THE EFFECT OF ELECTRONIC RESPONSE SYSTEMS: 
RELATIONSHIP BETWEEN PERCEPTIONS AND CLASS PERFORMANCE, 
AND DIFFERENCE BY GENDER AND ACADEMIC ABILITY

A DISSERTATION

SUBMITTED TO THE GRADUATE SCHOOL

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE

DOCTOR OF PHILOSOPHY

BY

JULIE M. KIEFER

DR. JON M. CLAUSEN - CHAIR

BALL STATE UNIVERSITY

MUNCIE, INDIANA

DECEMBER 2013
DEDICATION

I would like to dedicate this dissertation to my husband, Ted, for his unconditional love during this long process. I would also like to dedicate this dissertation to my parents, Mike and Sue, and my sister, Kristy, who have believed in me from the beginning.
ACKNOWLEDGEMENTS

I would like to thank Dr. Jon M. Clausen for serving as my dissertation committee chair and advisor, and Dr. Nancy Brooks, Dr. Sheron Fraser-Burgess, and Dr. Allen Truell for serving on my committee. My thanks and appreciation is also given to Larry Markle, Ball State University Director of Disabled Student Development. Without the support and assistance of each of you, this success would not have been possible.

I would also like to Dr. Greg MaGee and Gary Friesen for their gracious assistance with this study.
The current study sought to extend knowledge on effectiveness of Electronic Response Systems (ERS) or “clickers” in a college classroom by comparing student assessment performance between two sections (n = 41 & 42) of a Biblical Studies course in a small evangelical university. Student characteristics were virtually identical in the classes, taught by the same instructor. In one section, the instructor used ERS two to four times a week to administer quizzes or start discussions. Results showed no statistically significant evidence of improved performance in the ERS class, measured on a wide variety of assignment, quiz, and exam scores, including pre-test/post-test improvement in knowledge. Gender, prior GPA, and other demographic differences did not interact with the manipulation. It was speculated that use of ERS may have failed to make a difference in the current study because the system was not used frequently enough or for engaging activities, or because the use of ERS in a small class may not have provided benefits beyond the usual class experience. Interestingly, however, a student survey given at the beginning and end of the semester showed that students in the ERS class significantly improved their opinion of the system, indicating that they felt they had performed
better as a result of using the clickers. (Students’ opinions in the control class declined.) Thus, students believed that ERS had improved their performance, although objectively it had not. It was concluded that relying on student opinions on the benefits of ERS may be misleading.
# TABLE OF CONTENTS

CHAPTER ONE: INTRODUCTION .............................................................................................................. 1  
  Background ........................................................................................................................................... 2  
  Area of Concern ................................................................................................................................. 4  
  Problem and Purpose ....................................................................................................................... 8  
  Significance of the Study .................................................................................................................. 8  
  Research Questions .......................................................................................................................... 9  
  Definitions .......................................................................................................................................... 10  
  Basic Assumptions ............................................................................................................................ 12  
  Delimitations ...................................................................................................................................... 12  
  Limitations .......................................................................................................................................... 13  
  Summary ............................................................................................................................................. 14  

CHAPTER TWO: REVIEW OF RELATED LITERATURE .............................................................................. 16  
  Cognition, Constructivism, and Active Learning .............................................................................. 16  
  Electronic Response Systems ........................................................................................................... 24  
  Perceived Benefits and Disadvantages of ERS .............................................................................. 26  
  Literature on Aspects of ERS Requiring Further Study ................................................................. 44  
  Summary ............................................................................................................................................. 65  

CHAPTER THREE: METHODOLOGY ........................................................................................................ 66  
  Restatement of Purpose .................................................................................................................... 66  
  Participants .......................................................................................................................................... 68  
  Equipment Used ................................................................................................................................. 70
<table>
<thead>
<tr>
<th>Measure/Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measures</td>
<td>70</td>
</tr>
<tr>
<td>Research Design</td>
<td>71</td>
</tr>
<tr>
<td>Procedures</td>
<td>74</td>
</tr>
<tr>
<td>Data Analysis and Display Procedure</td>
<td>76</td>
</tr>
<tr>
<td>Summary</td>
<td>81</td>
</tr>
<tr>
<td>CHAPTER FOUR: RESULTS</td>
<td>82</td>
</tr>
<tr>
<td>Descriptive Statistics</td>
<td>83</td>
</tr>
<tr>
<td>Analyses of Research Questions</td>
<td>87</td>
</tr>
<tr>
<td>Exploratory Analyses</td>
<td>98</td>
</tr>
<tr>
<td>Summary</td>
<td>108</td>
</tr>
<tr>
<td>CHAPTER FIVE: SUMMARY AND CONCLUSIONS</td>
<td>111</td>
</tr>
<tr>
<td>Conclusion and Discussion</td>
<td>114</td>
</tr>
<tr>
<td>Summary</td>
<td>132</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>133</td>
</tr>
<tr>
<td>APPENDIX A. Taylor University IRB Approval Letter</td>
<td>147</td>
</tr>
<tr>
<td>APPENDIX B. Ball State University IRB Approval Letter</td>
<td>148</td>
</tr>
<tr>
<td>APPENDIX C. Demographic Questionnaire</td>
<td>149</td>
</tr>
<tr>
<td>APPENDIX D. Student Perception Questionnaire</td>
<td>151</td>
</tr>
<tr>
<td>APPENDIX E. Dr. Martyn Permission Letter</td>
<td>153</td>
</tr>
<tr>
<td>APPENDIX F. Informed Consent Form</td>
<td>154</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Figure 1.</td>
<td>Illustration of study design using the Campbell &amp; Stanley (1963) representation.</td>
</tr>
<tr>
<td>Figure 2.</td>
<td>Distribution of final course grade scores.</td>
</tr>
<tr>
<td>Figure 3.</td>
<td>Comparison between classes on exams.</td>
</tr>
<tr>
<td>Figure 4.</td>
<td>Comparison between classes on quizzes.</td>
</tr>
<tr>
<td>Figure 5.</td>
<td>Comparison between classes on scripture memorization.</td>
</tr>
<tr>
<td>Figure 6.</td>
<td>Comparison between classes on journal scores.</td>
</tr>
<tr>
<td>Figure 7.</td>
<td>Comparison between classes on reading scores.</td>
</tr>
<tr>
<td>Figure 8.</td>
<td>Change in perceptions of ERS between beginning and end of semester in the two classes on question “Using clickers in this class would improve my grade in the course.”</td>
</tr>
<tr>
<td>Figure 9.</td>
<td>Change in perceptions of ERS between beginning and end of semester in the two classes on question “Using clickers in this class would improve my understanding of the course subject content.”</td>
</tr>
<tr>
<td>Figure 10.</td>
<td>Change in perceptions of ERS between beginning and end of semester in the two classes on question “Using clickers in this class would increase my feeling of belonging in this course.”</td>
</tr>
<tr>
<td>Figure 11.</td>
<td>Change in perceptions of ERS between beginning and end of semester in the two classes on question “Using clickers in this class would increase my interaction with the instructor.”</td>
</tr>
<tr>
<td>Figure 12.</td>
<td>Change in perceptions of ERS between beginning and end of semester in the two classes on question “Using clickers in this class would increase my interaction with other students.”</td>
</tr>
<tr>
<td>Figure 13.</td>
<td>Change in perceptions of ERS between beginning and end of semester in the two classes on question “Using clickers in this class would improve my...”</td>
</tr>
</tbody>
</table>
classes on question “I would enjoy using clickers in this class.” .......................... 107

*Figure 14.* Change in perceptions of ERS between beginning and end of semester in the two classes on question “I would recommend using clickers in class in this course.” .... 108
TABLES

Table 1  Reports of Experience with Personal Electronic Devices ........................................... 84
Table 2  Summary of Main Outcome Measures (Graded Assignments and Tests) .................. 86
Table 3  Comparison between Control and ERS Student Performance, Main Assessments ... 88
Table 4  Comparison between Control and ERS Student Performance, Secondary Assessments
................................................................................................................................................. 89
Table 5  Summaries of ANOVAs for the Effects of Gender and Class on Main Student
Assessments .................................................................................................................................... 90
Table 6  Summaries of ANOVAs for the Effects of Gender and Class on Quiz Scores .......... 92
Table 7  Summaries of ANOVAs for the Effects of Gender and Class on Scripture
Memorization and Reading ............................................................................................................. 94
Table 8  Summaries of ANOVAs for the Effects of Gender and Class on Journals ............... 95
Table 9  Use of ERS in Kindergarten Through 12th Grade and in College ......................... 97
Table 10 Correlations between Student Performance and Pre-test, Post-test, and Difference
Scores .............................................................................................................................................. 99
Table 11 Summary of Studies in which ERS Classes (or Groups within Classes) Were
Compared to Controls .................................................................................................................... 117
CHAPTER ONE: INTRODUCTION

"Tell me, and I forget. Teach me, and I may remember. Involve me, and I learn."

Benjamin Franklin (as cited in LeFan, 2012, p. 42)

The principal purpose of this study was to explore the use of Electronic Response Systems (ERS) in a college course. This chapter begins with “Background,” a history of efforts to encourage interactions between instructor and student. This section introduces the concept of active learning, and describes some limited research done into the concept and the limitations of traditional active learning techniques. The second section, “Area of Concern,” describes the specific concerns addressed in the study. These areas of concern include use of ERS to maintain student attention, use of ERS as an active learning technique, and limited ERS classroom research. The third and fourth sections are “Problem and Purpose,” noting the lack of information on ERS use and the need for more information on it, and “Significance of the Study,” noting the ways in which the study helps supply the needed information. A fifth section presents “Research Questions,” and a sixth supplies “Definitions.” The chapter ends with sections on “Basic Assumptions,” “Delimitations,” and “Limitations.”
Background

Throughout history, instructors have recognized the importance of promoting interaction between student and teacher, as well as between student and student, to foster learning (Berge, 1996). While the modern label of “active learning” is relatively new, the concept underlying it is not. Educators have promoted active involvement of students in the learning process since ancient times for, as stated by Sophocles, “one must learn by doing the thing, for though you think you know it—you have no certainty until you try” (as cited in Mahmood, Tariq, & Javed, 2011, p. 194).

Strategies employed by instructors to promote student involvement in learning have varied over the centuries (Grabinger & Dunlap, 1995; Overholser, 1992). Using the method that has come to bear his name, Socrates sought to aid students in discovering answers to concepts themselves through the use of probing questions designed to channel the students’ own thought processes instead of just providing them with a solution (Overholser, 1992). Other educators have advocated different strategies. John Dewey proposed in 1910 the idea of “student-directed reforms and experiential learning,” and in 1961, Bruner “advocated discovery or inquiry learning around realistic problems” (Grabinger & Dunlap, 1995, p. 12). In more recent classroom pedagogy, “pair and share” may be used, in which students hear a question from the professor and then turn to a classmate to discuss their responses. As they do so, the professor circulates through the room to listen to what the groups are saying to each other or joins in the coupled conversations (Mahmood et al., 2011).

Active Learning

All of the methods described above exemplify a form of “active learning.” Phillips and Soltis (2004) noted that the concept of active learning derives from John Dewey’s proposition
that “learning happens as a result of our ‘doing’ and ‘experiencing’ things in the world as we successfully solve real problems that are genuinely meaningful to us” (p. 7).

Active learning can be defined as any instructional technique in which students are engaged in their learning process (Prince, 2004). It may involve traditional activities like homework, but “in practice active learning refers to activities that are introduced into the classroom” along with the traditional lecture (Prince, 2004, p. 1). Active learning necessitates that students think about what they are doing while they are involved in meaningful activities, and is contrasted with the traditional lecture format in which students sit and passively receive information that the instructor supplies (Prince, 2004). Keyser (2000) clarified that using active learning techniques does not mean that professors must entirely omit their lectures. Instead, short lectures of five to ten minutes can still be conducted for the purpose of introducing basic concepts of a new body of knowledge and then be followed by an active learning exercise.

**Limitations of traditional active learning techniques.** Historic forms of active learning discussed above, such as the Socratic method or pair and share, confront a limitation in that the professor can interact only with one student, or at most a handful of students, at one time. The instructor could not simultaneously know what other students in a class were thinking or to what extent they had mastered a concept. Now, however, in the last half century, the advent of electronic technology in the classroom has opened a new world of possibility. ERS (the handheld devices used for responses are colloquially called “clickers,” so the entire system is often referred to with that term) now allows all students in a class simultaneously to express views on a topic that the entire class can see and then engage in further discussion among themselves. Furthermore, it allows the instructor to know what concepts are understood, or not, and remediate misunderstandings immediately.
The goal of using ERS in the classroom is to promote student engagement and improved performance. Claims have been made that use of ERS can encourage and enhance active learning (Judson & Sawada, 2002; Lantz, 2010; Premkumar & Coupal, 2008), but these claims have not been empirically supported. It is argued that using ERS promotes active learning, through the use of clickers and the discussion that follows after a question has been asked (FitzPatrick, Finn, & Campisi, 2011; Madigan, 2006; Skinner, 2009). For example, a professor may pose a question to the class, and after the students click their responses, the results are displayed. The students can subsequently discuss among themselves why they chose certain answers, and the professor can circulate among the groups and participate in the discussion. (Berry, 2009; Cummings & Hsu, 2007; Sprague & Dahl, 2010).

**Area of Concern**

Universities are changing. According to Baker, Matulich, and Papp (2007), “We live in a dynamic, global and increasingly ‘flat’ world where technology is all around us” (p. 31), and universities are embracing this trend. Consequently, using videotapes and overhead projectors or giving multiple-choice tests using a scantron machine has become increasingly rare. Instead, in-class technology is expanding to include laptops, online testing, LCD projectors, and ERS (Morgan, 2008). According to Holderied (2011), these “interactive technologies have become ubiquitous in higher education as a means of delivering learning content to students in a more engaging manner” and promote active learning (p. 23). There does not seem to be an agreed-upon definition of the term “interactive technology” in education. Those found in the literature tend to be very broad, such as this definition from the description of the scope of the journal *Interactive Technology and Smart Education*: “As used in the context of this journal: Interactive
Technology refers to all forms of digital technology… emphasizing innovation and human-/user-centered approaches” (EmeraldInsight, 2012, para. 2).

