multiple case study of long-term CRS adaptors would allow instructors to reflect on how and why they used CRS over the semesters. Within that overarching goal, this research also investigated a variety of previously unstudied topics, including: evaluating if the technology actually achieved initial pedagogical goals, discussing how CRS goals have changed over time, and gauging changes in the attitudes of students and colleagues toward the technology. It is my hope this research might provide insights into these and other topics.

Chapter 3

METHODOLOGY

In an effort to better understand the link between Classroom Response Systems (CRS) and instructional pedagogy, this study investigated instructors who had extensive experience with the technology, focusing on those with at least five cumulative years of experience. This research investigated how instructors used CRS to meet their pedagogical goals, and also how the technology shaped their instructional methods during this time.

Proposed Methodology

My proposed methodology for this study is collective or cumulative case study constructivism. Constructivist theory is based on the idea there are multiple mental constructions based upon social context and personal experience (Guba, 1990). As Crotty (1998) wrote regarding this research method, "Meaning is not discovered, but constructed. In this understanding of knowledge, it is clear that different people may construct meaning in different ways, even in relation to the same phenomenon" (p. 9). In the context of this study, I attempted to investigate each instructor's self-created reality regarding CRS. Even though from site-to-site the technology is comparable (or sometimes identical), and the courses offered may be similar, each participant's experience with CRS is different. Stated another way, "Our individual personality – the way we think life is and the part we are to play in it – is self-created. We put together our own personal reality" (Lincoln & Guba, 1985, p. 73). In this type of research, the investigative focus shifts away from generalizability of findings to the world at large, and toward understanding the unique experiences of each instructor.

The Rationale of a Case Study

The choice to pursue this research as a case study was an attempt to better understand and explain how CRS worked in individual classrooms. If I simply collected and reported data without providing a context for this information, the research could not tell a complete story. However, utilizing case studies provided just such an opportunity. As Yin (2003) describes, "[T]he distinctive need for case studies arises out of the desire to understand complex social phenomena. [T]he case study methodology allows investigators to retain the holistic and meaningful characteristics of real-life events" (p. 2) Stated another way, "Some of us emphasize the name *case study* because it draws attention to the question of what specially can be learned from the single case" (Stake, 2000, p. 435, italics in original).

For this research, I employed the multiple case study methodology proposed by Yin (2003), specifically falling into the collective or cumulative case study framework. This methodology is often chosen because investigating the same phenomena through several studies "either (a) predicts similar results (*a literal replication*) or (b) predicts contrasting results but for predictable reasons (*a theoretical replication*)" (Yin, 2003, pp. 47, parenthesis and italics in original). This type of research is undertaken when no single case could contribute as much depth or understanding to a topic as would the examination of several cases. Within this research, "Individual cases…are chosen because it is believed that understanding them will lead to a better understanding, perhaps better theorizing, about a still larger collection of cases" (Denzin & Lincoln, 2011, p. 437). The use of multiple-case design usually creates a more compelling story, thus making the research more robust (Herriott & Firestone, 1983). Additionally, by the very nature of this research and the uniqueness of each instructor and educational setting, this study focused on theoretical replication rather than literal replication.

Since these instructors used comparable technology in an analogous setting, there was a likelihood for similarities in the research findings of these different cases. So, while each case was unique to itself, instances where similarities or themes emerged from the data were reported as such. In multiple case study methodology, it is the confluence of a unique story in the similar setting that provides both context and depth to this research.

> Every instance of a case or process bears the stamp of the general class of phenomena to which it belongs. However, any given instance is likely to be particular and unique. Thus, for example, any given classroom is like all classrooms, but not two classrooms are the same (Denzin & Lincoln, 2011, p. 370).

There are numerous examples of cumulative case studies (Connell, 1985; Kozol, 1991; Terkel, 2009), and an excellent model is Mary Pipher's *Reviving Ophelia: saving the selves of adolescent girls* (1994). In this book about the impact of contemporary culture on adolescent girls, each individual case has meaning unto itself. However, the collection of cases serves to paint a more detailed picture of this phenomenon, which bolsters the credibility of the study. My research goal was much the same, where each individual instructor related their personal experiences of long-term CRS use, but the collection of their cases in a single study painted a more detailed picture of the potential pedagogical impact of this technology.

Within the case study framework, I focused on what Stake (2000) refers to as intrinsic case study. This methodology is unique since,

> It is undertaken because…the researcher wants better understanding of this particular case. [I]t is not undertaken primarily because the case represents other cases or because it illustrates a particular trait or problem, but because, in all its particularity *and* ordinariness, the case itself is of interest. (pp. 437, italics in original)

Again, while generalizability was not the goal of this research, I certainly hope this study informs other instructors as to the experiences and issues they might encounter using CRS. To this end, Stake (2000) believes case study methodology can be utilized as an attempt to translate

experiences from one situation to the next. His main concern is if the researcher spends too much time trying to applying the case to other situations, "their attention is drawn away from features important for understanding the case itself" (p. 439).

Ensuring Research Quality

Whenever social research is conducted, there are typically four constructs used to judge the quality of the research design, which are: construct validity, external validity, internal validity, and reliability (Kidder & Judd, 1986). Yin's (2003) design for multiple cases studies addresses each of these constructs in turn.

Construct Validity

This is the ability of the study to correctly measure the concept of interest (Kidder & Judd, 1986). Following Yin's (2003) methodology to increase construct validity, I used multiple sources of evidence by choosing several instructors. Another way to increase this validity is establishing a chain of evidence. Here, I was at the mercy of the instructors and their ability to correctly recall and honestly report their experiences with CRS. For these reasons, Yin (2003) reports that construct validity can be difficult to establish in case study research.

External Validity

This concept explores the degree to which a study's findings can be generalized (Kidder & Judd, 1986). While the goal of this research was not generalizability, Yin (2003) still believes choosing multiple cases in this instance is important "because they [offer] contrasting situations, [and] the results represent a strong start toward theoretical replication – again vastly strengthening the external validity of your findings compared to those from a single case alone" (p. 54) Additionally, Yin (2003) also promotes the use of replication logic to increase external validity.

Internal Validity

This is the investigation into causal relationships, as opposed to unrelated happenings or illegitimate connections between events (Kidder & Judd, 1986). Specifically, because this was an exploratory study, a main threat to internal validity is relying on inferences drawn through the personal interviews (Yin, 2003). This might have occurred if I deduced outcomes were causal because logic dictated one event followed the other. In this study, internal validity was strengthened through the Dialectic process. The Dialectic provided each instructor the chance to explain actual causal relationship between events, which negated any need for me to infer causality based on my own logic.

Reliability

This is the concern that the research methodology can be replicated, and the results would be similar (Kidder & Judd, 1986). This is a unique construct because, again by the very nature of this study, results could never be identical. However, increasing reliability in multiple case study methods is achieved by using a case study protocol (Yin, 2003). This protocol employed a standard set of questions for each interview.

It is especially important to consider that while each instructor was initially asked identical interview questions, the value of constructivism was that the interview could (and did) change based on the subject's responses. Knowing this, an exploratory interview format was utilized for this study. Exploratory interviews use both structured and unstructured questions, "Based on the [researcher's] growing understanding of events and the informants' construction of reality" (Biddle & Anderson, 1986). Therefore, while the initial structure of each interview was identical, the form it ultimately took was completely contingent on the actual instructor

responses. Consequently, all standard interview forms were both identical, yet equally flexible and adaptable.

The Participants

For this study, I specifically targeted college and university instructors who used CRS in their classroom for at least five years/10 semesters. This baseline experience level was chosen because it allowed access to teachers with familiarity and expertise with the technology. These were instructors who understood how CRS functions, and have modified their course material, course preparation, and/or CRS usage to effectively fit their own teaching style.

Initially, I began my search for study participants within the state of Colorado. I chose this geographic area because it allowed me to conduct face-to-face interviews. I believed there were enough colleges and universities in the state employing CRS technology that I would be able to find an adequate number of participants. However, I also realized the "adequate" number of participants for this research was the amount necessary to identify themes and ideas emerging from the data. In the end, five instructors were deemed an adequate sample size.

My population of interest provided a constraint to eligible participants and also prevented random selection. Random selection is often a key component in the generalizability of research findings to the larger population. In constructivism, however, these were not limitations but rather the goal of participant selection and data collection. The aim of this research was not to understand how CRS is used in every classroom, but rather to investigate how the technology worked for these specific instructors.

> Generalization is often an effort toward simplifying our understanding of some phenomenon. If we can generalize an abstract claim and show how it holds under a variety of conditions, then we have a firmer grasp on the basic dynamics of the situation. But in qualitative research, we are not always interested in simplifying our understandings. Generalizability is most often a push towards breadth, and qualitative

> research is much more concerned with depth. More often than not, these two fundamental dynamics just do not coordinate all that well. (Shank, 2002, pp. 112-113)

Procedures

This research employed snowball sampling methodology. This research design relies on identifying potential subjects through relationships or personal knowledge of individuals who fit the research criteria. While commonly employed when studying individuals wanting to hide their identity (e.g. deviant or socially non-adaptive behaviors), it can also be utilized in any hard-to-find population (Faugier & Sargeant, 1997). "Many…qualitative researchers employ theoretical or purposive, and not random, sampling models. They seek out groups, settings, and individuals where and for whom the processes being studied are most likely to occur" (Denzin & Lincoln, 2011).

To begin my search for instructors whose CRS experience level matched my population of interest, I contacted an individual who oversees technology at one of the local universities. The person provided me with the names of a few instructors he knew employed CRS. After acquiring the names of faculty that meet my chosen criteria, I contacted these individuals by email or phone. Using a script, I explained my experience with CRS, the aims of my research, and then inquired as to their availability and willingness to serve as a potential research participant (Appendix B). A similar pattern occurred at the other universities where I looked for subjects.

When an instructor indicated a willingness to participate in the research, we then arranged a time and place for this interview. With four of these interviews, this involved my travelling to their campus and meeting either in their office or another convenient location of their choice. In the last instance, we met in a private residence. I sent the research questions to each subject before the scheduled meeting, giving them the option to read those queries and

contemplate the nature of the interview. At the commencement of each meeting, I explained my research protocol and asked for their permission to audio record the interview. At the conclusion of the meeting, I further discussed the research project and also informed each instructor I would make the completed findings available to them.

During this process of identifying and contacting each potential research subject, one goal was establishing interpersonal relationships. The creation of these relationships was critical since one of the keys to dialectic research is building connections and trust between researcher and subject.

Data Collection

Constructivist research often utilizes what are called naturalistic research methods, such as personal interviews and observations (Angen, 2000). A key component of Dialectic methodology and constructivist research is establishing trust between participants and researchers (Lincoln, Lynham, & Guba, 2008). The building of this relationship is key to the research process because constructivism is transactional in nature, and findings are co-created by both the researcher and subject (Guba & Lincoln, 2005). In an effort to establish rapport and earn trust, my goal was to conduct all research interviews in person. Face-to-face discourse allows both parties to read and react to each other's body language, something that cannot be gleaned through paper questionnaires or phone interviews. Face-to-face interaction improves dialogue efficiency because listeners become co-narrators through verbal and non-verbal responses, which can lead to better storytelling (Bavelas, Coates, & Johnson, 2000). Additionally, discussion is a key component of Dialectic methodology, which I am employing in this study.

I used a standard set of research questions (Appendix C) to conduct the personal interviews. In this research, interview transcripts were recorded in two methods. All face-to-face research interviews were audio recorded to ensure dialogue was accurate. Note taking was utilized when needed to help provide a more complete picture of the interview. However, since the goal of constructivist research is to build trust and understanding, the focus of interviews was always increasing conversation, as opposed to the more formal question and answer session. To this end, note taking was limited to brief summarizations of key points, or to help remember questions to be asked later. All participants' were informed that scheduling an interview or observation provided their consent to participate in this study (Appendix D).

Perhaps the single most important reason for using audio recordings is to capture the "actual details" of an interview (Sacks & Jefferson, 1992). Their research points out that no interviewer can accurately recall the actual words used in conversations, much less the pauses, tones, and intonations that add non-verbal meaning to conversations. Also, Sacks and Jefferson (1992) believe audio recordings add vigor to research because the researcher can replay the actual events of a conversation

> My research is about conversation only in this incidental way, that we can get the actual happenings on tape and transcribe them more or less, and therefore have something to begin with. If you can't deal with the actual detail of actual events, then you can't have a science of social life. (p. 26)

Personal Interview and Dialectic

One of the key components to constructivist research is employing dialectic methodologies. Dialectic has been defined as, "The notion that we have the capacity to criticize our modes of conceiving things and to do 'higher order' thinking (or critical thinking) about previously attained positions" (Wittrock, 1986, p. 488). For this research, dialectic takes the form of a discussion-based investigation into the truth of a subject. The effectiveness and

efficiency of this discussion is aided with the knowledge that, "The construction of realities must depend on some form of consensual language" (Lincoln & Guba, 1985, p. 71). When the researcher and subject share similar knowledge, language, and experiences, they can engage in a substantial dialogue to collaboratively create a meaningful reality (Angen, 2000).

The co-construction of data by the researcher and each instructor is perhaps the most critical component of this type of inquiry. Guba and Lincoln (2005) assert the quality of inquiry in constructivism is "trustworthiness and authenticity" (p. 196). Therefore, each set of data should be agreed upon by both researcher and instructor before it is considered to be a good fit. I have utilized the technology while teaching classes for 15 semesters, and I wrote my master's thesis on the subject. Because of my prior research and also my experiential learning with the technology, I believe I am well-suited to engage in dialectic methodology regarding CRS. Naturally, my experience comes with its own set of personal biases, but I attempted to limit these with my chosen research methodology.

Because each set of data only pertains to one instructor and one classroom, it is critical to realize this research is not intended to be generalizable in solving numerous problems (Guba, 1996). Lincoln et al. (2008) state constructivist inquiry does not focus on immediate change as much it is meant to lead to "Intellectual digestion" (p. 112). Instead, the aim of this research was to improve pedagogical praxis through personal reflection. As mentioned earlier, there are a multitude of reasons an instructor might have for utilizing CRS. However, this study investigated the difference between what researchers say *can* happen with the technology, and what instructors *actually* encountered. Constructivist research is ideally suited to address this issue because it is meant to bridge the gap between theory and practice

Within this study, there was a certain level of bias toward CRS, both from myself and the interview subjects. I have been using CRS my entire teaching career, and these instructors have used it for at least 10 semesters. Thus, it is safe to assume there is an inherent positive bias toward the technology from all parties. After all, the overall goal of this research was exploring *how* CRS was used, not *if* they should be employed. For the purposes of this research, this is also considered beneficial because all instructors have a deep experience with the technology and its potential benefits. It was also assumed we all use the technology because we believed it is beneficial in our classrooms. Additionally, there was a concern of researcher bias, which was addressed in detail in the methodology section of this study. Once these assumptions were stated and understood, the research moved forward and focused on the goal of this study, which was gaining a better understanding of long-term CRS use from the instructor's perspective.

Analysis of the Data.

After completing each round of interviews, I transcoded all audio recordings to a written transcript. Additionally, I used methods of conversational analysis proposed by Mason (1996) and Silverman (1998). Mason (1996) proposes investigating transcripts by performing a type of puzzle analysis. When a question, issue, or conflict arises, the researcher then works through the transcript to see both *how* it emerged and ultimately *what* was the resolution. This back and forth method is repeated throughout the entire transcript, and themes emerge from the process. Using this type of analysis helped me better understand the origins of a particular issue. It also helped to avoid the common research foible of looking at a single statement or utterance and assigning meaning without investigating its context. As Sacks and Jefferson (1992) illustrate, utilizing the entire conversation is critical because,

> Having available for any given utterance other utterances around it, is extremely important for determining what was said. If you have available only the snatch of talk that you're now transcribing, you're in tough shape for determining what it is. (p. 729)

Silverman (1998) suggests a similar conversation analysis method, but provides more specific steps to conducting this research. This methodology involves a three-step process:

1. Seeking to identify sequences in the conversation of associated or connected ideas.
2. Examining the roles or identities that speakers adopt in their conversations – e.g the investigator or the answerer.
3. Exploring the conversation for particular results, and then working backward to trace the path that led to that result.

General Inductive Approach

This data was analyzed using a general inductive approach. This is a common methodology for qualitative research, and differs from deductive analysis because it does not begin with a hypothesis or theory. Thomas (2006) describes inductive analysis as an "approaches that primarily use detailed readings of raw data to derive concepts, themes, or a model through interpretations made from the raw data by an evaluator or researcher" (p. 238). One of the keys to inductive analysis is multiple exposures to the raw data (Thomas, 2006). In an effort to help immerse myself in this data, I personally transcribed all the audio interviews to written format. This process involved repeatedly listening to the audio recordings until I had adequately captured both the words and the tone of the original interview. By transcribing the audio interviews, I increased my familiarity with the raw data and further enhanced my ability to find connections or themes that emerged from this research.

Once the raw data was in written form, I created separate research findings for each instructor. Because interviews occurred independently, it was important to present the data as separate findings so readers can gain a sense that each case was unique to itself. After presenting all of these interviews, I then identified similarities, themes, or ideas that emerged from the data.

Naturally, my own opinions and the research questions shaped my interpretation of the data. However, it was important I entered this process limiting preconceived notions or theories as to what the data would reveal. Thomas (2006) describes this as a key concept in the general inductive approach.

> Although the findings are influenced by the evaluation objectives or questions outlined by the researcher, the findings arise directly from the analysis of the raw data, not from a priori expectations or models. The evaluation objectives provide a focus or domain of relevance for conducting the analysis, not a set of expectations about specific findings (p. 239)

KWIC and Theme Analysis

Along with these methods, I also attempted to identify themes by employing keywords-in-context (KWIC) analysis and theme analysis. In KWIC, the written transcript of an interview is analyzed using a software program to identify key words or phrases based on word count or specific searches (e.g., for this study, learning, teaching, engagement, etc.). Once a particular word or phrase is found, a set number of words around this keyword are also shown to highlight the context (Ryan & Bernard, 2011). Theme analysis distinguishes "constructs that investigators identify before, during, and after data collection" (Ryan & Bernard, 2011, p. 780). Both Willms et al. (1990) and Miles and Huberman (1994) advocate that the researcher begins to develop themes by studying literature, and then adding or subtracting from this list as they analyze their own data. To this end, I used the themes derived from my literature review to develop a framework of CRS adoption and use. As I conducted each interview, I modified these themes as necessary as they emerged from these data analysis techniques.

Addressing Potential Researcher Bias

Potential Bias should always be identified and disclosed in any study to help readers understand this can influence a study. The researcher perspective was disclosed in the introduction, and the potential areas of bias are discussed here.

Limiting Bias

In an effort to eliminate some of the researcher bias inherently possible in this type of research, I attempted to member check the data from each instructor by making their individual research findings available to them. The review of this data by the respective instructors was voluntary, and feedback was not required to proceed with the study. Yin (2003) believes this is essential because it introduces an outside entity to the research that can help make the study more robust.

> To test your own tolerance for contrary findings, report your preliminary findings – possibly while still in the data collection phase – to two or three critical colleagues. The colleagues should offer alternative explanations and suggestions for data collection. If the quest for contrary findings can produce documentable rebuttals, the likelihood of bias will have been reduced. (p. 62)

Ethical Research Protocols

The focus on ethics for any study is paramount. Before conducting field research, this study was analyzed and approved by the university Institutional Review Board (IRB). On a personal level, I was also aware of the need to be cognizant of ethical guidelines for gathering and reporting of data. While there is not a standard code of ethics beyond IRB, there are still a number of sources that suggest following certain ethical principles when conducting research. Bogdan and Biklen (1998) provide four basic tenants for ethical research:

1. Unless otherwise specified, protect the identity of research subjects.
2. Treat subjects with respect and seek their cooperation in research.

3. If negotiation permission or establishing terms of the research, abide by that contract.
4. Tell the truth when reporting the findings.

My biggest concern with these four guidelines was actually number four. The remainder of the principles worked themselves out while I was conducting the research, but I was most concerned with presenting unbiased findings. As mentioned in the researcher perspective section, I have very strong opinions about CRS and their use in classrooms. I personally believe they are an integral part of my teaching experience and have contributed to the positive student evaluations I receive every semester regarding my course. But if my research did not bear out the same successful use and integration in other classrooms, I was afraid my first instinct would be to judge *why* CRS did not work, rather than painting an unbiased picture from the data. If I did not consciously focus on telling the complete story, I might have slanted my writing toward explanations that best fit my paradigm of CRS. As Bodgan & Biklen (1998) write, "Although for ideological reasons you may not like the conclusions you reach...the most important trademark of a researcher should be his or her devotion to reporting what the data reveal. Fabricating...or distorting data is the ultimate sin of a scientist" (p. 45)

Chapter 4

RESEARCH FINDINGS

These finding were derived from transcription of audio recordings, and further analysis of these written transcripts. Pseudonyms were used for all instructors, and findings are presented in the order each subject was interviewed.

Chip

Chip is an instructor in a science department at a large public university. He has used CRS for a number of years, and recalls that his first forays into the technology were based on his desire to better engage students in the classroom. In fact, he began utilizing engagement-based pedagogy techniques before CRS technology was widely used or even available. When he first began teaching at a university, his courses were 100 minutes long. He believed that in a longer class like this, it was nearly impossible to keep student attention for the duration of a class. Additionally, he wanted to find ways to increase engagement in his courses. So, he began to periodically stop class and ask questions that students would answer by submitting pieces of paper. He also specifically instructed students to discuss each question with people sitting near them. Chip found this was an effective way to break up the class monotony and also engage students, but it came at a price. Every day, he had to sort through 60 or more handwritten submissions. So when he heard about CRS, one of his reasons for adoption was that it provided a great way to increase engagement, plus it utilized technology to record information instead of his doing so manually.

Moving to the present day, Chip teaches an introductory-level course where an average of 98% of those enrolled are non-majors. Based on feedback, a number of learners in these classes

expressed a negative predisposition toward the course because, as Chip puts is, students say they are "not sciency people." He identified this negative predisposition toward science-based subjects as a potential hurdle to student success in his course. But rather than try to convince these learners they should embrace science as a field of study, he hoped to change their attitude about this course by increasing peer interaction in his classroom. In an effort to do this, he would pose a CRS question and then provide specific encouragement for students to talk to their neighbors about the possible answers. Chip believed that students inherently like talking to each other, so he hoped that by encouraging a behavior they already enjoyed, those feelings might transfer into how they felt about the course as a whole. His ultimate goal is this learning exercise was to move beyond engagement and specifically target student attitudes. He said this was a purposeful choice, and something that was distinctly different from "just the pure engagement."

Chip believed another benefit of increased interaction was that it allowed students to challenge their preconceived notions about classroom behavior. As he discovered throughout his teaching career, students often believe their instructors are always right. Therefore, when a question was posed to the class, the students were hesitant to answer aloud because they might be incorrect. However, when a student was encouraged to discuss something with a classmate, the result was quite different. They were used to having their friends and fellow students not know all the answers, so it was much less intimidating to discuss a topic because now they weren't discussing it with someone they considered to be an expert.

He saw two distinct benefits from this. First, when students had to explain a concept, it became very clear what they did and did not know about the topic. If they knew the concept well, it was great because then they explained it to their classmate. If they didn't know the concept now both parties were invested in filling in the knowledge gaps. The other benefit was

that Chip could walk around the classroom and hear the student conversations. He could listen to their assumptions, and also realize just how different they talked to each other compared to conversations they had with their instructors. He saw both of these as highly beneficial to better understanding his students.

Despite the many benefits Chip sees in using CRS, there are certainly some frustrating issues with their use. In an ongoing effort to improve their technology, many CRS manufacturers have modified their products through the years to include more features, such as the ability to send text messages to the instructor. Chip reports that what the manufacturers believe are improvements can actually serve as a barrier to successful technology use. He feels like the more things a CRS can do, the more likely it is that students will make mistakes, or they will spend time focusing on text entry versus lecture material and class interaction. To Chip, the technology would be better served if it was very simple to operate. He says too many of the CRS manufacturers keep wanting to add features, but he doesn't believe they have a specific goal in mind when doing so. In his opinion, the ideal technology is "as simple as a pencil," and designed to benefit "subject-matter related goals" while "facilitat[ing] peer instruction."

Chip reports he has made multiple changes to his teaching methodology since adopting CRS. When he first used the technology about 10 years ago, he said he was lucky to ask one question per class period, and even that did not go well in terms of student responses. As the semester progressed, he continued to ask one question per class until the students started consistently answering without issues. At this point, he moved to two CRS questions, and eventually settled on three questions per class. This was his average for about five years, and then he decided to make a conscious change to increase the number of questions per class. About four years ago, he finally broke the three question barrier, and now finds himself asking

roughly six questions in a one hour class. Chip admits this last increase was a struggle, not only because of student behavior, but also for personal reasons. Students are willing to passively listen every day, and he was willing to lecture and explain for an entire class period. So, it took a good deal of willpower for Chip to ask all those questions and then "shut up" to wait for discussion and responses.

The final step in his evolution of CRS-based pedagogy was for Chip to focus his classroom on meta-cognition and self-sufficiency. He illustrated this point by explaining a specific series of CRS questions that help students understand his goal for the class. His first question asks students if they want the answers to a CRS question or if they want hints to figure out the answer. Chip reports the typical response is split about 50/50. Next, he asks students which of the options they believe will lead to them learning more. Here, typically about 80 percent say that providing hints leads to better learning. Last, he asks them which of the options they think a typical boss wants them to employ. Here, roughly 93-97% of students say that providing hints, and not providing answers, is the preferred response.

Chip believes these types of meta-cognitive questions and discussions are critical to student success with CRS. In fact, over the last five years Chip has made it a priority to both include these types of CRS questions, and also spend time in his classes discussing the idea of meta-cognition. One of his overarching goals for any class he taught was for students to think about their own learning. He says one very powerful question that really guides him at this point is, "If you meet your students five years from now, what do you want them to remember from the class?" Chip says just pondering this has helped him focus his teaching attention on what really matters. He wants them to improve when making judgments, to get better at different learning styles, and to really know what they *don't* know.

This metacognition does not happen if the students don't understand it is a goal in the course. To that end, Chip begins each semester by talking about metacognition and establishing this will be part of the classroom climate. He believes it is important to be honest and talk about his expectations from the start. So, he tells students it is their obligation to participate, to stay engaged, and to take an active role in their learning. He makes it clear from the start that if they are expecting to sit back and just be taught all semester, they are in the wrong classroom.