**Student Attention**

Getting students to pay attention in class is important. According to Baker et al. (2007), “The average student’s attention span is only seven minutes,” and as a result “if students are asked to sit through a traditional 50-minute class that involves lecture only, they will become disinterested and disengaged very quickly” (p. 28). Although such claims vary widely, largely because of the lack of a consistent definition of attention span, and there seems not to have been historical comparisons made, there is general agreement that college students have relatively short attention spans (Wilson & Korn, 2007). Most current undergraduate students have grown up using the Internet, and making use of a wide variety of technology is second nature to them (McCurry & Hunter-Revell, 2011). They text their friends to plan an event after class, as they “are creating and engaging their social world in ways shaped by the technologies that surround them” (Guthrie & Carlin, 2005, para. 3). They carry iPods, laptop computers, cell phones, and iBooks. No longer do they read traditional paperback books but instead employ a Kindle to peruse the latest bestseller (ACRL Research Planning and Review Committee, 2010). A survey of over 28,000 college and university students in 2006 showed that half owned four or more electronic devices, defined as a digital camera, computer, music/video/game device, wireless hub, personal digital assistant (PDA) or smart phone. Over 92% owned at least two such devices (EDUCAUSE, 2006). As Baker et al. (2007) noted, “They are visual and kinesthetic learners who prefer to experience the world through multimedia and not in print” (p. 27). Thus, their attention can presumably be held for longer periods by electronic devices than by lectures.
Knowing these characteristics about this group of students, it is incumbent on professors to do all they can to reach them in their classrooms and have lessons designed to engage their learning styles (Baker et al., 2007). After all, upon graduation these students will enter the workforce and become the next generation of leaders. Baker et al. (2007) have argued that it is essential “to do all we can to prepare them for a dynamic, uncertain and clearly digital world” (p. 31). Using ERS in the classroom can be one step toward preparing them for the digital world of work for which Baker et al. believe they will need training.

**ERS as an Active Learning Technique**

ERS clickers are small handheld devices, similar to a TV remote control, normally the size of a credit card. They allow students to engage in classroom instruction as they answer questions by pressing the keypad on the device. The results are transmitted to a receiver in front of the classroom, which inputs the information and anonymously displays it on the screen utilizing a program such as PowerPoint (Sevian & Robinson, 2011). Therefore, the classroom is not only centered on the professor teaching the lesson, but the ERS engages the student as the instructor speaks (Holderied, 2011; Mahmood et al., 2011). Dill (2008) argued that through this engagement students are actively participating in the process of learning, and the professor is connecting to the technologically-savvy students. Because this generation of students has grown up with a wide variety of technologies, including texting and clicking to reveal sites on the Internet, and seeing clickers used on TV shows like *Who Wants To Be A Millionaire*, this technology is one with which most students today are very familiar (Caldwell, 2007). Using such devices will help students become more active in the classroom, according to Guthrie and Carlin (2005).
Overview of ERS Classroom Research

There have been many investigations into the use of ERS in university classes. For example, instructors have looked at the effects on student attendance when ERS was introduced into a course, finding noticeable improvement in attendance rates (Hatch, Jensen, & Moore, 2005; Ribbens, 2007). One study examined whether students participate more in classes that use ERS versus those that do not, and found nearly 100% participation in class sessions where ERS was used (Carnaghan & Webb, 2005). Another study looked at whether satisfaction with the use of ERS in class led to higher overall course evaluations for the instructor, concluding that such use did result in higher evaluation scores (Miller, Ashar, & Getz, 2003).

Questions that have not been fully studied include:

1. To what extent does the use of ERS affect actual academic success of students?
2. What are students’ perceptions of how well they do in class as a result of using ERS? In terms of self-efficacy, is there a match between how much of a difference they perceive in their academic performance when ERS are employed and how much of a difference actually occurs?
3. To what extent does the use of ERS affect the engagement, academic success, and perception of academic success of male and female students differently?
4. To what extent does the use of ERS affect the engagement, academic success, and perception of academic success of students with higher and lower GPA differently?

This study sought to answer a number of these questions.
Problem and Purpose

Proponents of using ERS in the classroom argue that it can enhance student academic performance by engaging them in active learning so that they will better internalize course content (Eastman, 2007; Eastman, Iyer, & Eastman, 2009, 2011; Hoffman & Goodwin, 2006; Judson & Sawada, 2002; Martyn, 2007). While researchers know much about general student perception of the benefits and disadvantages of using ERS, researchers know very little about the extent to which differences in academic performance correlate with such perceptions. Also unstudied is whether ERS use affects male and female students, or academically more or less gifted students (as measured by GPA, for example), similarly or disproportionately.

The purpose of this study was to obtain more information about the use of ERS in a college classroom, specifically whether academic performance is better than in a non-ERS class, whether students’ perceptions of ERS differed depending on their experience, and whether perceptions and/or ERS effects differed by student gender and/or academic ability. To make these determinations, a quantitative study was conducted in two sections of a course, one using ERS and the other not. Questionnaires were given to students in both course sections regarding their perceptions of the advantages and disadvantages of using ERS, and the results compared to actual quiz and test scores. The course section that did not use ERS served as the control group. Specific discussion of the methodology will take place in Chapter Three.

Significance of the Study

This study is important because, unlike previous studies that focused primarily on subjective evaluations from students and professors as to the benefits and disadvantages of ERS in the classroom as a means of advancing active learning, this study examined whether such
perceptions are warranted and corresponded with actual differences in academic performance. It also contributes new knowledge about whether use of ERS benefits different groups of students (male and female; students with higher or lower GPA) equally or whether there are significant observable variations corresponding with these characteristics. Finally, the study aids the university at which was conducted to assess the value of using ERS in the classroom and whether or not to expand ERS into additional course sections and classes.

**Research Questions**

A main question for the study has been devised that encompasses student perceptions of ERS and academic performance (scores on tests and quizzes) of the students in class. The main question is:

*What is the effect of ERS use within a small introduction to Biblical Studies course?*

This question can be broken down into several sub-questions:

*Q1: Is there a significant difference between student assessment performance based on use of ERS?*

*Q2: Is there a significant difference between student assessment performance based on use of ERS with gender added?*

*Q3: Is there a significant difference between student assessment performance controlling for the influence of GPA?*

*Q4: Is there a significant difference between student assessment performance controlling for the influence of GPA with gender added?*
Q5: Is there a significant difference in student perceptions in the use of an ERS based on their use of ERS?

Definitions

A number of concepts and technical terms are key to understanding this study. This section provides definitions of these concepts and terms.

Active Learning

Active learning is an instructional technique to engage students in the learning process (Prince, 2004). Active learning primarily references activities that are introduced into the classroom and necessitates that students think about what they are doing while they are involved in meaningful activities, and is contrasted with the traditional lecture format in which students sit and passively receive information that the instructor supplies (Prince, 2004). The goal of active learning is to improve student retention (Hoffman & Goodwin, 2006). Active learning is the process whereby “students engage the material they study through reading, writing, talking, listening, and reflecting,” and it “stands in contrast to ‘standard’ modes of instruction in which teachers do most of the talking and students are passive” (“What is active learning?” 2008).

Clicker

A clicker is a handheld device that students use in classes with ERS. Clickers can range in size from that of a television remote control to as small as a credit card. Clickers are one of the main components of the ERS, and they are the devices used by students to enter their responses to multiple-choice questions solicited by the professor (Ribbens, 2007).
**Electronic Response Systems**

Electronic Response Systems (ERS) are a type of computer system used in the classroom to poll students and gain instantaneous response through electronic remote clickers to questions from the professor (Caldwell, 2007; Deal, 2007; Karaman, 2011). ERS include the clickers and receiver that professors and students use in class to transmit electronic data. The results of the information received can be displayed on a projected screen. The data provide immediate and anonymous feedback (Ribbens, 2007). ERS can be used for a variety of in-class activities including discussions, reviews, and tests (Kenwright, 2009). TurningPoint is the brand name of the ERS used at the small, midwestern university where this study was conducted.

**Real-Time Feedback**

A benefit of ERS is real-time feedback: Professors are able to know instantly the students’ responses to the questions. An instructor knows immediately if the class understands a concept or is confused by it. This immediate feedback allows for the modification of instruction according to whether the class correctly or incorrectly perceives what is being taught (Ribbens, 2007).

**Receiver**

The receiver is a device, usually located in the front of the room, which electronically receives, collects, and stores the information transmitted from the clickers. Receivers are wireless and can be transported from room to room. They can collect information from more than one professor’s course (Lantz, 2010).

**Self-efficacy**

Self-efficacy “is the belief about one’s capability to learn or perform effectively” (Bandura, 1994; Ramdass & Zimmerman, 2011, p. 198). It deals “*primarily* with cognitive
perceptions of competence,” and “self-efficacy judgments are meta-judgments, or reflections, about one’s mental and physical abilities” (Hughes, Galbraith, & White, 2011, p. 278). “A person may consider himself or herself to be quite efficacious in a certain area, e.g. mathematics, but much less so in another, e.g. languages” (Vrugt, Oort, & Waardenburg, 2009, p. 351). Students with high feelings of self-efficacy will perform better academically than those students with lower feelings of it (Ramdass & Zimmerman, 2011).

**Basic Assumptions**

In the course of this study, several basic assumptions were made. They are:

1. The professor of the course has had ample training in how to use the ERS.
2. The average academic ability level of the students in the control group was equivalent to that of the students in the experimental group.
3. The students did not cheat or copy during examinations, which would skew the test results.
4. Students learn equally well in the class section that met for 50 minutes on Monday, Wednesday, and Friday as they do in the class section that met for 75 minutes on Tuesday and Thursday.

**Delimitations**

With this study, there were several delimitations in the sense that the researcher made decisions that restricted the scope of the study somewhat.

1. The principal delimitation was that the researcher chose to conduct the study at a certain university. This was a practical decision related to convenience and access. Although
restricting the generalizability of the results, the particular site is dissimilar in many ways from those of previous studies, thus contributing new information to the field, as described in detail below.

2. The researcher chose to focus on smaller classrooms. This limited the number of participants, but also provided new information, as very few previous studies on the use of ERS have been conducted in small classes.

3. Similarly, the classes studied were liberal arts courses, in contrast to the more technologically-oriented subjects in most previous research.

4. The researcher decided to keep to a minimum the material to be gathered from the students, focusing more on exam and quiz scores that would be available from the instructor. This was done to encourage participation and to minimize disruption to the classes.

Limitations

In addition, some basic limitations exist with regard to the time of the study, sample size, and diversity of the students.

1. The instructor of the classes studied did not use ERS at every class meeting, but rather once or twice a week. Therefore, the impact of ERS use might have been less than with an instructor who depends more heavily on it. Mitigating this is the fact that this instructor’s approach was probably fairly typical of instructors who use ERS, as can be seen from the descriptions in the following chapter.

2. The study took place at a small, private, evangelical midwestern university. This university is an interdenominational Christian institution. The student body of
approximately 1,900 undergraduates, while drawn from 44 states and 22 foreign countries, is nearly 35% from one particular midwestern state. It is comprised of 56% female students, 44% male students, and 12% minority students. Thirty-eight percent of the student body graduated in the top 10% of their high school class, with an average high school grade point average of 3.6 on a 4.0 scale (“Profile,” 2012). Therefore, generalizing to other, more diverse college populations may be limited.

3. The study was conducted only from January 30-May 10, 2013. The sample was students enrolled in two sections of an introductory Biblical Studies course. Thus, results may be limited to this time and setting.

4. The sample size was limited to 83 students, with approximately even division between each section of the course. A larger sample would have presumably yielded more reliable results.

5. One section met three days a week for 50 minutes, and the other section met two days a week for 75 minutes. Therefore, the classes may not be completely comparable.

6. Student GPA was obtained through self-reporting. Thus, accuracy of this data is limited by the knowledge and honesty of the participants.

**Summary**

The principal purpose of the study is to explore the use of ERS in the college course. This chapter began with a section on “Background,” a history of efforts to encourage interactions between instructor and student. This section described active learning and the research done into the concept. Following this was a section on “Area of Concern,” describing the specific concerns to be addressed in the study: maintaining student attention, and ERS as an active learning
technique, and including an overview of ERS classroom research. The third and fourth sections were “Problem and Purpose,” on the lack of information on ERS use and the need for more information on it, and “Significance of the Study,” on the ways in which the study helps supply the needed information. A fifth section presented “Research Questions,” and a sixth supplied “Definitions.” The chapter ended with sections on “Basic Assumptions,” “Delimitations,” and “Limitations.”
CHAPTER TWO: REVIEW OF RELATED LITERATURE

This chapter summarizes the literature relevant to the question of what effects Electronic Response Systems (ERS) may have in a class in which it is used. It begins with a section on cognition, constructivism, and active learning, followed by a section on the development of ERS, described in chronological order, and the purpose of ERS use in the classroom. The third section, “Perceived Benefits and Disadvantages of ERS,” takes up much of the chapter. It includes subsections on student-perceived benefits and disadvantages and faculty-perceived benefits and disadvantages. A fourth lengthy section is “Literature on Aspects of ERS Requiring Further Study.” This section encompasses subsections on improved performance, direct comparisons of ERS and non-ERS classes on performance, student subgroups, and other understudied topics.

Cognition, Constructivism, and Active Learning

Cognition

Improving student performance requires an accurate understanding of cognition, or how people gain knowledge and understanding. In the first half of the twentieth century, belief about how people learn was dominated by the theory of behaviorism, in which learning was seen as a process of forming connections between stimuli and responses. Learning was assumed to be motivated primarily by drives (e.g., hunger) and rewards and punishments (Bransford, Brown, & Cocking, 2004). However, according to these authors, early behaviorism was limited by its focus on observable stimulus conditions and their associated behaviors. “This orientation made it
difficult to study such phenomena as understanding, reasoning, and thinking—phenomena that are of paramount importance for education” (Bransford et al., 2004, p. 8).