Chip also believes that utilizing CRS, and specifically employing teaching methods that encourage student discussion, results in additional benefits. He thinks using the technology for this end helps encourage all students to engage in behaviors that good students already practice. In many instances, he remembers a handful of students leaving the classroom and continuing to discuss course concepts in the hallway after class. He soon noticed that these were some of the most successful students. In a way, he believes CRS can help bring those conversations back into the classroom where they can be shared by more than just a handful of successful learners. He admits this idea may be conjecture, but says it makes logical sense with what is occurring.

Chip says it is very hard to gauge overall student perception toward CRS. He can't begin to guess as to how the students really feel about CRS, or if their opinions have changed since he began using the technology. He does know they are widely employed because it is reported on his campus that roughly 4 of 5 undergraduate students are using CRS each year. He believes that because so many students regularly utilize the technology, they have an expectation of how the devices should be used. Additionally, he believes the campus culture is such that instructors who misuse CRS generally receive strong negative feedback. Chip also feels that any consistent negative student perceptions of CRS have a common link. In his opinion, roughly 5-10% of

students in his classes will realize CRS-based courses and peer instruction means more work for them, which they dislike on principle.

Chip rarely finds himself defending the use of the technology to other faculty, which he attributes to their widespread use on his campus. According to the CRS Service Manager at the university, there are enough devices sold every year that approximately 80% of all students are using them. However, Chip says he does encounter instructors who typically have two concerns with adopting CRS in their classroom. The first is that it will take more time, and the second is instructors' fear they need to reduce the amount of material they can cover. While the first consideration can be a legitimate concern, he has a very specific response to the question of covering course material. "When you carefully explain and lecture, students master about 25% of what you're staying. So, if you drop 10% of your curriculum, but you up [student mastery] efficiency from 25% to 50%, it's a winner.

Rodger

Rodger is also an instructor in a science department at a large public university and has been teaching the same course for about 16 years. During this time, he repeatedly struggled with what he viewed as a consistent problem. The top 20% of his class seemed to learn regardless of the circumstances, and there was also a bottom 20% that would not put in the necessary effort to flourish. In his opinion, both of these groups of students were not heavily influenced by his teaching methods. What did concern him was all the students in-between those groups. Rodger believed these students really did want to succeed, but consistently struggled to learn. This was the group that Rodger felt he could impact the most.

Despite Rodger changing his teaching methodologies about halfway through his teaching career, he still did not see a significant change in student performance. This was confirmed by

both student grades, and also their responses on teaching evaluations. He was dissatisfied because if students really wanted to learn, and he was invested in teaching them, why couldn't these two identical goals come together? Clearly, there was a disconnect somewhere. Rodger expressed his frustration this way, "We're a research university and if I was going to put the time in and they were going to pay the money, they should get more than they were clearly getting."

Rodger was first exposed to CRS by a vendor who promised many benefits to using the technology. However, what really seemed to convince him to adopt CRS was observing a colleague utilize them in the classroom. He was impressed at the level of student engagement, and saw a classroom which was very different from his own. He realized CRS would allow him to ask very conceptual questions, and adoption would not be very difficult. More than anything, Rodger liked the idea the CRS would change the focus of his classroom. "I wanted to make my classroom more of an engaged classroom - shift a little bit more toward learner-centric as opposed to simply being teacher-centric."

Rodger later stated that increasing activity and engagement was the primary motivation behind almost any change in his classroom, regardless of if he was using CRS or another technique or technology. He states he wasn't really concerned with the specific type of engagement, and was happy when he saw an increase in active learning engagement, individual student engagement, or student-teacher engagement. That being said, he still knew this was an uphill battle. He stated that if he could rank engagement on a scale of 0 to 100, he started out at 20 and over time gradually increased to about a 40. He indicated that he never really reached a higher threshold because he still found himself talking in the class the majority of the time.

As to whether the technology achieved these goals, Rodger described this as an ongoing process. In the beginning, he made CRS worth 15% of the course grade and also limited

students receiving points to when they answered questions correctly. He soon found this technique was insufficient because many students would simply hope to hear the correct answer from a classmate and then copy that answer. Although this increased engagement and collaboration, it was not the type of discussion and interaction he wanted. He has since changed his course format so CRS is only 5% of the course grade, and students earned these points by participating rather than answering questions correctly. This change resulted in a drop in attendance, seemingly because the overall CRS grade is now worth 1/3 of its original value. Rodger said attendance is still higher than before he implemented the technology. He also acknowledged that although his primary goal of using CRS is not to increase attendance, he believed more students coming to class every day is certainly a valid benefit.

Asked how his goals for CRS changed over time, Rodger has seen more change in his instruction techniques than in the intended learning outcomes. As previously mentioned, he lowered the CRS grade proportion and started awarding points for participation rather than needing to answer correctly. He said this new focus led him to ask fewer CRS questions than before, but these questions were designed to be more sophisticated, encouraging higher cognate learning goals and processes. He also hoped increasing the complexity of CRS questions would encourage more discussion and interaction among the class. However, Rodger said he still tries to emphasize that the real goal was for students to figure out what they were thinking and how to approach a problem. Rodger felt this was a much more successful use of the technology than he originally employed, but getting to this point was an evolutionary progression. It involves re-writing and re-engineering both the lecture and associated CRS questions to make sure they are hitting the target in terms of either content or concepts.

Despite his emphasis on increasing understand versus getting the question correct, Rodger still sees a significant difference between how students answer an in-class CRS question and how they perform on an exam question over the same topic. For example, it is rare that a CRS question will have less than 60% correct student responses, and often times the number will be as high as 80%. Yet, that same concept on an exam may only see half the number of correct answers. To Rodger, this clearly indicates that students are still asking each other for the correct answer in class as opposed to discussing the concept that underlies the question. Students will ask a classmate for the correct answer, but still won't explain why that answer is correct. This disappoints Rodger because, as he puts it, "They're still indoctrinated in getting the answer is what matters more than the process of getting to the answer."

Asked if there were any unintended benefits of adopting CRS, Rodger again went back to attendance. When he first implemented the technology, he saw an increase from about 50% daily attendance to what he would estimate was 80%. He also noted a slight shift in student performance. He noticed less exam grades of D, and consequently what appeared to be a comparative overall shift in scores. He saw a roughly proportional shift of exam scores increase from D's to C's, and a concurrent shift from C's to B's. Of particular note is that he did not see an overall increase in exam scores of A. Based on these results, Rodger concluded it was probably the students that needed more help that actually benefitted most from CRS use. However, he was quick to point out that he could not directly attribute this shift to either the use of CRS in his classroom or it could be these students benefitted from attending class more frequently.

Another unintended benefit of CRS for Rodger was gaining an insight into how students thought. When he asked a CRS question, specifically one where students discussed the answer,

he would walk around the room and listen to what they are discussing and their train of thought. An example he provided was when he heard students discussing a topic where it was obvious they did not understand the subject, but this was clearly due to a breakdown of communication. He showed them a picture where the scale was in kilometers, and from hearing their conversations it became obvious they believed the scale was in meters. He then addresses the entire classroom to make sure everyone was on the same page before they proceeded with the next topic. As Rodger reflected on this experience, "I don't even bother to think to share [the scale] with them, so that's been another unintended consequence [of CRS]. It's been a vehicle to get an insight into their thinking, [both] misconceptions and preconceptions."

Rodger didn't see many issues or barriers to adopting CRS. He did concede it was a pain to do the extra work of transferring points from the CRS software to the university-based online system (they don't automatically communicate). There was also the usual issues of students not bringing the CRS to class (he has a 10% allowance for these occasions), and there were times when a clicker made it to class without its owner being present. The average student is not usually noticed on this occasion, but when the star point guard of the basketball team received points and he was obviously not in class, the issue became more apparent. While this did constitute cheating, and Rodger has warned students about the dangers of this action, he said he has never pursued punishment for this behavior. He says this is mostly because the process for pursuing this type of misconduct is long, tedious, and overseen by a student-run organization. Rodger admits he knows they were cheating, but the fact that CRS points constitute just 5% of the course grade, this has very little impact either way. So, while Rodger freely admitted there were a number of aggravating trivial things regarding CRS he would rather not deal with, he also said that any negatives were vastly outweighed by the positives.

As he previously alluded, Rodger has changed his teaching style multiple times since he first began using CRS. He modified many things in his classroom over this time period, including adding homework assignments and reading quizzes to encourage students to utilize their textbooks. He also added learning journals in an effort to encourage reflection and meta-cognition. In addition, to these things, he also removed some course content in an effort to cover less material while making sure what he did teach was improved. However, he does not believe CRS was the impetus for these changes. Instead, Rodger looked at CRS as the first step on his journey. "I think I've been motivated, not BY [CRS], but [CRS was] part of the response to a greater yearning, a bigger motivation" [emphasis in original interview].

Rodger noted that not all of these implementations were effective. He has since dropped some of these activities because of both logistical limitations and student feedback. He noted that any activity which was not worth a grade was generally poorly received by students. Additionally, when assignments were worth a small percentage of the course grade, students often complained because they did not feel the effort required to complete the work was equivalent to the "reward." His intentions were never to increase the workload or even to give them more possible points to earn in the course. Instead, the goal of every exercise was always to increase learning, which he repeatedly tried to explain to them. Regardless, students still saw an inequity between their effort and the direct link to an immediate grade. They never seemed to understand the bigger purpose behind *why* the type of assignment was more important than the result itself. As Rodger put it, "How about you [do the work] and we measure the value of that when you take the exams or the quizzes. That's where you show me it had an impact."

Rodger says this feedback was particularly negative when it came to upper division non-major students and the learning journals. This was especially apparent when the questions being

asked were obviously focused on ways to both learn and study. Here, students seemed resentful of these efforts because they believed they already knew how to study and learn effectively as evidenced by their cumulative grade point average (GPA). Rodger disagreed with this premise because he felt a student's GPA was more an indication they could successfully take exams and write papers, not necessarily that they knew effective methods to actually learn concepts. After all, these students weren't science majors and they had waited until they were upperclassmen to take an introductory-level course. For Rodger, this was usually a dead giveaway these students had some trepidation toward science courses in the first place.

Another noteworthy change in Rodger's methodology was that he stopped using CRS in his upper-division courses which were exclusively for majors. He explained this decision by again referring to the evolution of his teaching methodologies. As he moved toward a middle ground between student- and teacher-focused classrooms, he found the structure of CRS questions was too limiting for what he was trying to accomplish. For instance, when he wanted to ask a question that would evoke deeper discussion, the format of only having four to five responses did not accomplish this effectively. Knowing there were a limited number of answers, and knowing one of these had to be correct, the students didn't focus on anything but trying to figure out that answer. However, Rodger believed the discussion of a topic, and specifically when students really explored the topic in deeper-level conversations, was much more valuable than simply picking a correct answer from a list of five options. In these upper division courses, he wanted students to act more like constructivists. So, he created learning scenarios with open-ended approaches so students could drive their own learning, rather that employing the CRS methodology of asking questions and only being able to provide a maximum of five distinct answers

Rodger further illustrates the reasons behind choosing to employ CRS in introductory courses for non-majors versus not using them in upper-division major courses.

> Especially at that lower level I think there are just some rather rigid ways of thinking in [some subjects]. If you have a good grasp of those, you can use [CRS] and scaffold it in a way to guide the development of those ways of thinking, to illustrate those ways of thinking, to repeat it, and repeat it, and repeat it so that becomes ingrained. I think we have ways of thinking in [our department] for sure, and I suspect the majors to be farther along in their comprehension of that. But, the introductory courses are introductory. They're 98% non-majors and 2% of the majors are in their first course. So you don't have that, you have to build that. That would be an effective use of [the technology] where you're basically trying to pour a foundation. But when a foundation is there are you're trying to construct a complex building, like I said I think [CRS] are less valuable there.

When asked if he thought student perceptions toward CRS had changed over time, Rodger responds that he had no idea because he never really tried to measure this. He said that he hopes it had, but he doesn't believe he had seen a noticeable difference positively or negatively in his teacher evaluations. The one thing he was sure of was that he has more students in class every day, more students communicating with him, and more students seemingly engaged and interested than before using CRS. Again, he was quick to point out these result could be either from using CRS, or from the numerous other pedagogical changes he implemented in recent years. So, despite the fact that he had never conducted research on the topic, he did believe there was a difference in some student perceptions of the technology. He believed there were a fraction that find class more enjoyable, specifically the time spent in lecture. However, Rodger was quick to add, "I have no evidence of that. It could be wishful thinking."

Rodger has heard about student resistance or negative feedback regarding CRS in other classes, but he had a logical explanation for this. Many of these faculty members adopted the technology simply because someone else used them with a level of success, or in some instances

they were encouraged to do so at a department or program level. In these instances, the instructor often believed if they adopted the technology, great things would happen. Unfortunately, as Rodger points out, very few faculty had any background in pedagogy, "So, they're using them without any training. They're driving a car and they never took drivers [education], or maybe even had to get a license, for some." In these instances, he specifically felt like he was more likely to see the technology misused. It may not be a coincidence that in these situations, he often heard faculty say that students didn't like CRS. His response to these instructors was very simple: "[Students] don't like exams either, but we all know you haven't dropped the exams. We don't just do what they like, you're just coming up with lame excuses not to use them."

In the last four years, Rodger said there are very few times he finds himself defending or explaining his use of CRS to other faculty. The technology is so prevalent on his campus that virtually every student he encounters has already used them, some dating back to high school or earlier. However, this was not always the case. When he first adopted them around 2005, and in the next few years after that, there was a fair amount of faculty resistance. When CRS was first adopted on his campus, many departments wanted to get all faculty members using the technology as soon as possible. Some even went so far as to hire post-doctorates to help build successful, pedagogy-based teaching material that faculty could then implement in their classroom. Unfortunately, what they came to realize was that many faculty were more interested in adapting the technology to their own desires, rather than adopting a system already based on best-practices. He saw the faculty modifying or removing the techniques that made the technology so useful, and they did this because they had their own thoughts of how CRS should be used.

Rodger shared two separate experiences that illustrated this point very well. The first was a faculty member who believed that answering questions via a show of hands, or by raising color-coded cards, was as effective as the anonymous responses afforded by CRS. Rodger had just concluded research on his campus that indicated the anonymity of the technology was part of what made them effective in a classroom. So, the two of them had long arguments over using CRS, in part because the other instructor could not fathom that anyone would be afraid to speak their mind or worry about what others would think about them. Even when presented with the research, the other faculty member did not agree with the data and basically rejected the notion that an anonymous CRS device was more effective than a show of hands.

The second illustration is quite similar. An instructor at the university would lecture for about 20 minutes, then ask 2 CRS questions over very specific and usually basic trivial information she just covered. However, when Rodger talked to her about her goals for the course, it was quite clear that having memorize these trivial bits of information was *not* her teaching objective. Her logic behind using this CRS methodology was that it forced students to pay close attention to everything in her lecture because they wouldn't know which of these minute details she would ask them about. Rodger pointed out to her that what she was really teaching students was trivial things mattered most because knowing these things was how they answered CRS questions correctly, and thus were rewarded with earning points. When students were presented with more complicated questions on quizzes or exams, which is what this instructor *really* wanted them to know, it was no wonder many of them didn't succeed because the in-class precedent was established for needing to know trivial information.

Nowadays, the most common conversation Rodger has with colleagues regarding CRS is less about adoption and more about successful implementation. He finds himself discussing

ways to utilize the technology to engender higher order thinking. He wants other faculty to understand that CRS doesn't have to just be "quiz questions" that provide different way of testing concept knowledge. Sometimes he uses sets of questions to illustrate how this works, explaining how the progression of questions is aimed at higher order thinking. The underlying pedagogical methodology is that each new question builds on the concepts from the last question, and additionally each new question explores a higher cognate levels of Bloom's Taxonomy.

Rodger proffers multiple suggestions for instructors who are just adopting CRS. He emphasized the idea that instructors should always have a learning goal so they can make sure CRS questions are tailored to that goal. He believes that when CRS are utilized without a learning goal in mind, they are often used ineffectively. Within the idea of learning goals, he offered two more suggestions. The first is that instructors should aim high with their learning objectives. He knows this will invariably lead to poor scores on CRS questions, but if instructors choose to then engage and listen to student discussions, they will learn exactly where the problems lie. The second is that instructors should use the technology to build knowledge rather than to test it. Examinations are designed to measure student knowledge, but if they never understood it in the first place, an examination isn't going to help them learn it now.

> No matter how clearly you enunciate it, no matter how obvious it is to [another person in your field], your slide told a story. The point is, those English majors didn't get it, and just doing it again won't change anything. You do something different when you find out where the problems are – and the problem IS YOU (emphasis in original interview).

Rodger offered a last piece of advice regarding CRS, which might almost be considered words of caution to faculty in general. This soliloquy becomes somewhat critical toward instructors, so I thought it was best expressed in his own words.

> [Faculty] can't accept that there can be a failure to learn, but there can also be a failure to teach, and if you only accept one of those two statements <pauses for effect>. Students want to accept the failure [is] in teaching, and faculty want to accept that the failure [is] in student learning. And neither party wants to believe that they have any responsibility. Everything faculty complains about students, are in fact, traits of faculty. Metacognition about teaching is not rampant.

Vicki

Vicki is an associate professor in a science department at a moderately-sized public university. She teaches a variety of classes in her department, including both introductory courses in her program, and also classes comprised primarily of juniors and seniors. She started using CRS at her former university quite a few years ago. For Vickie, adoption of the technology came about for a variety of reasons. Her husband taught at the same university and his particular college was starting to see an influx of CRS use. He began using the devices, and would share information about his experiences with them. However, at this time the technology was still not available campus-wide. Shortly thereafter, two things happened that led to her initially using CRS. First, the technology was adopted campus-wide, including being introduced to Vicki's department. Around the same time, Vicki had the opportunity to teach a larger enrollment course. She thought this course would be a great opportunity to try CRS, so she began using them at the beginning of the semester.

A major factor in her decision to adopt CRS lie in the fact that Vicki always believed course attendance was a critical component in student success. However, she knew the university had a policy prohibiting either taking attendance or rewarding students for attending classes. From what she understood about CRS, she viewed the technology as a mechanism to really encourage attendance.

It did not take long for Vicki's focus to move from attendance to participation and engagement. In fact, she said that transition happened within the first few weeks of using the

devices. She said part of this change occurred because of conversations with her husband about the technology, but the other was directly related to a change in student behavior in the classroom. She saw them engaged and interacting in a manner that she wasn't familiar with from other courses. She also saw a different level of enjoyment, from both the students and herself. "It was more fun to teach. It was more fun to go to the classroom and have that student interaction - not only with them interacting [and] talking about the questions, but having [all of us] discuss it."

This experience was more than anecdotal for Vicki because she asked specific questions about CRS in her end-of-semester student course evaluations. There were a few who complained about feeling "forced" to attend, but she says the vast majority of responses indicated three things: Students said they were (1) more motivated to come to class, (2) more motivated to be prepared for course topics when attending, and (3) more motivated to participate in class discussion. She said they also became more comfortable during course interactions compared to what she had seen from other large classes. She attributes this, at least in part, to the switch in emphasis from just answering a question right or wrong and then moving on. Using CRS, students didn't seem to have the same fear of an incorrect response because they knew the question would continue to be explored *after* they provided an answer.

Through the semesters, Vicki says her use of CRS would not be described as change as much as it should more accurately be called evolution. She still uses them for participation and engagement, but she has also found new and different ways to reinforce concepts. She has found ways to take ideas that were not originally in her CRS questions and incorporate those into using that technology. This includes math concepts and calculations where the learning goal is practicing and reinforcing skills, as opposed to having students perform the calculations and

simply identifying the correct answers from a list of possible values. This moves the goal of the exercise away from reaffirming correct answers toward understand the concepts behind those calculations. Vicki reports her comfort level has increased over time, leading her to be really creative with questions. She also says she really enjoys asking opinion questions whose sole purpose is to stimulate conversations or discussions in the classroom.

Vicki says one unintended benefit of using CRS is that using them in class has been very enjoyable. There are multiple times that she describes the classroom experience with CRS as "really fun." She says there are times when this is on purpose, like when she decides to use them to play a game in class. But other times, she says the fun just happens because the students are willing to both ask questions and express themselves. She goes on to say that these questions are not just about concepts they don't know, but there are also times when they specifically question her. Vicki says that many professors might not invite these types of questions, but she makes a conscious effort to view this constructively as opposed to thinking it is criticism. As she put it, "The instructor is not always right. And it shows that, yes, we are still human…[and] we're still learning to some extent."

Vicki doesn't see any drawbacks to using the technology, but she does identify some unique challenges. Over time, she found that as she added CRS question to her lecture, there were instances where too many questions in a class period took time away from covering other course topics. So the focus shifted onto incorporating concepts *into* the CRS question, as opposed to presenting the question before or after the topic was covered. As she put it, "[The challenge] was trying to get good questions, trying to make sure that they're relevant, [and] trying to make sure that they're really reinforcing and really valuable rather than just doing it to do it."

Along with the evolutionary changes regarding the technology already mentioned, Vicki says there is one other major change in her teaching methodology when using CRS. She described having a very difficult time dealing with the occasional CRS hardware or software issue. Now she says those types of issues do not bother her the same way, and often times she defers back to simply asking for a show of hands. She says students are very willing to participate in these types of activities, but she believes it is because CRS gets them used to answering questions every day.

Vicki says learning this type of personal flexibility has been extremely helpful, and it extends beyond dealing with computer issues. She provides the example of a class that didn't understand a specific CRS question, but in every previous course she taught, the students never had an issue with that question. She says that learning flexibility has helped her realize that every class and every group of students is different. So rather than worry that she has a poor question (which is may not be, since other students clearly understood it), she now knows to encourage them to talk to each other and explore the question further. So rather than thinking this is a negative occurrence, she now realizes the exploration of the topic between students can be a very positive experience.

Over time, Vicki has noticed different student perceptions of CRS. Overall, she currently sees higher levels of acceptance than when she first adopted the technology. She believes this can be traced to the fact that most every student now utilizes CRS in multiple classes. However, some of the other differences in student perception require more exploration. She relates two stories that provide more insight into her experiences. In one incident, Vicki started using the technology just after she arrived at her current university. The majority of students in the course were seniors, and many of them expressed resentment over having to purchase CRS devices

during their last or penultimate semester. They knew none of their remaining courses would use the technology, so they considered it an unnecessary expenditure. She described this course as the lowest student evaluation scores she ever received, and she wonders how much of this was the potential CRS issue, and how much might have been attributed to her being a new instructor at the school and doing things differently than other faculty members.

This incident was especially concerning for her because these evaluation scores were included in her tenure review. However, when she had the chance to teach the exact same course a different time, the student evaluations were much more positive regarding CRS. She said this was very beneficial to her review because it showed that in the identical course with an identical student class-level demographic, the technology was very well received. This data, along with positive CRS feedback from all of her other courses, helped demonstrate two things. One, the tenure review board saw this as an aberration rather than a trend. Two, Vicki concluded that if students weren't ready to embrace using the technology, there was only so much benefit they would find from CRS.

The other experience Vicki had regarding students perception of CRS occurred when she found herself teaching a course for another department that did not use the technology. In the years leading up to this, she had been using CRS in every course she taught. However, now that she was in a classroom without the technology, she did notice a change in student behavior compared to her other courses. As she put it, "I had people engaged who were sitting in [the] front [of the class], but I had several people who were disengaged. I would love to have had CRS for that." This experience might be attributed to the fact that she was teaching a new course, or it could be due to her working with a different group of students. Regardless of the

reason, she just didn't feel like these students were engaged in the same manner as her CRS-based classes.

Vicki has some specific advice for any instructors thinking about adopting CRS, or for those who are just beginning to use the technology. She believes it is critical to start small and only ask about two questions per class when first using CRS. Because the instructor is only presenting a very limited number of questions, she hopes this really helps them concentrate on writing effective questions that directly reinforce course concepts. She also says it is important for instructors to know *why* they are using CRS. Once they identify their specific reason for using the technology, they can write their questions and award points based on that reason. If not, she believes it is easy to misalign the CRS questions away from their desired intention. Her final piece of advice is to occasionally use humor in they questions. As Vicki puts it, humor can lighten the question, it can help instructors laugh at themselves, and it can lead to students feeling more comfortable in the classroom.

Craig

Craig is a lecturer in a science department at a moderately-sized public university. He began teaching there nearly 10 years ago, and has been using CRS for a good portion of that time. He describes his decision to adopt the technology arose from a familiar pattern he saw developing in his classroom. He would ask a question and see one of two things happen: The same two or three students would repeatedly raise their hands, or he would sit in uncomfortable silence until either he or a student decided to talk. He attended some professional meetings where CRS were used, and he began so see some value in the technology. In the end, his decision for adoption was that he was simply trying to find a way to "wake kids up in class and keep them engaged and involved."

Craig says it did not take long for his use of CRS to progress beyond simple interaction and engagement. He soon found a major benefit to using the technology was reinforcement. However, this extended beyond the tradition idea of reinforcing student learning of a concept by repetition. His students expressed that when they missed an answer, but saw that 60% of the class also missed the same answer, it reinforced to them that they weren't alone in struggling with the concept. So, the technology not only helped them learn through traditional methods of repetition and reinforcement, it also led to reassurance that their learning match that of their peers.

His use of the technology is still evolving, especially as he uses them in different courses with higher-level students. When he first started using CRS, Craig says he almost exclusively used types of questions that were very straightforward with clear right or wrong answers. Years later, he still uses these types of questions, but he has also discovered other ways to use the technology. He talked about teaching a course where they were covering program management and leadership strategy. He wanted to emphasize that there are multiple ways to deal with any problem, so he started presenting questions where ALL the answers could be correct, depending on the situation. This type of question was more effective in this context because it served as a springboard for discussion. Craig said the next thing he knew, 20 minutes later they were still having a whole-class discussion on the topic. He believed this was not something that would be likely to occur if he was still asking those straightforward questions.

> I did some looking…and a lot of the research out there says asking those blatantly obvious right or wrong questions is probably not all that helpful. It misses the point of the technology. Ask a question that can be taken 4 or 5 different ways and see what they think and don't necessarily count it right or wrong. Get them to think on a deeper level on a topic, and give them credit just for answering the question. It's so much more valuable if it's a very ambiguous questions with multiple correct answers.

Craig reports these evolutions were a pedagogical choice for him. He believed that purposefully using them to evoke discussion was more beneficial than asking what he calls "softball" questions with only one right answer. He has also seen other pedagogical benefits with the technology. He says the immediate feedback has been very beneficial in immediately addressing misconceptions. Craig believes spending five minutes in class addressing an issue is much more effective than dealing with multiple students having problems on exams or quizzes. By that point, he believes it may be too late to deal with their misconceptions.