By the late 1950s, the field of cognitive science arose to deal with the complexity of understanding humans and their environments. This new school of thought allowed study of mental functioning and permitted researchers “to test their theories rather than simply speculate about thinking and learning … and, in recent years, to develop insights into the importance of the social and cultural contexts of learning” (Bransford et al., 2004, p. 8). One such insight of cognitive science is that a person constructs new knowledge and understandings based on what he/she already knows and believes. Thus, in the new science of learning, “‘usable knowledge’ is not the same as a mere list of disconnected facts” (Bransford et al., 2004, p. 9). Instead, learning with understanding is emphasized (Bransford et al., 2004), such that true knowledge is “characterized as involving the development of organized conceptual structures, or schemas, that guide how problems are represented and understood” (p. 33). A schema provides an organized framework for new learning. New information is assessed according to pre-existing schemas, which may influence how readily memory retains new information (Klemm, 2012).

Therefore, according to Bransford et al. (2004), it can be difficult for novice students to learn with understanding. They may require time to explore underlying concepts and generate connections to prior knowledge. “In more general terms, the primary task of teachers and students is to develop strategies to enrich the formation of memory schemas. This means finding ways to increase the number and congruence of associations among facts and concepts being taught” (Klemm, 2012, para. 6). Because the amount of information that people can hold in short-term memory is limited, this process is improved when people can “chunk” information into familiar patterns (Bransford et al., 2004). In turn, “classes of words, pictures, and other
categories of information that involve complex cognitive processing on a repeated basis activate the brain. Activation sets into motion the events that are encoded as part of long-term memory” (Bransford et al., 2004, p. 125).

Thus, the “new science of learning” is helping to improve people’s abilities to become active learners, seeking to understand complex subject matter and better able to apply what they have learned to new problems and settings (Bransford et al., 2004). “From a cognitive learning perspective, learning involves the transformation of information in the environment into knowledge that is stored in the mind. Learning occurs when new knowledge is acquired or existing knowledge is modified by experience” (Learning theories, n.d., p. 107). A primary area of study among cognitive psychologists is constructivist theory that emphasizes the individual’s active construction of understanding (Learning theories, n.d.).

**Overview of Constructivism**

In constructivism, “learning involves constructing, creating, inventing, and developing one’s own knowledge and meaning” (Liu, 2010, p. 65). In this paradigm, people learn by doing. Constructivists see learning as a way of actively seeking new information and constructing meaning from it by connecting it to previous knowledge and experience (Alesandrini & Larson, 2002). Thus, “constructivists view knowledge and truth as created and not discovered by the mind” (Andrews, 2012, p. 40). It is therefore a tenet of constructivism that “knowledge and ideas come only from a situation where learners had to draw them out of experiences that had meaning and importance to them” (Kumar & Gupta, 2009, p. 39). During this process, learners construct and reconstruct their own meaning based on their previous experiences (Alesandrini & Larson, 2002; Andrews, 2012). The ideas that are constructed therefore have personal meanings for the students (Powell & Kalina, 2009).
The constructivist classroom lends itself to the discovery of individual knowledge by students. Learners “demonstrate their learning and understanding through different means such as developing critical questions, and summarizing ideas by their own words” (Liu, 2010, pp. 65-66). According to Jonassen (1994), constructivist learning environments also provide multiple representations of reality that avoid oversimplification and represent the complexity of the real world and emphasize knowledge construction instead of knowledge reproduction and authentic tasks in a meaningful context. Constructivists provide learning environments such as real-world settings or case-based learning instead of predetermined sequences of instruction, and encourage thoughtful reflection on experience (Powell & Kalina, 2009). Constructivist learning environments support collaborative construction of knowledge through social negotiation, rather than by competition among learners for recognition. The role of the teacher is not to lecture the students but rather to facilitate the learning as students reach their personal learning goals (Alesandrini & Larson, 2002). Constructivism implies that guided instruction is inferior to learning by self-discovery of principles, and many theorists make this point explicitly. Wickens (e.g, Wickens & Hollands, 2000) contended that strong guidance can produce very good performance during practice, but too much can impair later performance.

**Cognitive Constructivism**

One branch of constructivism is cognitive constructivism, which originated from the work of Jean Piaget (Kumar & Gupta, 2009). Piaget’s theory of cognitive development forms the basis for constructivist teaching and learning and proposed that humans cannot immediately understand the information that they are given but instead must construct their own knowledge (Kumar & Gupta, 2009; Powell & Kalina, 2009). Piaget also contended that “social interaction does occur and may be part of the learning process; but it is the individual who constructs
knowledge based on his or her personal experience” (Powell & Kalina, 2009, p. 246). In Piaget’s framework, the learning process is composed of schemes, assimilation, and accommodations, which create new learning (Ozer, 2004).

The classroom environment in a cognitive constructivist classroom is one in which learning is a self-motivated process where students construct knowledge through their own experiences (Kumar & Gupta, 2009). “Piaget’s cognitive constructivism theory incorporates the importance of understanding what each individual needs to get knowledge and learn at his or her own pace” (Powell & Kalina, 2009, p. 243). The teacher is not focused on directly teaching specific skills to the students but rather serves in the role of a facilitator who promotes discovery “by guiding learners as they attempt to assimilate new knowledge to old and to modify the old to accommodate the new” (Kumar & Gupta, 2009, p. 43). The teacher also must provide a classroom full of interesting activities that encourage students to construct their own knowledge through exploration (Kumar & Gupta, 2009). “Videodisks, CD-ROMs and simulation software enhance learning, while telecommunication tools, like e-mail and the Internet, provide contexts for dialogue and interaction within the classroom, the schools, and the community leading to the social construction of knowledge” (Ozer, 2004). Students can also be provided with, for example, comprehension questions that guide their reading of new material and help them to accommodate the new concepts they are learning (Kumar & Gupta, 2009). Upon completion of a lesson, in the cognitive constructivist classroom students often are evaluated through student portfolios and teacher observation. Thus, students “are assessed on what they know rather than what they don’t know” (Kumar & Gupta, 2009).
Social Constructivism

Another variant of constructivism is social constructivism, pioneered by Lev Vygotsky (Liu, 2010). This theory holds that knowledge is socially constructed and that meaning is created when individuals interact with each other and the environment in which they live (Andrews, 2012; Kim, 2001). This “social aspect of constructivism is vitally important. For it is mainly through the mediation of one or more other people that pupils make intellectual progress” (Watson, 2001, p. 143).

In the social constructivist classroom, students engage in activities that create relationships and directly affect what they learn. Ideas are constructed when students interact with each other and the teacher to construct cognitive knowledge. In order to create this learning environment, “teachers should promote dialogue of the material so that students can critically think about what they are learning” because if students “think critically, they will walk away with personal meaning that was constructed on their own” (Powell & Kalina, 2009, p. 245). This internalization of knowledge occurs at a different rate for each student depending on their own experience, but “Vygotsky believed that internalization occurs more effectively when there is social interaction” (Powell & Kalina, 2009, p. 244). Activities to promote social interaction in the classroom include problem-based instruction, group webquests, peer collaboration, and reciprocal teaching” (Kim, 2001).

Active Learning

Active learning involves any activity where students do not listen passively to an instructor lecturing but rather are actively engaged in classroom instruction (Faust & Paulson, 1998). Farrell (2009), summarizing Bonwell and Eison (1991), proposed that teaching strategies to promote active learning include student involvement in: higher order thinking skills beyond
mere listening; activities such as reading, discussing, and writing; and emphasis on the
development of skills and students’ exploration of values and attitudes

Bransford et al. (2004) argued that “new developments in the science of learning …
emphasize the importance of helping people take control of their own learning” (p. 12). They
also noted that feedback is not only important for instructors, but for the students. This feedback
is far better done in the context of the classroom than after the final exam has been graded and
the students have turned their attention to other subjects. Ultimately, the goal is for students to
learn to assess the quality of their own work, an important component of active learning (Farrell,
2009). Some examples of active learning in the classroom are to have the students participate in
debates, role playing, class discussions, simulations, peer teaching, or in-class writing activities
(Bonwell & Eison, 1991; Faust & Paulson, 1998). Active learning may also involve the use of
ERS in the classroom where students are engaged as they respond to questions using clickers
(Martyn, 2007).

According to Mayer (2005), as active learning exercises occur, three cognitive processes
happen that are essential for active learning: selecting relevant material, organizing selected
material, and integrating selected material with existing knowledge. When a learner selects
relevant material with active learning, he/she “pays close attention to appropriate words and
images presented in the material. This process involves bringing material from the outside into
the working memory components of the cognitive system” (Mayer, 2005, p. 37). The selected
material is then organized, which constitutes “building structural relations among the elements”
and “takes place within the working memory component of the cognitive system” (Mayer, 2005,
p. 37). Finally, the learner integrates the selected material with existing knowledge. This process
“involves building connections between incoming material and relevant portions of prior
knowledge,” and “involves activating knowledge in long-term memory and bringing it into working memory” (Mayer, 2005, p. 37). Thus, these cognitive processes with active learning are necessary to achieve the goal of active learning, which is to improve student retention (Hoffman & Goodwin, 2006).

Decades of research have demonstrated that active learning is significantly more effective than passive learning (Bunce, Flens, & Neiles, 2010; Chasteen, 2009; Dill, 2008; Guthrie & Carlin, 2005; Killos, Hancock, McGann, & Keller, 2010; Premkumar & Coupal, 2008). Active learning occurs when students consistently interact with the instructor and with each other (FitzPatrick et al., 2011; Madigan, 2006).

Application of Constructivist and Active Learning Principles to ERS

In *How People Learn*, Bransford et al. (2004) wrote:

One of the obstacles to instructional innovation in… courses at the college level is the sheer number of students who are taught at one time. How does an instructor provide an active learning experience, provide feedback, accommodate different learning styles, [and] make students’ thinking visible… when facing more than 100 students at a time? (p. 182)

Furthermore, a practical difficulty in applying what has been learned from constructivist and active learning research is that in a typical classroom, there will be some students who remain novices in the discipline while others have achieved near-expert skills. Virtually all research in the field has ignored this dichotomy. A reasonable practical approach would seem to be for the instructor to be able to shift back and forth between more or less structure depending on what the class as a whole, or an individual student with a question or evident failure to grasp a concept, needs at the moment to stay within his/her/their zone of proximal development.

Teachers presumably are intuitively aware of this need for different levels of instruction, but how can they know what is needed within any given period of a few minutes? The two
standard means of assessing a class’s level of understanding during instruction are by student questions and by a quick survey of students’ facial expressions. As described below, both have been shown to be imperfect assessments. The use of ERS has been promoted as a valuable addition to this limited arsenal. Not only does it provide real-time feedback on students’ understanding (e.g., Sprague & Dahl, 2010), but there is evidence that it also encourages greater openness on the part of students to reveal their failures in understanding (e.g., Sevian & Robinson, 2011), thus improving the instructor’s and peers’ ability to respond with an optimal level of instruction. Furthermore, it seems to encourage greater inter-student assistance, promoting the “social construction” aspect of learning. By its nature, peer-to-peer discussion is far more efficient than the professor’s lecture in conveying a customized snippet of instruction leading to the desired response of, “Oh, now I get it!”

**Electronic Response Systems**

Primitive forms of ERS first emerged approximately fifty years ago (Bugeja, 2008; Caldwell, 2007; Dill, 2008; Judson & Sawada, 2002; Karaman, 2011; Smrek, 2011; White, Syncox, & Alters, 2011). The earliest forms of ERS were hardwired into students’ desks so that they could be individually utilized (Smrek, 2011). Today, due to technological advancements, handheld clickers are wireless and range in size from that of a remote control to a credit card (Meezan & Fisher, 2009; Smrek, 2011; Stowell & Nelson, 2007). They afford students the opportunity to input answers that are immediately received by their professors.

**ERS Development: 1960-1990**

ERS were first introduced in the early 1960s to assess audience responses to unreleased commercials, movies, and television shows via focus groups (Bugeja, 2008). The use of ERS in
advertising strongly suggested potential applications in education, leading to adoption in college classrooms to allow fast, anonymous responses to questions on student opinions (Judson & Sawada, 2002).

In the classroom, ERS enabled students instantly to answer professors’ questions (White et al., 2011). Also, professors could provide instant feedback for students (i.e., percentages of correct and incorrect responses) (White et al., 2011). Despite great interest in the technology, high costs associated with ERS prevented widespread adoption at that time (White et al., 2011).

ERS would not be widely utilized again in higher education until the 1980s (Judson & Sawada, 2002). A similar system utilizing traditional calculators hardwired into Macintosh computers (Smrek, 2011) ultimately led to the reintroduction of ERS into the classroom (Dill, 2008). However, the technology needed further modification before widespread application could occur (Judson & Sawada, 2002).

The IBM Corporate Education Center (CEC) solved the remaining technological problems in 1988 (Smrek, 2011). To examine the validity of its new ERS system, IBM conducted usability experiments with employees at training sessions (Horowitz, 1988, described in detail below). This data illustrated some of the benefits of ERS in both educational and training settings, leading IBM further to develop the ERS.

**ERS Development: 1990-Present**

By the 1990s and into the early 2000s, ERS moved into the classroom and became viewed as a reliable, valid, and handy form of technology. Once these technologies moved into the classroom and met with success, ERS continued to evolve (Caldwell, 2007; Karaman, 2011). The systems developed from large to small and transmitted information in real-time (Judson & Sawada, 2002). Companies also developed software that allowed professors instantaneously to
display classroom data on software such as PowerPoint (Caldwell, 2007). ERS now proved useful in supplementing traditional classroom methods.

In the 2000s ERS, promoted by the media, became an integral part of popular culture. The public became familiar with clickers via television game shows like *Who Wants to Be a Millionaire* and *The Power of Ten* (Caldwell, 2007). These game shows relied on systems identical to those used in the classroom. Students familiar with these game shows quickly adapted to use of these devices. Presently, ERS are used in disciplines ranging from behavioral studies to statistics and may be found in numerous colleges and universities (Bugeja, 2008; Caldwell, 2007; Dill, 2008; Karaman, 2011; White et al., 2011).

When students choose an answer to a question on their clickers, the devices “emit infrared [or radio] signals that are picked up by a receiver and sent to the instructor’s computer” (Hatch et al., p. 26). Each clicker has its own number assigned to it, so the students’ names can be recorded, but usually are not known to the rest of the class when the results are projected on the screen (Kenwright, 2009).