Another conscious change Craig made regarding the technology is employing peer learning strategies. Inspired by the peer learning research of Eric Mazur, he now specifically employs these types of exercises using CRS. He'll pose a question that has one correct answer, but he tries to provide more than one plausible answer. So, when he shows the student responses but the class is split as to what they believe is correct, he'll say, "Okay, we can't agree on what the right answer is. There is a right answer, tell me what you think." This is followed by students explaining why they picked a certain answer. As this process continues, the students come to the correct answer as a group, and in the meantime, they are essentially teaching each other in the process. He describes this as an evolution with CRS that directly resulted from using them long enough where he began to realize "what more the technology itself could do."

He does caution that using CRS in this manner should be a very deliberate choice from the instructor. Craig describes some instances where he employed the exact methodology described above, but the students weren't explicitly aware that he was attempting to show them how each answer could be "correct" provided there were different scenarios. Instead, the class would talk about the question and the variety of answers, and then move to the next topic. However, some students would raise their hands because they were still trying to find the "right"

answer. When this happened, Craig reported it was fairly obvious that students became easily frustrated. He said that he needed to really make a point of explaining to the students that *discussion* was the goal of the question, as opposed to them attempting to logically conclude which answers were right and wrong.

Craig has not seen any significant drawback to using CRS. He says that, just like any other technology, there are occasional problems that arise. He reports it does take a little more time outside of class because you need to consciously plan and integrate ways to incorporate CRS questions into the course, and then go back after class and manage the data. However, he says that additional time commitment is minimal. For those instructors concerned that CRS might take too much additional time in the classroom, Craig doesn't see that as a problem in his courses. He says that he only asks two or three questions per class, and these are typically focused on reinforcing concepts or they serve as a jumping off point for talking about a topic. For any instructor concerned that CRS might take too much time away from covering course material, he says, "I'd probably argue that maybe there's a different way you could use the technology and still accomplish [your goals], but do it in less time."

Craig has seen a significant change in his teaching style and methodology from before using the technology to now. Along with his evolution of using CRS already described, he says there are times he will employ a CRS-based technique without actually using the technology. For example, he says there are times when he thinks of something on the fly that would be a good CRS question, but he doesn't have one prepared for that topic. He says he has learned to employ those same peer learning techniques, even without using the technology. He is not sure these techniques are as effective as when the students actually see their peers' responses and know the class answers are split. However, Craig does believe this is still a valuable learning

exercise without the technology, and also says, "From a methods standpoint, I probably do some [things] I wouldn't have done six or seven years ago prior to using them."

Craig feels that students perceive the technology is beneficial in the classroom, and he has some data to reinforce that belief. Every semester, he polls the students and asks them about CRS, specifically about their usefulness, student engagement with and without the technology, and the enjoyment of class. He reports the responses have consistently been nearly unanimous as to the students liking them and realizing they are used for more than just gaining attendance points. From their responses, it seems to Craig that students realize there is value in the technology and they believe it is helpful. He believes this starts with them doing better in the class, but it really stems from their ability to understand the material at a deeper level. He believes this is better than what they might be familiar with, which is just consuming information that is quickly regurgitated.

Craig rarely finds himself defending the use of CRS. In his experience, he is more likely explaining how he uses the technology or helping to solve a problem with the software or hardware. Most of his conversations with faculty fall within a few specific areas: How does he use them, what is the personal value of using them, how can they be used regardless of program area or level of expertise, and what methods does he employ? He never really hears much "pushback" about CRS, and wonders if this has to do with the culture of using the technology at his university. Regardless, he says most of his time is spent discussing interest in adopting CRS, or helping find ways to make the technology more effective in the classroom. Craig finds himself explaining that they can be used for more than attendance or asking true and false questions. These conversations become very important because, as he puts it, "You can certainly

misuse [CRS]. It's not designed to be a multiple choice test. Certainly you can do that, but you're not using it right if that's all you're doing."

There were many times where Craig was asked to help an instructor who was just starting to use the technology. From his years of experience, he offers some very specific suggestions. First, he believes it is important to capture as much data as possible in the beginning, and then the instructor can figure out later what to do with that information. Over time an instructor may figure out over time what segment of the data they want to study, but they can only do so if they capture that information from the beginning. To that end, Craig suggests trial and error with the technology. He also suggests starting small. He proffers that an instructor first using CRS should focus more on quality than quantity. He believes it is much better to create two or three well-designed questions than to try and write many of them just to increase the frequency of use. He believes more people should focus on effective use and specifically avoid overuse. In his own words, Craig offers some very specific advice for instructors beginning to use CRS.

> Use it very minimally but use it very purposefully and think about what question you're asking. When are you asking it, why are you asking it, and [have] a sort of rhyme or reason behind asking it. I'm purposefully wording a question a very specific way at a specific time to reinforce something or introduce something.

Michael

Michael is an instructor at a large public university. He says his initial reason for adopting CRS was student influenced. There was one course in his college that always had an issue with attendance. No matter who instructed the class, they could only muster around 50% student attendance. Concurrently, some students in another course Michael taught began providing feedback that they would appreciate receiving something for attending. He knew that the university policy prevented rewarding students for attending a course. However, they could earn a reward for participation in course activities. As he began researching ways to accomplish

this, he believed CRS might be the tool he needed. The technology allowed the students who attended to earn points for answering questions, and earn additional credit for providing the correct answer. He said the technology was not about punishing those who didn't attend, but recognizing those who participated in class. He readily admits that some of the reasons for adopting CRS were self-serving. Michael knew he could accomplish a similar task by providing paper quizzes. However, he didn't want to manually grade papers, and CRS software could upload results directly into the university online learning management system.

Michael reported that CRS was about 90% effective in achieving his initial basic goals. But, as he learned more about the technology and as the needs of the course changed, he found it necessary to modify how he used CRS over time. When he first began using the technology, he would ask five questions, but only near the beginning of class. The students caught on to this pattern, and Michael soon noticed that students would come to class long enough to earn the participation points then leave after the last question was presented. This became disruptive to the entire class, as did those students who arrived late. So, he began modifying his CRS strategy to offer one question at the beginning of class, two at the end, and then a question about every 10 minutes during the course. He further incentivized participation by offering a bonus point if students answered every question during a class period.

Throughout the years, Michael said that he went through roughly 12-15 iterations of how he used CRS in his classroom. He attributes these changes to the evolution of his goals for using the technology. First, it was the reward for coming to class and participating. Then, it became the means to keep them in class the entire session. Continuing over time, he was able to more closely align his overall course goals with how he used the technology. Michael believes that critical thinking is the most important thing a student can learn. So, as he spent more time using

the technology, he saw it could be effective in helping to achieving exactly that goal. In time, he learned to shift away from what the technology actually did, and shift towards what the devices allowed him to do. As he put it, "It wasn't the tool itself, it was the outcomes that were important – the learning outcomes, not the point outcomes."

It wasn't long before he realized that the students were changing their behavior, as well. When they realized they could use their textbooks to help answer questions correctly and earn points, some began bringing them to class daily. Other times, he would get near the end of a course meeting and the class was engaged in a discussion. The students knew their last two questions, including the one that earned them a "bonus," had yet to be asked. They would diminish their conversation or even stop contributing altogether, and some even asked when the last questions would be provided. Michael did not want to interrupt the discussion and the spontaneous learning, so he would say to them, "Everyone is here. You're learning by being involved." He saw this as both a sign of engagement, and an indication that students were taking responsibility for their own learning process.

Michael began seeing other indications that students were taking ownership for their learning. The course had a paired student project and a five-person project. He began to realize that students saw who was bringing their text to class and knew who was paying attention and engaged in discussions. When it came time to choose partners or groups, students looked to pair up with people they already recognized as "good students." Once Michael saw this behavior, he began using it as a way to motivate students. He would say, "Look, if you're not doing anything, do you think the person next to you wants to work with you?" He would also ask for a show of hands to the question, "How many of you want to work with someone who doesn't buy-in?" These became ways for him to use existing student behavior to help motive those who needed it.

He did set the table for this type of behavior from the beginning of the course. In one of this first class meetings, Michael would outline his expectation that students needed to own their learning. He would ask the class questions like: Who gets you to class? Who does your laundry? Who makes sure that you eat every day? Naturally, every student would respond they were personally responsible for these activities. At which point, Michael would tell the students this was the same level of behavior and responsibility he expected from them in his course. Once he set that expectation, the students knew their behavior and their ability to succeed was in their control.

Students also began to question things more readily. There were times when Michael presented a topic in class, then a student would retort, "The author said something else somewhere else." He responded this was correct, but then asked the class why this was. Often times, it was another student who answered the question, and they explained that the reason for the apparent contradiction was the situation was different. This invariably led to a discussion of why the situation made for contradictory information, which was itself another learning opportunity. Michael also recognized this as peer teaching, which became another benefit of employing the technology to help engage students.

One other additional benefit to using CRS was student excitement. Michael says that students started responding with excitement when they answered a question correctly, sometimes even briefly clapping or softly cheering. He said this seemed to occur more frequently on questions with equally likely answers, and where the class vote was roughly split between those answers. He said it was never a matter of them gloating over those who missed the answer as much as it was celebrating success. He reported this was just another example of students moving from passive to active learners. He also saw students became less inhibited, which he

believed was a direct result of them gaining confidence. To Michael, this made perfect sense. The student formula for classroom success was not that difficult. The basic premise was: one, you have to come to class prepared, and two, you need to be actively engaged. When students did these things, they performed well on CRS questions, their grades reflected this success, and they felt good about themselves.

When he first adopted CRS, Michael notice some fairly significant issues with the technology behind the devices. There were times when he could not get the software to link with the hardware, He explains this was a problem with the University servers, which brought about its own unique bureaucratic issues. Regardless, it still meant he could not record participation points during that class session. He went on to explain that when this happened, his primary goal was to reassure the students they would still receive their participation points, but also minimize their potential frustration. As he put it, "The points were important to them. The points were important to me. But, not more important than encouraging them not to become negative about the process." Michael also found that the students were so familiar answering questions to the best of their ability that they continued to do so in these situations, even though their responses were not going to count for points on those days.

One of the main changes Michael saw in his teaching style over the years using CRS was that he would talk less while encouraging students to talk more. He doesn't know if this was a purposeful change, but he did realize it happened. He said he began focusing less and less on how *he* could motivate or engage them, but instead concentrated on students facilitating *their own* motivation. When he saw students talking after he posed a CRS question, he started realizing they were often discussing that very question. So rather than trying to explain everything to students, he felt he could help with their growth by not talking all the time. "[It]

stopped me from talking and controlling communication and making dictates on what the information meant to them talking to each other."

However, he believes this change in teaching styles would be difficult for many instructors because it represents a lack of control. In his experience, the vast majority of people teach to themselves. That is, they teach in the way that they construct knowledge. For those students who learn in an identical manner, they don't have a problem in the course. However, Michael says this methodology is missing the point. He believes an instructor's primary job is engaging as many students as possible, and really exploring how they can help each one of them. He believes CRS helps him accomplish this task because it allows him to relax in the classroom. He could post a question, and then sit back and really observe what the students were doing. Rather than talking and explaining all the time, it really allowed Michael to become more knowledgeable about his students.

Michael relayed a personal experience about learning this lesson the hard way. It happened long before he started using CRS, but the story really seems to shape his philosophy of what effective teaching looked like.

> The first time I ever taught, Supervised College Teaching, I was lecturing a classroom of 70 or 80. And I really thought I was doing great. And I turned to a person about 15-20 rows away, and I asked, "What did you think about it." There was no response, so I asked again. And [the student] responded, "Did you mean me?" And I said, "Yeah, what did you think about it?" And the student said, "I haven't been paying attention to you all class." And I took my pen out and put it in my ego balloon and said I better figure out where they're coming from, not where I want them to come from.

Over the years, he has seen a variety of student perceptions about the technology. In the beginning, there were quite a few complaints about paying for something they were only using in one class. At that point, Michael's was the only class that employed CRS they would be taking before finishing their degrees. However, after they started using the devices for a few weeks, he

never heard anyone complain about the money factor with that particular class. The next semester, he actually started teaching courses that were approximately 70% sophomores. Because these students were earlier in their academic careers, and because the technology was gaining more adoptions on campus every semester, he never heard any complaints about money after that first semester. Michael believes that overall, students were happy using the technology. In a typical semester where he taught between 120 and 160 students, he might have one or two complaints on course evaluations that CRS "forced me to come to class."

He does believe the technology is helpful in deterring some common negative behaviors in the classroom. Michael reported he no longer needed to focus on discouraging cheating because the devices were very effective at encouraging interaction. So, rather than students craning their necks to read from each other's work, they spent time sharing and collaborating with each other. He was quick to point out that he always taught in smaller classes, and thought it might be a problem in courses with more students. On one occasion, he knew someone was cheating because there were two more CRS votes than students in the room. Of course, he had to address this issue through to its logical conclusion. But, he said those types of incidents were exceedingly rare.

He rarely needed to defend the use of CRS to his colleagues, but often found himself explaining them to fellow instructors. Michael frequently engaged in conversation with other faculty already using the devices, and he would hear about the problems they encountered with the technology. Regardless of the specific problem, he would continue to promote using CRS to these instructor because he believed so strongly in their utility. Over time, these conversations seemed to shift from talking about problems to sharing best practices when using the technology. For those who continued to use CRS, many started focusing on employing them more effectively

in the classroom. For those not interested in the devices, they stopped talking about it completely. In fact, he says he could usually tell after the first conversation there were instructors who would never consider using them.