**Perceived Benefits and Disadvantages of ERS**

Only a single recent review claims to have comprehensively summarized the benefits and challenges of ERS reported by previous researchers, covering the period 2000-2007 (Kay & LeSage, 2009). The authors noted that

A comprehensive review of the literature reveals no less than 26 different labels for ARSs [audience response systems]…. One key issue with inconsistent labeling is the difficulty it poses in locating and staying current with the latest research. For example, four relatively recent reviews on ARSs… referenced 16–25 studies per review, yet this quantity represents only one quarter to one third of the peer-reviewed articles available on ARSs from 2000 to 2007. (p. 820)
The authors also noted that almost no studies had been conducted in social science or humanities subjects, and that “the conclusions from the current review reflect the attitudes and learning efforts of undergraduate students who were studying science- or mathematics-based subject areas in relatively large classes” (Kay & LeSage, 2009, p. 820). They organized their review under three broad categories of benefits (classroom environment, learning, and assessment benefits) and three of challenges (technology-based, teacher-based, and student-based).

Classroom environment benefits included increased attendance, more focused attention, anonymity of participants, and engagement in class. Learning benefits were increased interaction with peers, discussion of misconceptions, contingent teaching (instruction modified based on student feedback), increased performance, and qualitatively better learning. Assessment benefits cited by Kay and LeSage (2009) included feedback, formative assessment (to improve student understanding), and ability of students to compare their responses to others.

The review cited technology-based challenges as including the need to remember to bring remotes to class and equipment malfunctions. Teacher-based challenges were the need to respond to student feedback, somewhat reduced time to cover course topics, and the time required to create appropriate questions for use with ARS. Kay and LeSage (2009) cited student-based challenges as the need to shift to a new learning method, confusing discussion, extra effort, possibly more frequent testing, monitoring of attendance, identifying students when not used anonymously, and negative feedback. Finally, the authors noted that research on ARSs has been unsystematic, mainly anecdotal or qualitative, focused on attitudes rather than actual learning, and a narrow range of settings. They concluded that “more research is needed on individual differences [including] gender, grade level, age, and learning style” (p. 826).
Thus, use of ERS involves a multitude of perceived benefits and disadvantages (Bugeja, 2008; Irons, 2012; Kay & LeSage, 2009; Lantz, 2010; Taylor, 2007). For the present purposes, these benefits and disadvantages are best examined by grouping them into student-perceived benefits, student-perceived disadvantages, faculty-perceived benefits, and faculty-perceived disadvantages.

**Student-Perceived Benefits of ERS**

When used effectively, ERS technology affords numerous benefits. Studies show that students who use ERS find their courses more engaging (Berry, 2009; Bugeja, 2008; Caldwell, 2007; Doe, 2010; Eastman et al., 2011; Irons, 2012; Judson & Sawada, 2002; Kenwright, 2009; Kolikant, Drane, & Calkins, 2010; Kyei-Blankson, 2009; Lantz, 2010; Martyn, 2007; Ribbens, 2007; Skinner, 2009; Wolter, Lundeberg, Kang, & Herreid, 2011). One may, therefore, surmise that students who use ERS in the classroom are more attentive and less distracted, resulting in fewer attention lapses.

A major question arises with the discussion of whether transparency or anonymity is best when using ERS. The decision as to whether to keep responses anonymous is made by professors with results that may or may not meet with the approval of the class (White et al., 2011). The studies that follow reflect the varying views of different students on this topic.

**Student preparation, camaraderie, and participation.** Students who use ERS are better prepared in the classroom (Berry, 2009; Caldwell, 2007; Lantz, 2010; Ribbens, 2007). Knowing that their responses are going to be displayed, students recognize the need to read course material ahead of time and complete the required assignments. Thus, they have the chance to correctly, and publicly, answer the questions posed in class that require responses through clickers (Sevian & Robinson, 2011). Public response occurs especially when professors assign a
specific clicker to each student, thereby retaining the ability to assign grades rather than allowing anonymity with the devices. This practice enhances and increases student accountability (Sprague & Dahl, 2010).

More camaraderie may also develop in class through ERS implementation. Throughout the semester, students begin to cheer for each other when the class does well and the majority of the students respond correctly to a question. This situation occurs even in the smaller classes that adopt the devices (‘Interactive ‘clickers’ changing…,” 2005).

Students have reported that they feel more comfortable participating in classes that utilize ERS rather than in those that do not (Eastman, 2007; Eastman et al., 2009, 2011). Together, this research by Eastman and colleagues indicated that students like the anonymity, and they do not fear giving a wrong answer in front of their peers. At the same time, they become interested in comparing their knowledge to that of their classmates. Students feel confident when they answer as well as their peers, and appreciate the collaborative learning. Thus, they also enjoy being able to discuss the responses with their fellow classmates. These students see ERS not as a technological gimmick, but rather as an effective educational tool (Eastman, 2007; Eastman et al., 2009, 2011).

**Student satisfaction.** Data from a number of student satisfaction and student perception surveys support students’ satisfaction with ERS. Judson and Sawada (2002) discovered that students have continued to express positive support for ERS for nearly 40 years. Students think that the devices help them listen more intently in class and thus better understand what the instructor teaches. They also believe that ERS prompts them to attend class and process the material more deeply. For example, during the last session of courses using ERS, Skinner (2009) presented his students with an 18-item course assessment survey. On average, results
demonstrated that students believed that the devices helped to facilitate improved performance, found their use enjoyable, and would recommend that the technology be used in other courses. A University of Colorado survey showed that students liked the ways in which the devices enabled the professors to ask a wide variety of conceptual, recall, and numerical questions (Killos et al., 2010). Sixty-six percent of students preferred when professors followed up ERS questions with discussions. The survey asked students what they do during delivery of RS questions. The majority of the respondents claimed to be actively participating in class (Killos et al., 2010).

Another survey showed that students liked ERS so much that 70% of them would highly recommend their use (Milner-Bolotin, Antimirova, & Petrov, 2010). From their perspective, the main advantage occurs as a result of instant feedback that helps them process the material immediately and fully (Milner-Bolotin et al., 2010). Using ERS also increased overall satisfaction and student attitude with courses in comparison to those classes that did not use them (Eastman et al., 2011). The study also showed that instructors’ evaluation scores by the students were higher in the courses that utilized ERS.

Guthrie and Carlin (2005) discovered that 61% of students preferred courses that used ERS over those that did not. Seventy-one percent of those interviewed indicated that they participated more in courses that used ERS. The researchers also found that the more experienced professors became at using ERS, the more students liked the course. While the additional price of purchasing the clickers initially bothered many students, the majority felt the benefits of utilizing clickers far outweighed the cost. Along with the increased participation, students agreed that they interacted more with their classmates and were more engaged when responding to questions when using clickers. The survey also showed that the majority of them enjoyed operating the clickers, thus making learning more pleasurable.
FitzPatrick and her associates (2011) have studied the application of ERS in a variety of classes, both large and small, for several years. They looked at factors including how well the ERS increased and maintained student attention and provided feedback on student understanding. Across several studies, the researchers reported that students believed the use of ERS encouraged active learning, increased participation and comprehension, and created a positive learning experience (FitzPatrick et al., 2011).

Additional research has also been conducted on student perceived benefits of ERS. A 2009 study conducted in a large Canadian university’s Introductory Marketing Course (Sprague & Dahl, 2010) found that students rated ERS well. Students found them both worthwhile and effective and appreciated the ways in which ERS allowed them to realize their weaknesses while reporting their answers to the class anonymously. The students enjoyed receiving instant feedback to their responses to the professor’s questions, and could in turn determine their own level of comprehension on the discussion topic at hand. This study showed students recognized that ERS met the needs of various learning styles, especially those of students who find the traditional, large classroom a difficult place in which to feel welcome. Students who normally do not become excited about learning acknowledged looking forward to coming to the classes in which ERS are used. Significantly, the students who reported that the ERS improved their performance actually did outperform their peers in the control group.

Carnaghan and Webb’s (2005) student satisfaction surveys revealed that the average student response suggests strong student satisfaction with the use of ERS. Eighty-four percent of the students believed that the advantages of using ERS outweighed the disadvantages. Seventy-four percent of students claimed that the courses that utilized ERS felt more enjoyable when compared to the courses that did not.
A student satisfaction survey of ERS conducted by Cummings and Hsu (2007) found similar results. Seventy-one percent of the class believed that ERS caused them to pay more attention in class and be more engaged. They also liked the instant feedback ERS provided. In a study of small classes that introduced ERS into the curriculum, 75% of students reported benefits to the technology (Hatch et al., 2005). Ninety-six percent of the students in an environmental science course, which implemented ERS and had less than 40 students, stated that they liked using the clickers. Ninety-two percent of them felt that the devices helped them to discover what they did or did not know, and 83% of them claimed that the ERS assisted their learning from their professors and classmates during instruction time. This reported improved learning can be attributed to the fact that the students enjoyed the conversations that emerged from the questions posed by the instructor and used with the clickers, and they liked the interactive activities (Hatch et al., 2005).

A survey conducted by Kyei-Blankson (2009) found that students had favorable perceptions of using ERS in class. The study reported that students feel they learn when active engagement occurs in the instructional process and believe that the utilization of ERS helps them understand difficult concepts. Seventy-eight percent of the surveyed students found ERS to be an appropriate technique for teaching, as ERS prompt student engagement and, they believed, help students to perform better on exams in class. Especially when combined with other strategies used by the professors, such as peer instruction and whole class instruction, the students believed that the ERS helped them monitor their progress. After the professor asked each question and the answers were projected, 72% of the students reported liking knowing what their peers were thinking, and 67% felt encouraged by having contributed to the correct answer. More than 80%
of the class felt that the discussion that followed the displaying of the answers promoted their learning and assisted them in performing better in class.

Ultimately, the studies cited above show that ERS provided students a non-threatening environment, allowing increases in knowledge retention. In concert, the studies reviewed in this section illustrate the added value of ERS, and that a majority of students believe the technology should be used more often.

**Student-Perceived Disadvantages of ERS**

Although numerous benefits exist to implementing ERS into the classroom, some students see disadvantages. Some, especially those in a large lecture hall, like to remain anonymous. Students expressed dissatisfaction when names and grades became associated with clickers (Kolikant et al., 2010; Stowell, Oldham, & Bennett, 2010). Without anonymity, students felt more pressure and stress to do well in class than they did in their large classes that did not use ERS (Carnaghan & Webb, 2005). The stress may have occurred because their professors did not always give them enough time to answer the questions, causing the students to answer incorrectly (Kyei-Blankson, 2009). When students felt they had too little time, they may have disliked being in the group that incorrectly answered the question, when the response to it was displayed in front of the class on the monitor for everyone to see. Milner-Bolotin and her associates (2010) found the most significant complaint among their surveyed students was that not being anonymous forced them to attend class, especially when the professor could tell by looking at the screen how many students attended class each day and, specifically, the names of these students. A study conducted at Northwestern University noted that students do not like the Big Brother aspect of the ERS, even in the university’s already small courses, and that they dislike that their professors can watch every click they make (Steinberg, 2010).
Students recognize that cheating may occur with ERS and, like their professors, are frustrated by this cheating; they know that some students bring clickers to class for their friends and answer questions for them, so that absent individuals inappropriately receive credit. Students do not see this practice of having friends answer for others as fair (Bugeja, 2008).

Whether or not anonymity occurs with the use of ERS, students still perceive drawbacks. Eastman and her colleagues (2009) examined whether using ERS enhanced the students’ retention of the material and satisfaction with ERS. While the students expressed more satisfaction with the courses that used ERS, the researchers did not find sufficient evidence to conclude that students retained more information in courses that used ERS versus those that did not (Eastman et al., 2009). A study by Karaman (2011) found no long-term effects in differences of recall of information taught in a course between students who used ERS compared to those in courses that did not. Though it rarely occurred in the studies, reports do exist of students purposefully answering the questions posed through ERS incorrectly to slow down the professor’s lecture and have more time for discussion with their peers in class (Bugeja, 2008).

**Cost in money and time.** A common complaint among students is that the clickers add an additional expense to already costly textbooks and other course requirements (Berry, 2009; Bugeja, 2008; Chasteen, 2009; FitzPatrick et al., 2011; Guthrie & Carlin, 2005; Sprague & Dahl, 2010). The cost of a clicker to a student varies from university to university, but typically has ranged from $10 to $40 per clicker, depending on whether the institution sells only new devices or also offers the option to purchase a used one. The cost may increase if multiple clickers are required for an individual student. For example, within the same university different departments sometimes have adopted different types of ERS, resulting in the added expense of having to purchase multiple clickers (Lantz, 2010). Moreover, students do not like having to buy a clicker
and then use it for only one class. Some institutions adopt complex clickers, with buttons that professors never utilize in class. Therefore, the students wished that less expensive models of clickers could be used instead (Shapiro, 2009). Some universities have begun to mitigate this expense by providing students the option to purchase a new clicker at the beginning of their freshman year and then sell it back at the end of their senior year, for half the cost, as long as it is still in working condition (Shapiro, 2009). The universities then sell the used clickers to students who wish to buy a less expensive used one instead of a new one (Shapiro, 2009). Others universities have adopted one ERS for the entire university (Taylor, 2007). This universal adoption means that all of the departments utilize the same system, and the students may thus purchase one clicker that can be used for every course throughout their university careers (Taylor, 2007).

Time also contributed to frustration students had with ERS. Instances occurred when students believed that ERS took up too much time in the classroom (Sprague & Dahl, 2010). This perceived waste of time included time spent by professors who had to set up and take down the receivers, due to the system not having a permanent installation in the classroom (Sprague & Dahl, 2010). Some students felt that time spent setting up and taking down ERS should have instead been used performing other activities that aided in their learning or the professor’s teaching of the class (Sprague & Dahl, 2010). Relocation of the systems may also damage the ERS (Hatch et al., 2005), and when such damage occurs time is taken away from the lesson to repair the equipment. Students also became frustrated with the time lost through occasional glitches with the technology, which the professor had to solve by stopping instruction during class (Guthrie & Carlin, 2005; Kyei-Blankson, 2009).
Some professors’ lack of experience added to the students’ perceived disadvantages of the ERS. Gok (2011) interviewed 12 students concerning their feelings toward the use of ERS in class. The students liked the individual feedback given by ERS, but they disliked it when professors were not competent in the use of the system. A University of Colorado survey of students’ perceptions of ERS also found a strong correlation between the professors’ level of experience with the system and students’ perceptions of the effectiveness of the technology (Killos et al., 2010). A similar study conducted by FitzPatrick and her associates (2011) also discovered that 55% of students believed that the instructors did not use ERS enough and could have utilized it more during class time. Student dissatisfaction related to the professors’ inexperience with ERS, or reluctance to use the devices, and it created a negative impact on the students’ attitudes toward these professors’ courses.