Michael relayed an account of two colleagues in his department who taught the same course he did, but stopped using the devices after one semester. In those courses, the grading criteria was set by the department, so there were only 10% of the points any instructor could use at their discretion. In prior courses, these points fell into the category of "professional behavior" and could be awarded or deducted for a variety of student behaviors. These typically ranged from timeliness, to paying attention in class, and could even be deducted for "unprofessional" attire. Based on his interaction and conversations with these two instructors, Michael believed they dropped CRS from their courses because they didn't want to give up the control those professional points provided. These instructors felt they yielded control of their classroom because they could no longer give what Michael called "bad marks" to these students for their detrimental behavior or clothing choices.

Ironically, Michael said the first person he needed to convince to use CRS was himself. He said there was an instructor in his department who began using them a year before Michael adopted them. As he heard that instructor talk about the devices and what they could do, Michael thought to himself, "That is stupid, why would you ever do that?" He went on to explain that even when he did choose to use them, it was not because he thought they were great, but rather he thought it could solve a specific problem without creating significantly more work for himself. It was only over time that he began reading the literature and observing and experimenting with other ways to use the technology. In the end, he concluded it was the proper employment of CRS that actually led to all the benefits often proffered by research.

For those just starting to use the technology, or for those considering adoption, Michael says the first thing he suggests is really exploring CRS literature. In preparation for the interview, he said he found plenty of sources on why they should be used, and how to use them effectively. To that end, he also suggests seeking out an instructor who has used them for a while. He refers back to the fact that it took him 12-15 different iterations of using CRS before he became really happy with his chosen methods. He is quite sure other instructors have shared a similar experience, and could pass along those small changes and nuances that really helped them. He also recommends instructors start to think beyond the idea of "right answers." He recommends learning to use the technology well enough so an instructor can start providing multiple correct solutions to a given question. Because this type of question can move away from the dichotomous right or wrong answers, this will lead to a variety of teachable opportunities.

Chapter 5

DISCUSSION

The goal of this research was to provide a more complete and compelling narrative of how CRS was utilized by five different instructors. In this study, there is an element of theoretical replication (Yin 2003) because the same type of technology was employed in each instructor's classroom. However, this is where many of the similarities between research subjects ends. These instructors taught at three different universities, and every instructor works in a unique department from the others. In some instances, the physical technology was not identical because different universities adopted different CRS brands as their campus-wide standard. Additionally, these instructors did not receive identical training on using the technology. Lastly, the personal research each instructor conducted into the pedagogical benefits of CRS occurred independently from each other.

Addressing Generalization

As previously mentioned, the goal of a cumulative multiple case study is not generalization. Each instructor's experience is independent of the other and should be treated as such. However, Stake (2000) explains it is sometimes difficult to separate commonalities that emerge during data analysis, and generalizations of these types are impossible to avoid. It is important to remember that commonalities in this study are isolated to these five research subjects. For instance, each of these instructors might indicate they use CRS to help achieve an identical goal. This does not mean we need to infer that specific goal is the reason other instructors should also adopt the technology. Indeed, it appears a better goal than trying to generalize findings is creating research that is rich enough it allows others to generate their own

informed interpretation. "[R]esearcher's [should] describe the cases in sufficient descriptive narrative so that readers can vicariously experience these happenings and draw conclusions (which may differ from those of the researcher)" (pp. 439, parenthesis in original).

Emerging Themes from Data Analysis

Because the instructors' experiences were largely independent, it seems noteworthy when they expressed similar sentiments regarding the technology. As the same words or ideas were repeated by multiple instructors, they were identified as shared experiential trends for this group. While many of these trends are similar to the common reasons for CRS adoption presented in the Introduction, it should again be noted this data was analyzed using the general inductive approach. I was aware of the common reasons provided for adoption, but my research questions regarding this topic were open ended. Rather than ask them if any of the common reasons were a factor in their choice to adopt the technology, I simply asked why did they started using them (See Appendix C).

Engagement

There was a word that every instructor mentioned in conjunction with how and why they used CRS: engagement. Each instructor talked about the desire to engage students in the classroom and keep them involved in the learning process. The idea of engagement is currently gaining traction as one of the key elements correlated to student success. In fact, there is now a National Survey of Student Engagement (NSSE) released every year to evaluate this pedagogical concept. First published in 2000, this survey instrument has been completed by 4.5 million students at 1,574 participating colleges and universities ("National Survey of Student Engagement," 2014b). The NSSE looks at student engagement in two ways. The first is student time and effort devoted to "their studies and other educationally purposeful activities." The

second is how institutions "get students to participate in activities that decades of research studies show are linked to student learning."

One hypothesis derived from a past NSSE survey postulates the role that expectations play in engagement. Kuh (2003) suggests students rarely exceed their own academic expectations, and in general they only do what is demanded of them. However, a notable exception to this phenomenon is when instructors challenge students to exceed their self-imposed expectations while concurrently providing support for that success. The most recent NSSE survey concluded "Faculty who spent more time working to improve their teaching interacted more with students. They also had significantly higher learning expectations for their students and more often used effective teaching practices" ("National Survey of Student Engagement," 2014a, p. 8). Certainly, utilizing CRS to improve student engagement is an example of raising student learning expectations.

Another premise arising from past NSSE data is the speculation that students and teachers find it easy to enter a "disengagement compact." Kuh (2003) describes this as "I won't make you work too hard (read a lot, write a lot) so that I won't have to grade as many papers or explain why you aren't performing well" (p. 28). This "agreement" is seen as a failure from both learners and instructors because it holds neither party liable for exerting less than maximum effort.

Peer Instruction via Group and Cooperative Learning

Multiple instructors mentioned peer instruction as one of the key benefit of employing the technology. McKeachie, Pintrich, Yi-Guang, and Smith (1986) found that students instructing each other can be a successful method to increase student learning. For CRS, this can take a variety of forms, ranging from the simple instances where students see their peers'

answers all the way to a very structured group exercise where learners work together to achieve a common goal. Chip, Rodger, and Michael all specifically mentioned employing group work in their courses. However, both Rodger and Michael specifically mentioned this group work did not involve CRS. So, while CRS can be used for peer and group instruction, at times some instructors wanted to employ the pedagogy independent of the technology.

It should also be noted that using CRS to achieve cooperative learning requires utilizing very specific techniques. This is because students simply working together is not the same as cooperative learning. To truly attain cooperative learning, there must be a common goal where all students in a group are rewarded for their collective achievement instead of their individual efforts (Johnson et al., 1991). Put another way:

> A cooperative group has a sense of individual accountability that means that all students need to know the material…for the group to be successful. Putting students into groups does not necessarily gain positive interdependence and/or individual accountability; it has to be structured and managed by the teacher or professor (Roger & Johnson, 1988, p. 35).

Michael discussed this concept, albeit without making specific reference to the specific pedagogy. In his course, the students completed both a two-person and a five-person group project. He recalled that students started taking notice of who came to class with their textbook and prepared to answer CRS question. When it came time to self-select for groups, those students who demonstrated preparedness were highly sought after, while unprepared students were left searching for partners or groups. This falls in line with cooperative learning theory because unprepared students would be viewed as marginally beneficial or even potentially detrimental to the collective group effort. Michael even began pointing this out to his classes in an effort to motivate them. He would say, "Look, if you're not doing anything, do you think the person next to you wants to work with you? How many of you want to work with someone who doesn't buy-in?"

Increasing Responsibility in the Classroom

Some of these instructors believe CRS is one way to return accountability to both sides. Students become responsible for more of their learning, and instructors have to employ different pedagogical methodologies to utilize the technology effectively. Michael mentioned a shift in student learning responsibility multiple times. He describes how after he started employing the devices, he saw an increase in student interaction. If he failed to note the correct answer to a CRS question, or if there were any other issues regarding the technology, students immediately asked him about this, or contacted him outside of normal class hours. He saw this as a major improvement from what he was used to, with students only interacting when they needed to. He mentioned that before using CRS, there were times the only contact he ever had with some students was an email letting him know they were ill and could not make it to class. Chip cited a similar reason for employing the devices. He believed one of the advantages of utilizing them was to shift the expectation and the onus back to the learner. As he put it, "[CRS] put a little bit of obligation or responsibility on the students. You know, 'Gee, are you coming in here expecting to sit back and I'm going to teach everything?' Wrong. Wrong class."

Using CRS Evolves with Time and Experience

Every instructor said there was a process by which they moved beyond the original goals they set when adopting CRS. While individual reasons for adoption varied, all of these teachers expressed they wanted to do something different than the traditional lecture-based classroom. Words like "evolution" and "iterations" came up repeatedly, indicating there was a change and growth from what they did in the beginning to when they finally felt satisfied with how they chose to use CRS. Chip said there was a period of about five years when he only asked three question per class. However, he became convinced that peer learning though discussion was

working in his classrooms, so he has since doubled his CRS questions to a total of six. Craig describes that he first started using the devices in a very straightforward manner, only asking questions with clear right or wrong answers. He came to recognize CRS could be used to stimulate higher order discussion if he wrote questions where ALL of the answers were right because this forced students to analyze concepts as opposed to regurgitating facts. Vicki talked about reinforcing concepts, but described how that evolved in her classroom. Through the semesters, she found that she was excited to use CRS in new and creative ways to help teach her students important calculations they would use in their professional careers.

These changes may not be surprising, considering these instructors chose to employ the technology CRS in the first place. However, this raises a very important question: Does this type of evolution and change originate from the instructor and their chosen pedagogical methodologies, or is it because the technology continues to reveal its versatility with more experience? It seems very likely that both contribute to these changes, with each instructor deciding the prevalence of each factor.

Success is not Methodology Dependent

Every instructor espoused the virtues of CRS, which is not surprising. As previously stated, why would anyone use this technology for at least five years if they didn't believe it was beneficial? However, each instructor provided different reasons or methodologies regarding their use of CRS. Rodger teaches a course whose enrollment typically fluctuated between 110 – 150 students every semester. He was very clear about using CRS in this course, saying, "I would never teach that large lecture class again without them." At the same time, he also teaches an upper-division course with about 40 students, but chooses not to employ the technology in that class. He specifically wants this group of learners to understand how concepts are connected, so

his concern is, “when you write a [CRS] question, and you [only] have four [or] five [possible answers], you constrain their choices, you constrain their thinking.” Conversely, Craig chooses to use the technology in exactly the opposite manner. “I enjoy and see more value in using them in smaller classroom settings than in the 60-70 seat lecture halls. I try to get as much of the small classroom experience in the big classroom as I can, but it’s just tough.”

Sometimes Less can be More

Multiple instructors expressed that using CRS helped them realize they should talk less, or even find times to stop talking altogether. As Chip put it, “They were probably really learning more talking with each other than listening to me.” For instructors to realize there are times when their voice might actually get in the way of student learning can be a very large paradigm shift because it directly contradicts traditional instructional methods where talking and explaining *are* teaching. This idea is thoroughly described in Donald Finkel’s *Teaching with your Mouth Shut* (2000), and Jane Vella’s *Learning to Listen, Learning to Teach* (2002). Michael’s experience seems like an excellent example of this phenomenon. Through his self-described 12-15 iterations of evolving how he used CRS, he realized over and over that the traditional teaching methods were insufficient in helping him achieve his ultimate goals. As Michael put it, “I just kept saying, I feel like I’m doing less and they’re learning more.” Ultimately, he realized there were certain times when facilitating conversation was a far more effective learning tool than any teaching method he might employ. The most recent NSSE survey concluded the same thing, saying, “The more time faculty spent trying to improve their teaching, the less time they spent lecturing in their courses and the more time they spent engaging students in discussion, small-group activities, student presentations or performances, and experiential activities” ("National Survey of Student Engagement," 2014a, p. 8).

One could argue that when Michael declared he was "doing less," what he really meant was that he acted *less* rigid or adhered *less* to traditional teaching methods. When an instructor stops sharing their views on a subject, this provides students with the freedom to express what that topic means to them, or discuss how to apply it to their personal life. Ultimately, if topics can be applied, they become knowledge that is retained and recalled more readily. Garside (1996) compared instruction using traditional lecture and group discussion methods. She reported that group discussions produced significantly more learning of higher level items. Another study saw higher mean test scores with group discussion compared to traditional lecture methods (Safari, Yazdanpanah, Ghafarian, & Yazdanpanah, 2006).

Knight and Wood (2005) also studied the technique of reducing lecture and increasing interaction, and their findings indicate this can lead to higher learning gains with students demonstrating a better understanding of course concepts. Research suggests the interaction component may be specifically critical to this process. Gayford (1995) found learning was more effective in group discussion than when students worked alone. This research also noted the student groups benefitting most from these discussions were those displaying middle and lower ability. A study by Brady, Seli, and Rosenthal (2013) found similar results when investigating CRS and student learning gains.

> When efforts are made by instructors to improve learning situations, it is the lower and middle level learners who stand to gain the most. The higher performing students seem to adjust and perform regardless of how difficult a subject, how great the demands of the course, or even how boring the lecture is perceived to be (p. 898).

These findings are similar to Roger's anecdotal experience that the top 20% of students in his classes succeed because they are self-directed, and the bottom 20% don't succeed because they lack motivation. However, it was this middle 60% that "wants to learn and they struggle to learn." This was the group Roger felt he could impact most by using CRS.

Employing Deep Learning Pedagogy

Rodger, Vicki, and Craig all discussed ways they employed CRS to encourage higher order (i.e. deeper) learning in an attempt to increase understanding of course concepts. Over the semesters, Vicki had students perform calculations in her class because this is a critical skill for learners in her field of study. Eventually, she evolved her CRS use to the point where she employed the devices to teach the concepts behind the calculations rather than just having students identify a correct numerical answer. Rodger said one of his changes over time was to cut back on the number of CRS questions he asked per class. He then revised the remaining queries in an attempt to teach students a process-based methodology that focused on higher-cognate learning goals. Both of these examples are identical to the notion proposed by Hounsell (1997), who said that deeper student learning can be achieved by teaching concepts and principles rather than focusing on specific facts.

Craig discussed how he evolved beyond using CRS to ask standard multiple choice questions with straightforward answers. He wanted students to understand how contingencies can impact certain outcomes, so he began asking questions where all the listed solutions would be correct given certain situations. His goal was to teach problem solving, not recall and regurgitation of facts. This is similar to other deep learning pedagogy methods where learners are given the contextual foundations of a scenario and then asked to provide explanations, formulate predictions, and pose questions (Chin & Brown, 2000; Cox & Clark, 1998).

Redistributing Power in the Classroom

Considering the research findings regarding discussion and interaction, it begs the question as to why lecture is still widely employed. One possible reason for this could be the power dynamic in the classroom. There is an obvious discrepancy between the power of the

learner and that of the teacher, and instructors find themselves in a position of authority for multiple reasons: They hold a higher degree than their learners, they are considered the subject matter expert, they issue student grades, and ultimately they are responsible for the format of the class. For all of these reasons and more, the teacher's voice carries the greatest weight, and is what most students are conditioned to listen to.

Research suggests that both teachers' and students' perceptions of their power in the classroom can have an impact on the education experience (Lovorn, Sunal, Christensen, Sunal, & Shwery, 2012). With this in mind, the question becomes how to acknowledge and account for this power differential. By purposefully reducing lecture while simultaneously encouraging more discussion, instructors are attempting to deviate from traditional classroom power roles with the specific intent that students are constructing their own learning. In other words, the instructor purposefully shifts the learning responsibility back to the students, empowering them to discuss what information is personally most beneficial. Perhaps not surprisingly, multiple studies indicate that discussion can lead to higher achievement and better learning gains (Garside, 1996; Gayford, 1995; Knight & Wood, 2005; Safari et al., 2006).

These instructors provided other examples of how CRS helped shift the classroom power dynamic. Multiple instructors mentioned that after they started employing the technology, they believed students in these classes tended to question things more readily. They would challenge something they read in the course textbook, or they might ask questions that extended beyond the scope of the course. At times, these questions even extended beyond the scope of that instructor's knowledge. Both Michael and Vicki individually expressed this is hard for some instructors because they take this type of questioning as criticism. However, every single

instructor interviewed for this research specifically expressed that challenging traditional teaching methods was a good thing.

There may not be a better example of challenging the traditional classroom than when a student questions either the instructor or the course textbook. Any individual who has tried to teach knows that sometimes the instructor does not know all the answers. When a student is engaged enough in a course to challenge information normally presented as fact, this represents a challenge to normative behavior in the classroom. As Michael put it,

> They didn't feel like they were second class, [like] this is the professor (he holds his hand high), [and] this is where I am (he drops his hand lower). So it built more of a respect, a mutual respect from both [sides].

Additionally, when an instructor admits to not knowing a piece of information, but then tells the class they will research the answer, it lets every student know this type of challenge is not only allowed, it is welcomed. This helps students understand the instructor is human just like everyone else. However, it also sets two very important precedents in the classroom. First, the instructor demonstrates they are an active part of the learning process. These instructors are demanding engagement and responsibility from students, but they also display these traits in their teaching. Second, this provides an excellent example to students – sometimes you already know the answers, but other times you must seek the solutions. After all, the basis for knowledge and research does not start with answers, but with the pursuit of questions.

<u>More Evidence for Increasing Student Achievement</u>

This research uncovered some other noteworthy occurrences. As mentioned in the research findings, Michael was limited as to how many points he could assign to CRS participation. Because of departmental policy, instructors only have freedom to dictate 10% of the overall course grade. Thus, from a purely quantitative perspective, CRS points could only

impact a relatively small proportion of the total points earned in the class. With that in mind, when Michael looked at performance in identical courses over the years, he saw an increase in student grades post-adoption of the technology. Michael was quick to point out his opinions as to why these changes occurred. "I can't say it's all because of the [CRS] because I never tried to inflate grades, and I was a really rigorous grader." Since he believed these improvements were not a result of earning points with CRS, he attributed them to the other factors in the classroom. He saw students more engaged, they came to class prepared to answer questions, and they took more responsibility for their learning.

Michael provided an example of how all of these things came together in his classroom. When he utilized CRS, the software allowed him to set a time limit for each question. He would be happy to extend this time, and could easily do so with the CRS interface. However, he only did this if students specifically asked for this time extension. At the beginning of the semester, a student would be working on the problem and realize they didn't have enough time to complete the answer. That student would raise their hand, wait to be called on, and then ask for more time. Invariably, by the time all of those things occurred, the time limit for the question expired. It wasn't long before students learned to communicate concisely, and would just start saying, "20 more seconds, Michael." This showed him that students were engaged and they took responsibility for their own learning.

Enjoyment

Another interesting observation was realizing how many times Vicki mentioned CRS in conjunction with fun and enjoyment. She also talked about using the devices to provide humor, and emphasized that writing CRS questions allowed her to express creativity. Each time she mentioned these things, she specifically discussed them in terms of how they improved the

student experience in the classroom. Research indicates there is a positive correlation between teacher and student enjoyment in the classroom (Frenzel, Goetz, Lüdtke, Pekrun, & Sutton, 2009). Another study found that students "valued a formative assessment activity that was fun, nonthreatening, and gave them feedback on their learning" (Hudson & Bristow, 2006, p. 36). Both the literature and the interviews conducted for this research indicates CRS can accomplish these three goals.

From her interview, it was apparent that Vicki enjoyed using CRS. However, she directed these efforts with a very specific methodology in mind because she utilized the technology as a vehicle to enhance overall student enjoyment in her classroom. It wasn't as though having fun would replace learning, it was that having fun could enhance learning. Put another way, "Effective teachers choose pedagogies that allow them to enjoy the process and get their students involved" (Nakamura & Csikszentmihalyi, 2005).

Technology versus Methodology

To a person, each instructor provided an example of employing a teaching methodology normally used with CRS, but doing so without actually using the technology. Craig often asks questions on the fly and has students respond just through discussion or by a show of hands. In his smaller, upper-division courses where he doesn't use CRS, Rodger still frequently employs think-pair-share exercises. He wants to challenge these students, and he wants peer learning to occur, but as discussed earlier, he doesn't see the need to employ the technology to achieve those goals.

Individually, and in their own way, each instructor expressed that CRS is a means to accomplish their overall pedagogical goals. Whether the goal was engagement, increasing discussion, addressing student misconceptions, or a combination of these things, the technology

could help achieve any of these objectives. Nonetheless, this should not be further extrapolated that the technology is the single best way to accomplish any of these particular goals in a classroom. As Michael put it, "It wasn't the tool itself, it was the outcomes that were important – the learning outcomes, not the point outcomes." There are multiple ways to achieve any of the above goals, and many of them do not employ these devices. However, it appears one of the main benefits of CRS is that they can accomplish a multitude of learning goals in a relatively easy manner. The technology is not particularly expensive for students or the universities, the software and graphic interface is not typically considered challenging to utilize, and there are enough adopters in each school that help seems relatively easy to find.

A great example of this is from Chip. He said that one of the unintended benefits of using the technology is that he would ask a CRS question, and then walk around the classroom to listen to student discussions. After doing this, he quickly came to realize there was much more value in listening to these discussion than in simply waiting for all the students to answer via their devices, and progressing from there. Normally, there are many choices in what an instructor does after seeing all the student answers. Typically, they can affirm the correct answers, address the misconceptions, or open the floor up to a whole-class discussion. However, Chip said none of these things were as valuable to him as simply hearing their discussions. Students engaged differently on a peer level, and they used different language in these conversations. They weren't necessarily afraid of being wrong, and when they tried to convince each other, it became apparent what they did and did not know. This type of discussion became a critical goal in Chip's classroom, and CRS was simply a means to that end.

Research on this topic also produced some rather fascinating results. In their research on peer instruction, CRS use, and student discussions, James and Willoughby (2011) found that

roughly 38% of student discourse was a "standard conversation." They defined this term as a dialogue "where conversation partners discussed aspects of at least one multiple choice alternative provided in a clicker question, and individual clicker responses were representative of ideas that individuals had articulated." In the remaining 62% of the conversations, students either deliberated about answers that were not one of the multiple choice alternatives provided by the instructor, or provided a CRS answer they had not discussed with other students during their dialogue (James & Willoughby, 2011).

While these finding may have a multitude of implications for utilizing CRS for peer instruction techniques, there seem to be two conclusions that can be safely drawn from this study. The first is that instructors would be wise to utilize pedagogy techniques that allow them to hear these conversations. The second implication is that the statistical data provided by CRS indicating the number of student responses for any particular answer may only tell part of the story. After all, if students are choosing an answer they never discussed, it could indicate a lack of concept knowledge. After all, a students can select the correct multiple choice response without knowing how of why the answer is factually correct.

Moving Forward and Suggestions for Further Research

One might hope these benefits ultimately pay off in better-equipped college graduates. Gardiner (1998) conducted a meta-analysis of the American educational experience. He investigated what our society expects college graduates to possess, and then evaluated students on those expectations. He found the average college graduate struggled to deal with abstract concepts, there was a lack of understanding regarding the critical thinking process, and some showed very little improvement in problem-solving skills from pre- to post-college. His meta-analysis further revealed that 70-90% of instructors primarily used lecture methods in the

classroom, active participation in some classrooms occurs only about 14% of the time, and about 90% of questions employed by teachers only required recall of facts, not comprehension of concepts (Gardiner, 1998). While his research is correlational, it does imply that students are ultimately "getting out" of their education what instructors are "putting in."

From these stories, there are a number of emerging research topics regarding CRS use, or integrating more interaction and student centered teaching into the classroom. In a five instructor sub-sample, there was a discrepancy over using them in different sized courses. One possible study could compare how and why the devices are used in large or small enrollment courses. Another study could investigate instructors who bypass traditional CRS question methodology and focus on using the devices primarily to encourage discussion. Further research could also explore pedagogy that encourages student interaction and investigate other ways CRS could be used to encourage student collaborative learning. Additionally, it could be revelatory to investigate CRS and power dynamics in the classroom. This could be studied from a student-centered perspective and investigating their perceptions of power and CRS. It could also be examined from the instructor viewpoint and exploring the conscious decision to redistribute power to the learners.

Two other potential ideas for future research emerged during the dissertation defense. One idea was a correlational study investigating CRS and student grades. Since there are myriad studies on this subject, I believe it would be much more beneficial to explore using the technology to enhance deeper thinking, or investigate how they might help an instructor teach complex course topics. An example of this is a study regarding CRS use in a 300-seat organic chemistry course (Morrison et al., 2014). In this research, the technology was employed for "sequence response applications" in which a set of questions are given, and then the answers to

each question specifically contain multiple variables that essentially multiply the overall potential number of correct answers. This technique can approximate free response and also decreases the probability of arriving at the correct answer via random guessing. The instructors found CRS could be used to effectively teach conceptually challenging concepts, and also to teach the conceptual skill of multistep problem solving (Morrison et al., 2014).

The other potential study would be to use an identical interview technique, but then incorporating a mixed-method longitudinal design that also triangulates student course evaluations and grades over time. I think this would be especially interesting if the study focused on instructors who were new CRS adopters (using them less than one year), and the data would follow their growth and evolution in using the technology through year five. This would essentially be another way to tell a very similar story to my present research, but adding student data to bolster the investigation.

Additional Recommendations Using Scholarly Personal Narrative

I would also like to offer some professional recommendations based on this research and my personal experience using CRS. To accomplish this, I am going to use the Scholarly Personal Narrative model made popular by Nash (2004). He defines this as a methodology where the researcher's knowledge and experiences, shared in the first-person, are given scholarly recognition. He believes Scholarly Personal Narrative is important because it acknowledges:

> That your own life has meaning, both for you and for others. Your own life tells a story (or a series of stories) that, when narrated well, can deliver to your readers those delicious aha! moments of self and social insight that are all too rare in more conventional forms of research (p. 24).

In my personal use of this technology for the last seven years, I have seen very little sharing of experiences or techniques directly between instructors. When I have asked other teachers how they got started with the technology, almost every response has been the same.

They knew someone who used CRS, they asked that other person about how or why they use the devices, and this was followed with a specific decision to adopt the technology. Some instructors then attended a brief session outlining some very basic ways to use CRS. (The one I attended before initially adopting the technology was a one-hour session hosted by the device manufacturer. I also know our university has an on-campus group that supports instructors, and their office also offers brief introductory sessions). After this initial session, it is my experience that virtually all instructors act alone in researching or improving how they use CRS.

There are a variety of ways these instructors gain further knowledge about utilizing the technology. Each of the three institutions where I performed my research has essentially the same resources. There is a webpage talking about the technology, which includes links for setting them up, using them, and getting help to resolve problems. The website also has links to topics like best practices and research espousing the value of CRS, and this information is easily accessible to any faculty member.