**Faculty-Perceived Benefits of ERS**

Professors who have used ERS report numerous benefits to implementing it into their courses. ERS provide real time feedback. If the students do not grasp a concept, the professor knows immediately that they did not understand it (Eastman, 2007). This immediate knowledge is because professors can ask a question and instantly see how the students respond based on the results displayed in the graphical representations provided by the ERS instead of having to try to gauge by themselves if the students understand the material (Eastman, 2007). If the students do not grasp a concept, as may be evidenced when, for instance, 75% or more of the class responds incorrectly to the posed question, the professor knows immediately that the students need more explanation (Eastman, 2007). Students’ responses to these questions presented by the ERS thus allow professors to modify their instruction, during class, based on the needs of the students and the instant feedback provided by the ERS (Caldwell, 2007; “Classroom clickers make…”; Cline,
Instructor then may take the time to review the concept before moving on to further instruction. This immediate modification of the instructor’s plans occurs with a quiz or test as well. If they had planned on moving on to a new topic in class on a particular day, but find that the majority of the class failed the quiz, the professors know that they need to review the concepts that were on the quiz (Ribbens, 2007). The added bonus is that the instructors no longer have to take the time to grade the quizzes manually and can instantly tabulate the results of the assessment, which are automatically saved into the grade book provided by the ERS software (Ribbens, 2007).

**Attendance.** When ERS is implemented in class, another benefit of the technology cited by faculty is a noticeable increase in student class attendance (Caldwell, 2007; Eastman, 2007; FitzPatrick et al., 2011; Milner-Bolotin, 2010; Ribbens, 2007; Sprague & Dahl, 2010; Steinberg, 2010; Taylor, 2007). Faculty perceive an increase in numbers of students attending because they can quickly take attendance and see how many students come to class each day. Before using the clickers for tracking attendance, professors in large classes had to gauge attendance based on a visual survey, passing around sign-in sheets, and/or having graduate students count the students (Carbone, 1999). Those professors teaching small classes normally orally called student names, but this time usage could be eliminated by the introduction of the clickers. Just one click of a button takes attendance when students walk into class and literally signal their presence (Steinberg, 2010). When not used anonymously, a student’s name is associated with the device, and students receive a grade for the questions answered with the clickers. This public recording
of student presence may also lead to the increase in attendance, according to Caldwell (2007), Eastman (2007), and others.

Ribbens (2007) conducted a case study and found that attendance increased by 20% in his 9:00 a.m. small course that used clickers after he started conducting graded activities with the ERS. The higher attendance rate may have resulted from the fact that students did not want to skip his class, out of fear of missing a graded assignment administered through ERS. It also may have been because the students enjoyed the way that Professor Ribbens utilized the ERS in his instruction, which made the course enjoyable to them (Ribbens, 2007).

**Student participation.** Because of the tracking systems in place in ERS, professors using it discovered that students’ participation in class increases the more they become engaged in the lessons (Berry, 2009; “Classroom clickers make…”; Cline, 2011; Eastman, 2007; Eastman et al., 2009; Kenwright, 2009; Kurdziel, 2005; Kyei-Blankson, 2009; Milner-Bolotin, 2010; Skinner, 2009; Sprague & Dahl, 2010; Steinberg, 2010). They found that students no longer slept in class or texted their friends during instructional time. Instead, they actively participated in the lesson (Caldwell, 2007; “Classroom clickers make …”). Professors and students also interacted throughout the discussions from the questions and talked to each other about why the class did not understand the questions in which the students scored particularly low, according to the histograms displayed on the screen (Cline, 2011). Almost all of the class members discussed why they chose their answers. Those students who responded accurately had the chance to reflect on their correct answers and interact with the rest of the class and their professor by teaching their peers why they answered certain responses correctly (Kolikant et al., 2010). The students no longer just listened to a one-way lecture by their professor but instead participated enthusiastically in a two-way conversation with the instructor, who now interacted with the class
(Kolikant et al., 2010). Part of this increased participation could have resulted from receiving a participation grade, but some professors employed the clickers anonymously (Kolikant et al., 2010). Hence, more interested and involved students in a course that utilizes ERS may have resulted in increased participation. At the same time, students may have enjoyed learning with ERS, and the professors felt that this increased enjoyment improved student performance in their courses (Ribbens, 2007).

**Student understanding.** Professors also reported that ERS helped their students feel better about their understanding of concepts in the class (Eastman, 2007; “Interactive ‘clickers’ changing…,” 2005; Manzo, 2009; Ribbens, 2007; Steinberg, 2010). When the majority of students answered a question correctly, they sometimes erupted into applause for each other (Caldwell, 2007). In smaller courses, the professors could tell that previously shy students participated more in class through the discussions and could no longer try to hide in class (“Interactive ‘clickers’ changing…,” 2005; Stowell et al., 2010). Sometimes, only a few students incorrectly answered a question. Knowing that other students also did not understand a concept, the professors believed, helped the students realize that they needed to study more but also that they were not alone in that situation (Ribbens, 2007). Some ERS allow the students to let the professor know privately of their confusion simply with one click on the handheld device. The professor can then tell who does and does not understand the lesson, thus enabling them to gauge further the confusion of each student, while keeping the students from having to announce publicly that they are puzzled by a concept, according to Steinberg (2010). Thus, ERS improves communication between students and professors (Eastman, 2007; “Interactive ‘clickers’ changing…,” 2005; Manzo, 2009; Ribbens, 2007; Steinberg, 2010).
Professors of small courses have been affected especially by the implementation of ERS and how they improve their connection with their students. In one study, the professors of small courses believed that they could judge how well the students would do in class simply by using their old teaching techniques (Sevian & Robinson, 2011). These methods included asking the students questions orally and being able to gauge the students’ understanding by looking at their facial expressions in the compact setting provided by the smaller classroom. However, to their surprise, the professors discovered that students did not always know the material and actually felt more confused than the professors thought them to be (Sevian & Robinson, 2011). This increased awareness of confusion may have been because the students could not look around the room and see how their classmates answered a question that required them to raise their hands to give a response. ERS thus afforded students the opportunity to be more honest with the professor in expressing how they really felt on the topics posed by the questions, according to Sevian and Robinson (2011). Some students the professors had assessed as understanding the material admitted to not comprehending it. Some students who professors thought did not know the answers, surprisingly, understood the topics. The shy students who rarely had a chance to talk, because the more vocal students often took over the discussions and dominated them, began to have a voice in the classroom during the discussions of the responses displayed by the graphical representations. Soon everyone began to participate in the conversations, and an increased collaboration when answering questions with clickers occurred in these small classrooms (Sevian & Robinson, 2011). While this study illustrates great benefits to using ERS in small classrooms, few studies like it exist that have examined the use of ERS outside of the large lecture hall (Hatch et al., 2005; Kyei-Blankson, 2009; Martyn, 2007; McCurry & Hunter-Revell, 2011; Sevian & Robinson, 2011; Wu & Gao, 2011).
Faculty-Perceived Disadvantages of ERS

**Time required.** Despite the advantages of ERS, faculty who have used them also see disadvantages to implementing the technology. Planning to use ERS takes time (Eastman, 2009; Hatch et al., 2005; Kolikant et al., 2010; Milner-Bolotin et al., 2010; Premkumar & Coupal, 2008; Ribbens, 2007; Sevian & Robinson, 2011; Sprague & Dahl, 2010). Initially, faculty spend time learning how to integrate the new technology into their courses. According to these studies, faculty members must spend their own time interacting with the ERS software installed on their computers to become familiar with it. As several of the above authors noted, learning how to use ERS in training sessions offered by their institutions both in person and online requires time. Practicing what they have learned also consumes time. Unless the professors use a textbook that comes with questions prewritten for ERS, they must spend time writing questions that work well when used with ERS. These questions include ones comprising basic recall, as in the cases of using ERS for quizzes, tests, and gauging if students understand a concept, to questions that engage students should the professor want to promote classroom instruction through conversation among students (Kolikant et al., 2010). Time may be consumed also when professors decide how to change from their traditional lecture-based teaching style to one that uses the hands-on, interactive activities necessary when using ERS. They spend time as they learn how to use ERS as a tool integrated into their instruction and not just see it as something to replace their old ways of teaching (Premkumar & Coupal, 2008). Faculty members may eventually come to the conclusion that too little time exists in the day to learn how to use the new assessment technology, revise their lessons, write the questions, and prepare for class (Premkumar & Coupal, 2008).
Another disadvantage of using ERS is that it also takes time out of other class instruction (Hatch et al., 2005; Kenwright, 2009; Premkumar & Coupal, 2008; Sprague & Dahl, 2010). In universities where permanent installation of ERS into the classrooms has not been completed, even for veteran instructors it takes approximately ten minutes to set up and take down the equipment at the beginning and end of classes in large lecture courses, because more student receivers are used (Hatch et al., 2005). However, in courses at small universities, this time can be cut in half, because only one student receiver usually collects all of the information for the clickers (Hatch et al., 2005). Either way, often the instructors must set up the system alone and cannot count on the university technology department to do it for them. Thus, the time spent preparing the system for classes takes away time from instruction and often results in the professors covering less classroom material (Sprague & Dahl, 2010). It also consumes time to display the question on the projected screen for the class to see. Students need to think about their answers before clicking their responses. A number of the authors cited above noted that once all the class has replied to the question and the histogram or other data projects onto the screen, it takes class time to discuss the differences between the correct and incorrect answers. This time can be utilized in groups or as an entire class. While this discussion occurs, if the professor must add information students need, the class must wait while the instructor types the questions or information into the computer (Kenwright, 2009). Technical glitches that occur in the system, such as students having problems with their clickers not responding to the receivers, or random glitches that occur with the ERS, also take instructional time away from the class period. Classroom set-up, student response, additional information, and error correction take away from the classroom instructional time available for the course (Hatch et al., 2005; Kenwright, 2009; Premkumar & Coupal, 2008; Sprague & Dahl, 2010).
Cheating concerns and cost. Another concern professors expressed is that they cannot prevent the cheating that students can possibly engage in when using ERS (Steinberg, 2010). Cheating is particularly common in classes where students know that the professor assigns a grade for answering questions in class. Motivation increases to attend these courses (Premkumar & Coupal, 2008), but a drawback is the possibility that, because students still want the credit for attending the course and the participation points for coming, cheating will occur. Those professors who instruct large classes have expressed concern about how to combat this cheating, and review of the literature did not reveal a simple solution to the cheating issues that may occur with ERS. Especially in large lecture halls with 100-800 students, this problem is difficult to eliminate (White et al., 2011). Due to the small size of clickers, even the presence of classroom observers fails to eliminate the problem: One student could conceivably bring numerous clickers to class (White et al., 2011). An individual could “attend” and “answer” for absent students in large lectures.

Along with the concerns about cheating, some professors who have not used ERS feel hesitant about passing the cost down to their students and see this cost as a pitfall (Bugeja, 2008; Eastman, 2007). Some professors voiced to Bugeja (2008) objection to the additional cost of the devices to students. They did not like the idea that the students had to pay for a clicker that could calculate who answered each question correctly, when the professors could simply count the students’ raised hands.

Disruption of teaching style. Some professors may not know how to adapt their teaching styles to fit the new technology, and may find it challenging to pace their lessons accordingly (Bugeja, 2008). As a result, the technology may detract from the students’ learning, because the professors may focus more on using the ERS than teaching the material (Kenwright, 2009;
Morgan, 2008; Premkumar & Coupal, 2008). The professor may find it challenging to pace lessons according to the students’ needs and to find a balance between incorporating the material that they normally teach with the new methods available through ERS. The difficulty in finding a balance may result in some professors going to extremes and either teaching classes only with the ERS or hardly using it at all, such as solely for the purpose of taking attendance. Other professors may assume that the devices alone will make the students smarter and may not adapt their teaching at all (Premkumar & Coupal, 2008). However, these potential disadvantages suggest that ERS need not only be introduced alone, but explicitly and officially integrated into the classroom. Thus, the important factor remains not merely university implementation of ERS, but rather, how instructors use them.

**Literature on Aspects of ERS Requiring Further Study**

**Improved Performance**

As discussed above, there have been many studies about student perceptions of ERS (FitzPatrick et al., 2011; Judson & Sawada, 2002; Killos et al., 2010; Kyei-Blankson, 2009). However, only a very limited number of studies considered the key question of whether grades were higher in a course that used ERS.

Some authors have made claims for ERS improving student performance on the basis of student reports, but without examining actual exam scores. Two examples of this were studies by Sprague and Dahl (2010) and Eastman et al. (2009).

Sprague and Dahl (2010) studied student preferences and attitudes towards ERS and identified student performance outcomes dealing with the use of the devices. They conducted their study with 93 students enrolled in two sections of a course at a large Canadian university.
The students used the Interwrite brand of clickers all semester for the purposes of quizzes and class discussions. Students then completed a survey that had a Likert scale as well as an open-ended question for the purposes of measuring their attitudes towards ERS and preferences towards classes that use them as well as student performance outcomes relating to the use of ERS.

The authors concluded, “clicker technology was broadly perceived by the students as increasing their satisfaction with the course (Introductory Marketing) as well as their perception of learning” (Sprague & Dahl, 2010, p. 96). To determine performance outcomes, a correlation analysis was used to assess student self-reported ratings of their performance with the actual grades achieved in the course. The significant positive correlation of $r(90) = .21, p < .05$ “verified that students who recognized the learning benefits through the use of PRS [Personal Response Systems] clicker technology did in fact perform better in the course” (Sprague & Dahl, 2010, p. 97). However, “a significant relationship was not identified between ratings of learning with PRS clicker technology and the self-reported grade point average of students” (Sprague & Dahl, 2010, p. 97). Thus, the benefits identified with learning through ERS were explicit only to the grade earned in the Introductory Marketing course.

Certain variables do not appear to have been considered in this study. There was no control group not using ERS. The data were collected at the end of the semester, when the students already may have known what their grade would be in the class, which could have biased their perceptions on the technology of ERS. Sprague and Dahl (2010) pointed out that, “An evaluation instrument was developed incorporating items from factors identified as pertinent to determining student attitudes regarding PRS clicker use” (p. 95). However, these factors were not identified.
Eastman, Iyer, and Eastman (2009) examined the attitudes of students toward ERS in three sections of a Consumer Behavior course that were taught using ERS. Pre-and post-tests, conducted at the beginning and end of the semester, measured the attitudes of 97 juniors and seniors on a five point Likert Scale.

The mean scores for the students’ attitude toward the subject matter at the start of the semester was 3.56, and after using ERS for a semester the mean rose to 3.72. (Unfortunately the authors did not describe the anchor points of the scale, so it is difficult to determine just what this means.) A $t$ test measured the differences between the two time periods, with a resulting $t$ value of 2.834 ($p < .01$). The change in means “indicates that the attitude towards the subject matter in a course using Interactive Technology [ERS] increased over time” (Eastman et al., 2009, p. 36).

While some students may have initially been hesitant about using ERS, as is evidenced by the 3.93 pre-test score of attitude towards interactive technology, their opinions changed, resulting in a post-test score of attitudes toward interactive technology being a mean of 4.18. Regarding whether or not students paid more attention in a course that uses ERS, the mean score of 4.09 demonstrates that students, on average, concurred with the statement that they pay more attention in a course that uses ERS versus one that does not. The students were fairly neutral regarding whether or not a course using ERS enhances attendance, as the mean score for this measure was a 3.73. They also were neutral in questions regarding whether or not using ERS helped them be better prepared for class, with a mean score of 3.46. The final questions involved the perceived level of retention that the students had for a course using ERS. The mean score for students’ retention was a 3.66, “indicating that, on average, the students were fairly neutral regarding whether a course utilizing Interactive Technology enhanced retention” (Eastman et al., 2009, p. 37).
In addition to the lack of a control group, the research did not address that student attitude toward course content could not be entirely attributed to ERS. The students may have just initially thought that they would not like the course but ended up liking the content anyway, which could have happened whether or not ERS was used in class.

**General Claims for Performance Improvement**

In addition to these journal articles, informal claims for performance improvement have been made in the context of general reviews of the use of ERS. An analysis by one professor of scores on quizzes given to students using ERS compared to those that took the assessment on paper found that, over the course of the semester, students exhibited a 20% increase in scores on the quizzes when taking them with clickers (“Classroom clickers make…,” 2012). One ethnography in a biology class that used ERS found that, of those students who attended class regularly, 88% of them could correctly answer test questions that had previously been posed by the professor using ERS during the course of the semester to assess their understanding of the material (Hatch et al., 2005). Again, however, the value of this finding is limited, as the study did not provide a comparison to classes in which ERS was not used. Thus, it cannot be determined whether the use of ERS impacted the scores favorably, or whether scores would have been the same, higher, or lower without its use.

**Direct Comparisons of ERS and Non-ERS Classes on Performance**

A number of studies have directly compared academic outcomes between classes that used ERS and classes that used a standard lecture format in post-secondary education. All those that could be located are described below. The 19 studies include only five that were mentioned in Kay and LeSage’s (2009) then-comprehensive review—most of the others were published in 2007 or later. Also noteworthy was Kay and LeSage’s comment to the effect that most reviewers
seem to have missed many examples of prior work, since the articles included at least three that stated something to the effect that “this appears to have never been studied before.” In most of the studies summarized below, there was also a survey or other aspect to the research, which in most cases merely reiterated the common findings of student satisfaction with the devices coupled with some complaints about the time it took from lectures and technical hassles. Most of these will not be described separately, although in some cases the studies were cited in appropriate sections above.

**Computer science classes.** Perhaps unsurprisingly, ERS tended to be introduced into computer science, technology, or hard science courses more than in social sciences or the humanities. Karaman (2011) studied 44 undergraduate students in a Turkish university who were enrolled in an information technologies in education course. The study investigated students’ perceptions of ERS and its effects on short-term and long-term academic success. The researcher randomly divided the students into two groups; the control group did not use ERS, and the experimental group did. The measure of student achievement occurred through two paper-based examinations of both groups: a midterm given four weeks into the study and a final exam administered four weeks later. Eight months after the experiment concluded, the final examination was given again to students in both sections to assess their retention level. To determine student perception of ERS, Karaman also administered a 16-question questionnaire that had both five-point Likert scale questions as well as open ended ones.

The results of the study showed that ERS “has a significant learning achievement effect in the first 4 weeks but not at the end of the second 4 weeks [or] after 8 months” (Karaman, 2011, p. 1436). In addition, “in terms of retention, there was no significant difference between the two groups either” (Karaman, 2011, p. 1436). Thus, despite the fact that 100% of the students
stated they would like to use ERS more, the researcher did not find it to be a valuable piece of technology in terms of student retention of material.

Martyn (2007) studied 92 students in four classes in an introductory computer science course taught by the same instructor. Two of the classes used the TurningPoint ERS system, and the other two used discussion. Outcomes were measured by final exam scores. The author concluded that “although… the mean scores were consistently higher for students who had used clickers” than those who had not, “contrary to expectations, learning outcomes of students using clickers did not improve more than the traditional active learning approach of using class discussion” (Martyn, 2007, p. 74). The researcher attributed this to the fact that the semester of the study was the professor’s first time using ERS.

Kennedy and Cutts (2005) studied the use of an electronic voting system (EVS) with 241 students in an introductory programming course in the computer science program at Glasgow University. The EVS was used in 13 lectures out of 24, and in each lecture, students were asked between two and six questions, interspersed throughout the presentation. The format of lectures was consistent, whether or not EVS was used. Students were given approximately two minutes to respond and were encouraged to discuss their potential responses “with their neighbour.” EVS use was voluntary, and some students used the clickers most of the time, others seldom or never.

Results were found to be rather complex, with EVS use having a large effect on results. “Students who were frequent users of an EVS and were relatively successful when they answered the lecturer’s questions performed significantly better than other students” on exams. “Other students—frequent EVS users who were relatively unsuccessful and infrequent EVS users who were relatively successful and unsuccessful—all performed similarly in assessment tasks” (Kennedy & Cutts, 2005, p. 266).
**Use of ERS in hard science courses.** King and Joshi (2008) examined the use of ERS in two large general chemistry courses for engineering students (totaling 620 males and 120 females) during the Winter 2006 and Spring 2006 semesters at a research institution. In all sections of the course, the students took the same exam and had the same grading scale. Students used clickers in class in one of the three sections in the winter term but not in the other two sections of the course. Response to the ERS questions was voluntary and not part of the students’ grade. Clickers by Turning Technologies, Inc. were used for the purposes of class discussions and responding to the professor’s inquiries during a lecture in the ERS section. In the spring semester, both classes used ERS, and “the previous year’s… lecture section was used for comparison, because the background and preparation of the spring students was assumed to be different from the winter students” (King & Joshi, 2008, p. 546). The students’ responses to the ERS questions were factored into their overall grade in the course.

The results showed that students who actively participated in the lecture had a greater likelihood of having higher final grades in the courses in all sections of the course than those who did not participate. However, King and Joshi (2008) discovered, “the non-active students [in the clicker sections] did about the same as the students in the sections without clickers” (p. 547). In addition, the average grade improvement was the same whether or not ERS was used. King and Joshi (2008) also concluded “when clicker questions were part of the grade, students who answered incorrectly in class did not perform better on the corresponding exam questions than students who did not answer in class” (p. 551).

The study did not address several variables that may have affected the outcomes. Each of the three sections of the course in the winter term was taught by a different professor, which may have resulted in different performance outcomes regardless of whether ERS was used or not. In
the spring semester, the instructor of the ERS section taught one of the two sections of the course, but the other professor had not previously participated in the winter study. Having taught previously with ERS may have given the professor who used the technology an advantage over the other professor, in that he/she had more experience using the devices and in teaching the course a second time. The fact that participation was voluntary in the winter semester and mandated in the spring semester may have affected the outcome of the study, because the students may have been more likely to try their best to answer the questions if they knew that their course grade was affected by a correct response.

Bullock, LaBella, Clinghan, Ding, Stewart, and Thibado (2002) studied approximately the same 200 undergraduate students over two semesters enrolled in an algebra-based physics course sequence. In the second semester, an unspecified ERS infrared system was used, and indicators of student involvement increased strikingly. Attendance increased by 130%, class participation by 1,700%, and pre-class preparation by 1,100%. The number of students completing the homework increased 650%. Finally, average exam scores improved significantly, from 45% correct to a score of 75%, an improvement of 70%. The authors concluded that, in addition to improving student performance, there would be substantial cost and time savings by replacing separate discussion sections with in-class ERS use.

**Biology courses.** Perhaps because classes in biology rely a great deal on illustrations, ERS seems to have been used more often in these courses, as well as in medicine (described below). Kang, Lundeberg, Wolter, delMas, and Herreid (2012) studied the effectiveness of an instructional method for college biology courses they had developed called clicker cases. These were described as follows.

A Clicker Case is a story (e.g., a problem someone is facing, such as cancer, or a historical event) that includes multiple-choice questions about the cases interspersed
throughout the story. It is presented via [PowerPoint]…. Students answer these questions using their clickers, which provides the instructor real-time feedback on the students’ comprehension of both material and context. The intention of adding these questions at strategic intervals throughout the story is to engage students in understanding not just the facts, but also the situation and application of biological principles within the story. (pp. 55-56)

Twelve instructors in the United States and Canada alternated presentation of seven different topics (e.g., cells, DNA, cancer) by either the clicker case method or a traditional lecture method. In following semesters they used the other method for that topic (e.g., if the clicker case approach was used for cells in the fall, the traditional approach was used for this topic in the spring). A total of 2,848 students in 20 classes participated.

The principal goal of the study was to see whether the approaches were differentially effective for males or females, and this will be discussed below. However, overall differences between the methods were also reported. Results were mixed. It was found that by post-test score only, the clicker case students did significantly better on two of the seven topics. However, by pre-test/post-test difference scores, while this difference was replicated on three of the topics, on two other topics students performed better with the traditional lecture method.

Ribbens (2007) conducted an autoethnographical study using ERS with a large introductory biology course at Western Illinois University in the Spring 2007 semester. During his course, eInstruction clickers were used to answer periodic questions during the lecture. Occasionally, the devices were used to generate classroom conversations, as he posed a question and had students turn to a neighbor and discuss their responses. This class, with approximately 120 students, was periodically compared to another section of the same course that he had taught two years previously.

Ribbens (2007) concluded that the use of ERS improved students’ performance. Specifically, he noted that after the first test, the students scored 8% higher than in the same
course two years earlier. In addition, the students the semester of the study received better grades at the end of the semester, with a class average that was almost 8% higher than in the previous class.

However, Ribbens (2007) based his results on two courses that were taught two years apart. His teaching may have simply improved over that period, which could also account for the increase in scores and resultant grades. It was unclear whether the textbook used in the two classes was the same. There is no indication that Ribbens tested for statistical significance in the differing scores. He also based his final conclusions on only one test grade and one average of class scores.

El-Rady (2006) used eInstruction’s Classroom Performance System (CPS) in one semester for extra credit in a 111-student biology course. The CPS was introduced after Exam 1. The following semester, in an identical class with 125 students, CPS was required. At the start of every lecture, El-Rady administered a quiz based on the previous lecture’s material and also used CPS during the lecture, posing class participation questions to evaluate students’ comprehension of the material. He encouraged students to form groups of two or three to go over each question before responding individually, and then went over the results with them. Using the same exams (with many fail-safe mechanisms to prevent them being kept by students), Exam 1 average correct was 61% in the first semester (before CPS was introduced) vs. 71% for Exam 1 in the second semester, which differed significantly at $p < .001$. Later exams (comparing optional vs. required use of CPS) differed by approximately 5%, although statistical significance was not reported.

A different approach to ERS use was taken by Preszler, Dawe, Shuster, and Shuster (2007). Going beyond the issue of whether wireless student response systems are effective, the
researchers compared exam results from six biology courses with a total of 807 students in which the number of ERS questions, using the eInstruction CPS, were systematically varied throughout the courses. That is, in some courses, question numbers were low (0-2), then high (5-6), then medium (3-4), while the ordering was different in different courses. Instructional impact was measured by proportions of exam questions answered correctly on the various topics covered by the course segments (e.g., questions on content in which ERS question frequency was low vs. questions on content presented with high numbers of ERS questions). ANOVA analyses indicated that use of more questions was associated ($p < .001$) with higher exam scores, and this effect was substantially stronger for lower-division than for upper-division courses.

**Other subjects.** Holderied, a university librarian, described a study he and other librarians conducted comparing the use of ERS with discussion vs. lecture in information literacy instruction sessions for an English composition course at the University of North Carolina-Pembroke (Holderied, 2011). The ERS group had seven sections with 117 students in total, and the control group had eight sections, with 117 students as well. During each 50-minute session in the ERS group, the librarians asked three ERS questions and facilitated their class discussions around the students’ responses. The control group received the same number of questions orally, and the students were then asked to respond with a show of their hands.

Holderied (2011) concluded “The active learning approach, coupled with the use of clickers, did indeed result in increased learning outcomes for the clicker group over the control group” (p. 27). Performance outcomes were measured using pre- and post-tests. The traditional group received a 63.3 on the pre-test and a 77.9 on the post-test, for a differential of 14.6. The ERS group received a 67.2 on the pre-test and an 85.9 on the post-test, for a differential of 18.6.
A possible unaddressed variable in the study, in addition to a lack of analyzing for statistical significance, was that all of the courses were not taught by the same librarian. The different skills of the teachers may have resulted in different performance outcomes, regardless of whether ERS was used.

A study by Shapiro (2009) was an autoethnography with 210 students in her large General Psychology course at the University of Massachusetts Dartmouth. “Attendance and test scores of students registered in fall 2006, prior to the implementation of PRS [personal response devices], were used as baseline measures to evaluate the performance of the fall 2007 class” (Shapiro, 2009, p. 16). Fifty-seventy credited multiple-choice questions were given with ERS over the course of the semester and counted for 14% of the students’ final course grades. The researcher discovered that attendance increased in the ERS class, and that “students’ test performance demonstrated greater retention and comprehension of information targeted by PRS questions” (Shapiro, 2009, p. 20). Shapiro also found it much easier to prepare and grade quizzes and tests in the large class with ERS than in the course that did not use it.