If an instructor wants to explore some of the deeper pedagogical methodologies, they are then left to explore scholarly articles and peer reviewed journals. While this information is also not terribly difficult to find, to really implement this knowledge takes a great deal of time and commitment. From my own experiences, it is very time- consuming to analyze your course material specifically looking for places to install CRS questions. Even if an instructor is willing to do these things, it is no small feat to correctly transform the pedagogical concept into a tangible reality that can be successfully implemented in your classroom. This takes not only time, but a fairly comprehensive knowledge and understanding of educational methodology and pedagogical techniques. Personally, I view this very similarly to the earlier discussion of surface versus deep learning. Instructors wishing to do things like simply reward attendance are using

CRS as a surface *teaching* tool. Just like students engaged in surface learning, these instructors are performing the minimum amount of work possible to achieve a minimal goal.

Unfortunately, I would have to say that, based on my experience and the available resources, most colleges and universities seem ill prepared to help instructors move to the next level of CRS instruction. The question then becomes, what are the ways that learning institutions can help instructors engage in what could be called *deeper teaching* (to continue with this analogy).

I am proposing three separate but related ideas that I believe colleges and universities could implement to help instructors advance their CRS teaching. The first is a face-to-face forum where teachers can gather and discuss use of the technology or the pedagogy behind their teaching methodologies. It would be important to discuss both of these ideas because, as per the research findings, the devices are really a means to achieve a pedagogical end. I believe instructor meetings twice a semester would be a useful starting increment of time. While a web-based forum would be easier to maintain, I believe instructors would only periodically engage in this manner, leading to less effective communication and sharing of ideas. Additionally, the rationale behind face-to-face discussion is the same as the reason for conducting in-person interviews for this research. Quite simply, these techniques lead to better discourse and sharing of information.

Another reason for choosing this approach is that it uses many of the same beneficial learning theories proffered in this research. After all, we are willing to challenge our students to benefit from different learning methodologies, but we could benefit from these exact same practices if given the opportunity. Instructors conversing and teaching each other is peer learning, and face-to-face interaction is designed to increase learner engagement. Additionally,

with instructors sharing their myriad personal stories of how they use the technology, this further illustrates that success is not methodology-dependent. This idea was driven home to me during my research interviews and while writing this dissertation. As previously mentioned, I have been using CRS for seven years, during which time I have written numerous research papers about the devices. Yet, with all of that experience and after reading so many scholarly articles on the technology, these five instructors shared ways they use CRS that I had never heard or thought of. This really illustrated to me that there are so many ways to use the technology and the accompanying pedagogy to accomplish learning goals.

The two other ways I am proposing to connect instructors to learn from each other is through mentorship and classroom observation. Both of these could be accomplished through something similar to a LinkedIn network of instructors who utilize CRS (if it was not a trademark violation I would attempt to call it ClickedIn). Instructors could register, provide their current level of CRS knowledge and experience, and then this information would be available to other teachers using the technology. Instructors with less knowledge or experience could easily find their more experienced counterparts and then arrange for mentorship or classroom observation opportunities. In fact, I would make sure that any new CRS adopters in the university were strongly encouraged to join the network so they could start benefitting even before using the technology. Not only would this provide more peer instruction opportunities, it also allow instructors to benefit from experiential learning.

I want to share a personal story that I believe illustrates the benefit of utilizing these methodologies. I have long valued the immediate feedback and contingent instruction that CRS provides in my classroom. This has always been relatively easy to achieve by simply asking questions in-class and then addressing student misconception when necessary. However, two

related ideas showed me I could be using these pedagogical techniques exclusive of CRS. First, it occurred to me that if feedback on in-class CRS questions was beneficial to student learning, the same should be true if students received feedback on their exam questions. Shortly after I had this thought, I read a research article in one of my PhD courses that confirmed feedback on test questions can actually enhance learning retention (Butler & Roediger, 2008).

Based on this information, I decided I need to improve student feedback on exams. However, this idea is easier said than done in a class of 90 students. I did not want to turn to online tests as I received feedback in another course that students did not believe online examinations were very valuable. Student answers were submitted on scantron forms, so I attached the individual grading report to each exam and then handed these back to students during class. Students were allowed to look over their exams and I also encouraged them to ask me questions.

Over roughly a five-year window, what was interesting to me was the distinct lack of questions raised by students. I knew what they had scored on the exams, so I obviously knew they missed some of the questions. However, students seemed hesitant to bring up questions in front of the class. Many times, when students did want to ask questions, they came up individually to address things with me.

I honestly believed students were benefitting from being able to review their exams. Still, it seemed clear to me that while I could answer any questions they raised over the exam, this benefit was rather limited by the lack of questions my students were asking. However, another observation I made was that a few students would ask each other about missed questions. I began to wonder if the most efficient way to accomplish my desired goal was to utilize peer learning. I decided to experiment with this hypothesis, so when the next opportunity for exam

review occurred, I specifically instructed students to discuss their exams and investigate missed questions by asking each other. The results of this were astounding, especially compared to what I had observed during the prior 5 years. After just a couple of minutes, the room was abuzz with conversations about course concepts. I quickly realized this method was vastly superior to what I had been doing, and decided I needed to incorporate this into other classes I taught. I believe this is such a valuable process that in one of my classes where students perform a multitude of calculations, I actually award half of the missed points back if students correct their exams AND provide specific feedback as to why they missed the question.

This story illustrates a few things related to my research. First, the benefit of the methodology is sometimes independent of using CRS itself. This was also borne out in my research, as a number of these instructors talked about the benefits of utilizing the pedagogy without the technology. Additionally, I personally believe one of the most beneficial aspects of this process was possessing the experiential knowledge that peer instruction is an effective teaching technique. In my opinion, it takes a great deal of trust and faith in the process to turn the classroom completely over to students.

Having just done this review process a mere three weeks ago, I was again amazed at how effective this technique can be. At the beginning of the review session, I announced that I was separating the students into groups where they would analyze their exam. One student actually groaned out loud, and he asked if this is all we were doing that day. I replied that the only way to earn points back was to review his exam and then provide me with specific feedback on missed questions. Of particular note to this process is that I say as little as possible and encourage them to first use their classmates as resources. I distributed exams back to students and they began reviewing them together. Roughly 30 minutes later, a rather amazing thing

happened. The student who had been complaining was actually approaching the other groups and offering to help them on some of the difficult questions. To me, this incident illustrated the value of the review process, but I think it also provided the additional benefit of giving this particular student a boost to his self-confidence. Additionally, as I walked around the room and heard them discussing their exams, I realized there was literally nothing I could have said at that time to help them learn the information any better than how they were teaching each other. In all honesty, this was one of the proudest teaching moments I have ever experienced and I could not wipe the big grin off my face the rest of the class. And, in a final tie-in to my research, this once again illustrated that sometimes doing less allows students to learn so much more.

Conclusion

These stories provide examples of how and why five unique instructors utilize CRS in their classes. In some instances, they provide specific details on using the technology in a variety of settings. At other times, they illustrate the overall importance of pedagogical goals and instructional methodology. With that in mind, there are obviously myriad choices of how to use CRS in any level of classroom. However, the goal of this research was to provide examples of how several long-term adaptors use the technology. Regardless of if a person is considering adopting the technology, or if they already use them extensively, the hope is this research serves as a valuable resource to any person seeking more information about CRS use in an applied setting.

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APPENDIX A

Script for Contacting Instructors who Utilizing CRS for at Least 5 Years.

GREETING

Hello

My name is Eric Milholland. I am a PhD Candidate in Education and Human Resource Studies at Colorado State University. I am conducting research for my PhD dissertation by examining how instructors employ Classroom Response Systems to achieve their specific learning objectives. To that end, I am seeking out instructors who have utilized CRS for a minimum of 5 years. I contacted the university bookstore and they informed me your course fulfilled that criterion.

I understand how valuable your time is, so before I precede any further, have you utilized CRS for at least 5 years and would you be interested in participating in this research?

IF THE RESPONSE IS "NO"

Would you happen to know another instructor who meets the 5 year CRS usage criteria?

AFTER THEIR RESPONSE, MOVE TO SALUTATION

IF THE RESPONSE IS "YES" OR "*WHAT DOES THE RESEARCH ENTAIL?"*

I want to assure you this research project has been approved by the Colorado State University Institutional Review Board (IRB) for human subjects. Any information I gather will be confidential and used for research purposes only.

This research is being performed from a constructivist framework. This means you and I will work together to co-create the research, and you will have input as to what data emerges from the inquiry process. What I need from each instructor is first conduct a face-to-face interview to discuss your learning objectives with CRS. I would then observe 2 – 3 of your class sessions to lend a third-person perspective to how CRS is used in your course. Finally, we would have another face-to-face meeting where we would discuss and create the emerging data. I may also need to contact you in subsequent weeks and months to further discuss or clarify our research finding.

BACKGROUND INTO THIS RESEARCH

For my master's thesis, I investigated student attitudes towards the use of CRS in their classrooms. Working with two of my mentors in our department, I was fortunate enough to get this research published in a peer-reviewed journal. As I have moved forward with my PhD in Education, and have continued to perform research on CRS, I thought it was important to alter my research focus. I have read numerous research articles regarding potential student benefits when utilizing CRS. However, I have yet to discover any research on how instructors utilize CRS to achieve specific classroom goals.

The reason I chose 5 years of CRS use as a minimum research criteria was because I believe instructors utilizing CRS for this length of time should (1) be very comfortable with the technology and (2) can understand and identify how they personally use CRS to achieve their desired learning objectives. Additionally, I am in my 6th year of using CRS in my own courses, and personally feel like it took me about 5 years to fully understand how I could effectively utilize CRS to achieve my learning outcomes.

I also believe my experience with CRS leaves me uniquely qualified to discuss and co-create constructivist research with instructors. While we may not teach the same subject or courses, I believe my teaching experience and prior research has prepared me to understand important concepts regarding the technology, such as: reasons for initially adopting CRS, potential benefits of the technology, and constraints or limitations of these devices.

If everything sounds okay to you, at this point I would like to arrange a time when we can hold our first interview.

DISCUSS INTERVIEW LOGISTICS – DATE, TIME, PLACE, DURATION

Additionally, if I can get your email address I will send you a copy of the research questions I will use as a guideline in our first interview. I feel it is important you look these over so you have plenty of time to consider your answers to these questions. I can also send you a copy of the IRB approval form or my research proposal.

SALUTATION – IF NOT PARTICIPATING

Thank you very much for your time, and I hope you have a great day.

SALUTATION – FOR PARTICIPANTS

Thank you very much for your time, and I look forward to meeting you and working with you on this research. Have a great day.

APPENDIX B

General Questions for Initial Face-to-Face Interview with Selected Instructors

1. As an instructor, what were your initial goals or desires when adopting CRS?
2. Do you feel that CRS was effective in helping you achieve these goals or desires?
3. Over time, has your use of CRS or your goals for the technology changed? If so, how?
4. What, if any, additional or unintended benefits did you find when using the technology?
5. What, if any, were the drawbacks of CRS adoption?
6. Have you changed your teaching styles or methods as a result of utilizing CRS?
7. Do you feel student perceptions of your course have changed since adopting CRS?
8. Have you ever found yourself in a discussion with colleagues where you were explaining or "defending" your use of CRS?
9. What advice would you offer for an instructor who was considering adopting CRS, or was just starting to use the technology?

APPENDIX C

Informed Consent Cover Letter for Instructors

CSU letterhead

Date

Dear Participant,

My name is Eric Milholland and I am a researcher from Colorado State University in the School of Education. We are conducting a research study on instructors and Classroom Responses Systems. The title of our project is "A multiple case study of instructors utilizing Classroom Response Systems (CRS) to achieve pedagogical goals." I am the Principal Investigator and the Co-Principal Investigator is Dr. Karen Kaminski from the School of Education.

We would like to conduct multiple interviews with you to discuss your learning goals associated with CRS and how you use the technology to achieve those aims. We would also like to conduct teaching observations so we can examine your use of CRS during a regularly scheduled class meeting. All research activities will take place at your university. Participation will take approximately 4 hours total for the interviews and we expect to observe you for 1 or 2 class meetings. Additionally, all personal interviews will be audio recorded to ensure data is captured completely and accurately.

Your participation in this research is voluntary, and scheduling an interview or observation indicates your consent to participate in this research. If you decide to participate in the study, you may withdraw your consent and stop participation at any time without penalty.

For this case study, you will be assigned a pseudonym and all personal identifying information will remain anonymous. The only people who will have access to this data are those directly involved with either its gathering or analysis. While there are no direct benefits to you, we hope to gain more knowledge of how instructors use CRS to achieve specific learning outcomes. Also, in exchange for your participation you will be given access to the completed research.

There are no known risks to participating in this study. It is not possible to identify all potential risks in research procedures, but the researcher(s) have taken reasonable safeguards to minimize any known and potential, but unknown, risks.

If you have any questions, please contact Eric Milholland at (970) 491-5127 or Dr. Karen Kaminski at (970) 491-3713 If you have any questions about your rights as a volunteer in this research, contact Janell Barker, Human Research Administrator, at 970-491-1655.

Sincerely,

Karen Kaminski, PhD
Principal Investigator
Assistant Professor
Colorado State University

Eric Milholland, PhD Candidate (ABD)
Co-Principle Investigator
Instructor
Colorado State University