Edmonds and Edmonds (2008) investigated whether McGraw-Hill’s Classroom Response System (CRS) technology increases student performance. To do this, a quasi-experiment using six managerial accounting courses was conducted at an accredited urban university. The study took place over two semesters, and three of the courses with 275 students were taught without using CRS technology, and three with 279 students used CRS. All of the courses were taught by the same professor and used the same syllabus, homework, course content, and tests. Students in the CRS group answered all questions posed (five or six per class) electronically through clickers used with the CRS. Students in the non-CRS group submitted answers to the selected questions on paper that was collected randomly by the professor, usually once per class.
The results showed that the students in the CRS courses performed an average of 1.94 score points (approximately 2/10 SD) better than the students in the non-CRS courses, significant at $p = .02$. Furthermore, this advantage increased to 3.15 points after controlling for gender, age, ACT score, and prior GPA (all of which were themselves independent predictors of course performance) in a multiple regression analysis ($p = .0004$). The researchers also determined that using CRS technology was the most beneficial to students with the lowest prior GPAs, and that CRS technology helps the low-GPA students without having a negative impact on the high-GPA students.

Finally, Kaleta and Joosten (2007) reported on a University of Wisconsin system study of ERS. This was part of a 4-campus project to encourage the use of ERS. Eleven courses were taught by the same instructors in two fall semesters, although the total number of student participants was not stated. Kaleta and Joosten reported that grades improved $p < .05$ with use of ERS, although the only statistics reported were that the proportion of students receiving a grade of C or better improved from 83.0% to 85.3%. It was emphasized that, as the second semester was the first instance of use of the technology, it might not represent its full potential. However, it may also be noted that a Hawthorne effect could have accounted for the improvements, as this was a campus-wide introduction of a new approach that surely received a great deal of attention in campus news outlets. That is, if students expected the new technology to improve overall student performance, they may have worked harder in order to keep up with presumably higher standards.

**Medical and post-graduate courses.** Along with a relatively high rate of studies in the sciences and biology, the medical field has received quite a bit of attention from researchers studying ERS. Berry (2009) conducted a case study in a first semester senior pediatric nursing
course that used Student Response Systems (SRS). The course was taught over Interactive Television (ITV) with students at a remote site as well as in person, “creating the challenge of whole-class engagement” (p. 295). The 65 students used ERS to take 13 quizzes, the best ten of which counted towards their final course grade. Exam grades and participation in case studies were recorded. Exam grades of that course were compared to those of the same course, not using SRS, taught the previous semester. Student $t$-tests showed that one of the three course exams and final grades were significantly higher for the students who used ERS in the classroom.

McCurry and Hunter-Revell (2011) also compared two small nursing research courses ($n = 35$ and $n = 29$), in which the sections used a personal response system (PRS) for some topics and not others. The study looked at the effectiveness of PRS when test and quiz questions were given with ERS versus when they were administered using pen and paper. Class quiz averages between and within groups were compared, forming a crossover design. McCurry and Hunter-Revell reported that “findings related to between and within class quiz scores were mixed, whereas the effectiveness of in-class PRS questions on paper-and-pencil quiz scores and PRS-targeted quiz items was significant” (p. 471). However, the researchers acknowledged that while the PRS benefited the students, a factor that may have influenced the scores could have been the different instructors that taught each section in a possibly different way from each other.

Pradhan, Sparano, and Ananth (2005) conducted a prospective, randomized controlled trial that presented lectures regarding contraceptive options to obstetrics and gynecology residents. Eight residents who received audience response system (ARS) interactive lectures showed a 21% improvement between pre-test and post-test scores, whereas the nine residents who received the standard lecture demonstrated only a 2% improvement (difference by $t$-test, $p = .018$).
In a more elaborate and carefully controlled study of 24 family medicine residents, Schackow, Milton, Loya, and Friedman (2004) studied the effects of ARS during didactic lectures. Sixteen lectures in eight pairs were presented by the same four faculty members. The 16 lectures were divided as follows: 8 were considered controls, consisting of 4 “basic” and 4 “interactive,” in which the audience was presented with questions; and 8 used ARS (RSVP system with radio clickers). Students were divided by last name and groups were alternated as to which of the three conditions they were assigned to for different topics. Effectiveness of the three types of instruction was measured by post-lecture quiz scores. Following the basic lectures, scores averaged 61% correct, whereas following interactive lectures without ARS they were 93% correct, and following those with ARS, 96%. The latter two conditions resulted in significantly higher \((p < .001)\) scores than in the basic condition, although the interactive and ARS conditions did not differ significantly. Here it might be noted that the obvious ceiling effect may have prevented any difference between these teaching techniques from being detectible. Other characteristics of the design (sequence of lectures) or residents (crossover group, postgraduate training year, In-Training Examination score, or post-call status) did not affect the differences.

Slain, Abate, Hidges, Stamatakis, and Wolak (2004) evaluated the impact of an interactive student response (ISR) system on students in the doctoral program of the School of Pharmacy at West Virginia University. Students enrolled in three courses were taught using a traditional lecture format in Year 1. In Year 2, course material was taught essentially the same way, except that an ISR system (Optionfinder) was added. The same four instructors taught all course work and covered the same material in both years. There were approximately 66 students in each class. The primary outcome of interest here was performance on examinations. Students
in all three courses scored significantly higher in Year 2, with significance values of $p < .001$, $p = .016$, and $p = .0002$, respectively.

Kyei-Blankson (2009) used Turning Point clickers in one section ($N = 20$) of a graduate-level course in statistics and methodology in education. Students used clickers three or four times per class to respond to questions assessing their understanding of statistical concepts being covered that day. Students were then allowed time to discuss their responses in small groups, and shared their responses with the whole class. Following this, the instructor explained why a particular response was right or wrong. In a second section ($N = 10$), clickers were not used.

Performance was assessed by scores on the final exam. The ERS group averaged a score of 24.9 ($SD = 3.77$), while the non-ERS class averaged 20.7 ($SD = 6.18$). The means differed by $t(28) = 2.13, p < .05$, and the author noted that students in the control group varied much more widely in their scores than did those in the ERS group. That is, the difference in academic achievement can be explained by saying that in the control class, some students did much more poorly than others, whereas in the ERS class this was not true, presumably because poorer students were either motivated to do better or helped by the class interactions. However, it should be noted that the large difference between $Ns$ may have affected results in the two classes, independently of the ERS manipulation. Kyei-Blankson (2009) also reported that students in the ERS class were very positive in their responses to a questionnaire at the end of the semester.

Finally, Horowitz (1988) reported on one of the earliest studies using an ERS system, which was conducted with professionals in business training. He concluded that ERS can be an effective tool not only in the college setting but in the professional training environment as well. In 1988, the IBM Corporate Education Center mandated that all of its new managers attend a one-week course at its headquarters. The executives wondered if higher levels of student
performance and retention could be achieved by giving each of the managers a clicker during the question and answer point of the lecture. They also questioned if the participants’ involvement and interaction during the training would increase if clickers were used. One goal of the training for the ERS was to “stimulate the active learning processing of data, information, ideas, viewpoints and beliefs at the same time as the learning is taking place” (Horowitz, 1988, p. 6). The executives also wanted to “provide students with frequent indicators of both individual and class learning progress which include comparisons with peer groups, previous classes and demographic subgroups- to encourage positive effects of self-assessment and competition among students” (Horowitz, 1988, p. 7). They did this using a clicker from Reactive Systems, Inc. and asked the students mainly multiple-choice questions.

The study had mixed results. According to Horowitz (1988), “the technology assisted the facilitator to complete all the learning points within the allotted time, and in some cases the total number of learning points were increased by 20 to 30 percent” (p. 10). In addition, test scores over the material taught in the training session increased by 27% compared to the sessions where ERS was not used (Horowitz, 1988). However, ERS did not make as dramatic a difference in the classroom environment as the executives had predicted they would. A data analysis found that this was due to the following: instructors were not familiar with using ERS; almost all of the questions asked to the students were in the format of multiple-choice questions that did not offer variety for the students; and when more than four choices were given for each multiple choice question, the students spent too much time selecting a correct answer (Horowitz, 1988).

This study did not identify the number of participants. Therefore, it is not known how many different groups, consisting of how many different students, received training with ERS
compared to those that did not receive instruction with it. In addition, statistical analysis was not reported to indicate whether the improvements were statistically significant.

**Summary of direct comparisons between ERS and standard lectures in academic outcomes.** As the studies reviewed in this section show, most work on comparing an electronic response system to the usual class format has been performed in more technical courses. Only three of the 19 studies were done in the social sciences (psychology, Shapiro, 2009), business (accounting, Edmonds & Edmonds, 2008), or mixed fields (subjects not specified, Kaleta & Joosten, 2007). Although ten studies compared the teaching methods contemporaneously, eight (plus half of one study) were conducted across two different semesters, and in every case the ERS class came after the standard class, so there might have been some bias in favor of the instructors’ experience leading to better student performance regardless of method. A number of the studies specifically reported that the ERS was being used by the professor for the first time, and most did not mention the instructor’s experience one way or the other. Because it has been noted that experience with the system makes a difference (e.g., Gok, 2011), it is hard to judge whether the results of these studies would apply to the more usual case in which, after a few semesters of use, the professor would be quite comfortable and skilled with the equipment and its integration into the course. In three of the studies, different faculty members taught the courses, also reducing comparability. Furthermore, it was found (King & Joshi, 2008) that students who declined to use the clickers when they were voluntary (for extra-credit) gained little or no advantage from them. In several of the studies reviewed it was unclear as to whether their use was required. Finally, and most importantly, of the 19 studies, approximately ten demonstrated positive effects of ERS, although not all included analysis of statistical significance, six reported
mixed results, and three showed no clear difference. Thus, there is much yet to be understood about the effects of ERS on student performance.

**Student subgroups.** While the studies that do exist have focused on macro perceptions of the benefits and disadvantages of ERS on a class-wide level, there is very little research touching on perceptions and effects of ERS on particular subgroups of students. For example, to promote effective and equitable learning it is important to know whether ERS benefits male and female students equally or to a disparate degree. This topic has received surprisingly little attention in research on teaching in general. For example, in the book *How People Learn* (Bransford et al., 2004), the term *gender* appears only once, in the context of “Prior knowledge also includes the kind of knowledge that learners acquire because of their social roles” (p. 72). The terms *males* and *females* did not appear at all, and there were only a couple of mentions of *boys* and *girls*. Although gender differences in learning styles are typically minor, especially at the college level, they do exist (Dwyer & Johnson, 1997), and whether such differences are biological or learned is irrelevant. As noted by the NASSPE, “there are no differences in what girls and boys can learn. But there are big differences in the best way to teach them” (2011, para. 31). Therefore, it is incumbent on college faculty members to be sure that a change in teaching technique will not result in an unfair advantage to one gender or the other.

Several studies have specifically compared the attitudes of male and female students toward ERS, although in 2009, Kay (2009) had noted that “To date, no research has been done investigating gender differences in attitudes toward [ERS]” (p. 731). Newmark, Seaton, and Stallings (2011) found no direct link between satisfaction with ERS and gender in an Accounting Information Systems course. As part of the study by Gok (2011), 523 students (241 males, 262 females), took an SRS attitude survey about ERS. It revealed that male students had a
significantly more positive attitude toward ERS than their female counterparts. This study did not, however, examine student grades or any potential impact of the ERS upon them. A study by González-Espada and Bullock (2007) on item-response time using an ERS found only trivial differences between males and females.

Edmonds and Edmonds (2008), as part of their study described above, did look at gender differences and reported no difference in the effect of ERS by gender. One study (King & Joshi, 2008), outlined above, was designed to examine gender differences in the use and effectiveness of ERS. In a study of 620 male and 120 female students taking a general chemistry course specifically for engineering majors over three different semesters, the authors concluded that female students participated to a greater degree in answering class discussion questions using clickers. Nevertheless, the authors also found that there was no difference in the grade performance of male and female students overall. However, this study was subject to several limitations. First, it involved only engineering majors. Second, the study involved two different instructors and thus could not account for possible differences in instructor teaching skill or experience in the use of ERS. Third, students received full credit for class participation grades simply by answering 75% of class discussion questions with clickers, regardless of whether the responses were correct or incorrect. Thus, the extent to which use of ERS impacted scores based upon course content knowledge is unclear.

In the Kang et al. (2012) study described above, the authors did find a gender difference. “Women either performed better with Clicker Cases, or about the same with either instructional method, but men performed markedly better with lectures in most topic areas” (p. 53). The results suggest that women and men experience the pedagogical approaches of lectures and Clicker Cases differently and that Clicker Cases are less favorable for men than women.
It appears that no other studies have examined whether use of clickers actually benefits male and female students similarly or disproportionately. Similarly, there seem to be no studies that have examined the extent to which perceptions and impact of ERS varies by student year in school (i.e., freshman, sophomore, etc.) and age. The closest investigation appears to be the study by Preszler et al. (2007) that found a stronger effect of ERS in lower-division than upper-division courses.

Finally, very few studies have examined whether ERS impacts academically stronger and weaker students to differing degrees. The Edmonds and Edmonds (2008) study found that ERS was more effective in raising student performance for low-GPA students than those with high GPAs. To make most effective use of ERS, educators should have this information, which is addressed in the current study.

Other understudied topics. Almost all of the studies cited above involved science, mathematics, and business courses, almost exclusively in large lecture hall classes. Largely unexamined in the literature is student perception of ERS and its possible effect on student quiz and test scores in a small, liberal arts general education course such as the introductory Biblical Studies course at a small, private, evangelical midwestern university that is examined in this study. One should not assume that the effects of using a particular technology, such as ERS, will be the same across these environments differing widely in course content and class size, because the nature and quality of learning that takes place in a small class environment may be substantially different from that of the large lecture hall course (Cooper & Robinson, 2000).

In conclusion, there remains much research to be done in the area of ERS. Past studies have been primarily qualitative in nature and have focused on the benefits and disadvantages of using clickers in the classroom as perceived by students and professors. However, most
researchers have not focused on whether such perceptions correlate with actual differences in academic performance. Those studies that have, described in detail above, have shown very inconsistent results. Nor does the existing literature adequately explore whether the use of clickers impacts male and female or academically more or less gifted students similarly or disproportionately. Finally, whether the perceptions and impact of ERS in a small, liberal arts course classroom may be similar or different than in a large science, mathematics, or business course lecture hall is largely unknown. This study is quantitative in nature and examines these unstudied and under-studied areas in the context of an undergraduate introductory course at a small, private, evangelical midwestern university.

Summary

This chapter summarized the literature relevant to the question of what effects ERS may have on a class in which it is used. It began with a “Cognition, Constructivism, and Active Learning” section, followed by “Electronic Response Systems” on the chronological development of ERS and the purpose of ERS use in the classroom. The third section, “Perceived Benefits and Disadvantages of ERS,” included subsections on student-perceived benefits and disadvantages and faculty-perceived benefits and disadvantages. A fourth section described “Literature on Aspects of ERS Requiring Further Study.” This encompassed subsections on improved performance, direct comparisons of ERS and non-ERS classes on performance, student subgroups, and other understudied topics.
CHAPTER THREE: METHODOLOGY

The principal purpose of the study was to explore the use of Electronic Response Systems (ERS) in a college course. This chapter describes how the exploration was conducted. Following a review of the purpose, the first section is “Participants.” This section discusses how access was gained to the sample of students and explains human subjects and IRB considerations. The following section, “Equipment Used,” describes the ERS equipment. The next section, “Measures,” presents the three types of measures used to gather data: a demographic questionnaire, a questionnaire on student perceptions of ERS, and course quiz and test scores. The fourth section, “Research Design,” provides a rationale for the type of design and lists factors that limit the design from being a true experiment. This is followed by “Procedures,” which describes recruitment of participants, how informed consent was obtained, how sections were assigned to the manipulation, and details of how ERS was used in the ERS class. Finally, a section on “Data Analysis and Display Procedure” discusses how data will be presented and analyzed in Chapter Four, and presents a power analysis.

Restatement of Purpose

The purpose of this study was to determine the effect of ERS on students and their performance in an introductory course offered at a small, private, evangelical midwestern university. ERS effects were assessed through a quantitative study conducted in two sections of the course, one using ERS and the other not. The studies described in the previous chapter
demonstrated that, in certain specifically examined courses, students’ grades were thought to be higher in classes where ERS was used. However, there appear to have been few studies examining whether use of ERS correlates with actual changes in academic performance, and results of those studies are inconclusive. Unlike most previous studies that focused solely on subjective evaluations from students and professors as to the benefits and disadvantages of ERS in the classroom, this study sought to determine whether such perceptions are warranted and correspond with actual differences in academic performance. It was also intended to contribute new knowledge about whether use of ERS benefits different groups of students (male and female and those with higher and lower GPA) equally or whether there are significant observable variations corresponding with these characteristics.

Research questions to be answered consisted of the following:

Q1: Is there a significant difference between student assessment performance based on use of ERS?

Q2: Is there a significant difference between student assessment performance based on use of ERS with gender added?

Q3: Is there a significant difference between student assessment performance controlling for the influence of GPA?

Q4: Is there a significant difference between student assessment performance controlling for the influence of GPA with gender added?

Q5: Is there a significant difference in student perceptions in the use of an ERS based on their use of ERS?
Participants

Sample

The participants were 83 students from two course sections of an introductory Biblical Studies class at a small, private, evangelical midwestern university. The 83 students were a convenience sample, because Professor Smith (a pseudonym), the instructor for these course sections, volunteered to host the study in his class. Professor Smith is an Assistant Professor of Biblical Studies.

Because this is a required course for all students at this university that most students take during the freshman year, the majority of the participants (62, or 74.7%) were freshmen. There were also 19 sophomores (22.9%) and two juniors (2.4%). Ages ranged from 18 (three 17-year-olds were dropped from the study) to 38, with a median age of approximately 18.4. As anticipated, the students were approximately evenly divided between males (35, or 42.2%) and females (48, or 57.8%). Although the course is required, students chose the section to sign up for during the usual pre-registration process. It happened that the numbers were close to evenly divided, with 42 (50.6%) in the M-W-F section, and 41 (49.4%) in the Tu-Th section. Both genders and school year were evenly represented in the two sections (for gender: Fisher’s Exact Test = .270; for school year, $\chi^2_{(2)} = 1.56, p = .458$; the two juniors were in different sections).

Two students dropped the class, so end of semester data was unavailable for them.

Human Subjects Considerations and Clearance from IRB

The IRB at the university where the study was conducted approved the study (see approval letter in Appendix A). IRB clearance was also obtained from Ball State University, where the researcher was enrolled and pursuing doctoral studies (see approval letter in Appendix B). The researcher completed and passed the National Institutes of Health training course
“Protecting Human Research Participants” as well the Collaborative Institutional Training Initiative (CITI) training course “Social & Behavioral Research-Basic/Refresher” and was therefore eligible to conduct the study. Professor Smith also completed human subjects protection training as required by the two universities involved.

Professor Smith has access to quiz and test score data of the student participants, as they were used for grades in his course. Student test and quiz scores and questionnaire responses were reported to the researcher only by numerical designations and thus were not associated with student names. A key was provided by Professor Smith to the researcher that assigned a unique numerical designation to each student, which identified only the student’s demographic information and whether the student was in the ERS section or the control group. Score data in a form that preserves student anonymity is stored in a locked cabinet, to which only the researcher has access, where it will remain until December 2013 when her dissertation is complete. After that time, the data will be destroyed. The information about the study stored on the researcher’s computer will remain in this password-protected environment for one year after completion of the study.

It should be noted that the professor who taught this course (designated in this study by the pseudonym Professor Smith) is an instructor who had used ERS for 4½ years and had expressed great interest in the results of this study. Therefore, there was some concern that he might unconsciously steer the results to fit his preconceptions. A number of methodological steps described below were imposed to try to minimize any potential bias.
Equipment Used

The university at which the study was conducted uses the ERS equipment manufactured and sold by Turning Technologies (2012) of Youngstown, Ohio. The ERS equipment includes a receiver usually positioned at the front of the classroom, a set of keypads or “clickers,” one per student, and software. The receiver is usually a small device the size of a large flash drive, which plugs into the USB port of a laptop or desktop computer. Also available is a small handheld device for use without a computer. The keypad is the ResponseCard RF. It measures 3.3” × 2.1” × 0.3” and weighs 1.0 oz, including batteries. It communicates with the receiver via radio frequency. It includes a signal (a green light) to indicate that a response was received, and operates within a range of 200 feet. The software used is TurningPoint Polling software (2008 version).

Measures

Demographic Questionnaire

Three types of measures were used to gather data for the study. First, a demographic questionnaire included questions on the participant’s gender, school year, age, and GPA, and questions to assess the participant’s level of experience with and approval/disapproval of the use of electronic devices, administered once on the first day of class along with the informed consent form. (See Appendix C for a copy of the demographic questionnaire.)

Perceptions of ERS

Second, a questionnaire assessing students’ expectations and/or evaluations of the use of the ERS in class was administered on the first day of class. A copy of this questionnaire can be found in Appendix D. This questionnaire was modeled on the questionnaire developed by
Martyn (2007) and used by her in a study comparing four sections of an introductory computer information systems class, with two using ERS and two using class discussion. Dr. Martyn granted permission (Appendix E) for use of the questionnaire in this study. Three students who missed the meeting in which questionnaires were administered were asked to complete them at their next appearance. At the end of the semester, Professor Smith re-administered the questionnaire to see if opinions had changed.

Course Performance

Third, with participants’ permission, scores on the course pre-test, quizzes, and tests were shared with the researcher, with names replaced by study ID numbers as described below. All such data was used as outcome measures. Professor Smith agreed, to the extent feasible, to grade exams without the knowledge of the students’ names and course sections, so as to minimize any bias he might have as to his expectations about section differences.

Research Design

Type of Design

The research design was a quantitative quasi-experimental study. It was quantitative (Creswell, 2009) in that all data gathered was in the form of numbers: questionnaire scores, quiz scores, and test scores. This was an appropriate type of method because the main goal was to compare groups of students on measures that are themselves normally expressed in numbers: quiz and test scores. It could be considered a true experiment (Creswell, 2009) in the sense that the course sections were randomly assigned to the treatment (ERS) or control (no ERS) conditions. However, there are many features that limit the experimental quality of the study. In effect, it could be considered an experiment with an $N$ of 2: the two classes. It might also be
considered an experiment with an $N$ of 83, but with many confounding or limiting factors due to the class-wide manipulation. A visual illustration of the study design appears in Figure 1.

\[
\begin{array}{ccc}
R & X & O_1 \\
R & O_2 \\
\end{array}
\]

R: random assignment
X: treatment
O: observation or measurement

Figure 1. Illustration of study design using the Campbell & Stanley (1963) representation.

Limiting Factors

The limitations described here are not general study limitations, but they do hinder the study from being a true experiment with high external validity (Creswell, 2009). They include:

1. The course instructor administered the manipulation, in that he used the ERS in one class and not the other. Although for the most part lectures, exercises, quizzes, and class requirements such as attendance and class participation were the same for the two classes, any necessary or unintended differences between the two versions would be confounded with the manipulation.

2. As only a single professor was involved, and only a single course studied, firm conclusions regarding the ERS manipulation have limited generalizability.
3. Classes often have their own “personalities,” with some enthusiastic and others playful, for example, regardless of any other detectible differences. This difference between classes may tend to make the performance, for better or worse, of any given student in one section more like other students in that section than like students in the different section. This tendency of students to behave like others in their section would violate the statistical assumption of independence of scores, and tend to make analyses non-conservative.

4. To some extent, the course performance (test and quiz scores) were determined by the same person (the instructor) administering the manipulation, so that these evaluations could not be blind as to the manipulation. To mitigate this lack of blind evaluations, the professor attempted, to the extent practical, to grade tests blind as to the student and section (see above). As tests and quizzes were not developed prior to the study, it was not possible to view his scoring rubrics.

5. The two sections of the course met with different class schedules, one on Monday, Wednesday, and Friday, and the other on Tuesday and Thursday. Thus, the manipulation was necessarily confounded with any differences between these schedules; for example, students signing up for the sections might have differed, or might have learned differently in the two ways the course material was broken up, or might have enjoyed the class to different degrees. On the other hand, the schedule does mean that material taught to the ERS class did not always follow that in the control class or vice-versa, so if the instructor modified his presentation the following day in response to class reactions, any effects of order of classes would have been approximately balanced between the two sections.

6. Although the manipulation was conducted after the first meeting of the class, it is possible that some students might have attempted to change their section or drop the class after
discovering in which section the ERS would be used. Therefore, any students who changed sections were to be dropped from the study, though in actuality no students changed sections. Students in both sections were expected to buy the clickers before the first class meeting, but arrangements were made with the student store to allow them to be returned for a refund if students were assigned to the control section. As it happened, two students, both in the ERS class, did drop the course. It is not possible to know whether dropping was related to the ERS.

Finally, a general limitation to the study was a reliance on self-reported GPAs in several of the analyses. Those analyses were valid only to the extent that the participants were honest and accurate in their reports.

**Procedures**

This section describes the study procedures in detail. The description includes recruitment of participants, informed consents, and differences between the ERS and control sections.

**Recruitment of Participants**

At the first meeting of each of the two sections, after taking roll to determine if students matched the enrollment sheet and following about 30 minutes of general course description and other routine business, to allow for late arrivals, Professor Smith then introduced the researcher, who described the study and passed out informed consent forms (Appendix F). The description, both orally and in writing, made it clear that Professor Smith would be using ERS in one randomly-selected class and not the other, and that this difference between the classes was his choice as the instructor but would be determined by a coin flip. Student participation would consist only of completing the questionnaires and allowing their test and quiz scores to be shared
with the researcher, with identities concealed by use of randomly assigned ID code numbers. That is, it was made clear that students in the class using ERS would still be required to participate in the class exercises using the clickers, whether or not they gave consent for participating in the study. Two students in the M-W-F section declined to participate in the study, while no students in the T-Th section declined. Since participation was solicited before it was determined which class was to use ERS, this was not an influence on decision to participate.

**Informed Consents**

The informed consent form included the usual space for signing to indicate consent, and for those who consented a request to complete the demographic questionnaire and questionnaire on their expectations, which were attached. The informed consents had previously been marked with a random identification number, which was also on the questionnaires, and included a separate sheet at the end with only the ID number. When the consent was completed, students were told to remove the sheet with their ID number and keep it with their class notes, and hand in the consent forms. The informed consents, which were the only document matching names and ID numbers, were separated from the questionnaires immediately.

**Determination of Groups**

After the first meeting of each section, it was determined randomly (by a coin flip) which section was to have the ERS intervention. This proved to be the Tu-Th section. The researcher attended the second meeting of each section to explain the study and request participation of three students who were not present at the first meeting of the classes. If students switched from one section of the course to another after learning of the ERS assignment, they were to be dropped from the study, as it may be that this action was partly influenced by their knowledge of the ERS manipulation. However, no students switched course sections.
Details of ERS Application

Professor Smith (personal communication, October 8, 2012) reported his use of clickers as: “I use them once or twice a week for [around 12] five (5) question reading quizzes, and once or twice a week for discussion starters (I usually have the students vote on their opinion or view, discuss with a neighbor, and then discuss as a class).” Otherwise, he strove to run the two classes similarly, but in the control class he gave quizzes on paper. He did not have students vote, as raising hands in response cannot be done anonymously. Students could make up missed quizzes and tests, although in the class using ERS, the make-ups were on a paper version of the exam. Students who forgot to bring their clickers to a class with a quiz could also take it on a paper version, but were penalized 5%, so there was a strong incentive for remembering to bring the clicker. As noted in Chapter Two, a significant drawback of using ERS is that instructors inexperienced with using it may not use it well, which leads to student dissatisfaction. Professor Smith had used ERS a number of times previously in the past 4½ years. In this sense he was typical of those who use the system routinely, in contrast to some studies in which ERS was introduced into classrooms for the first time for purposes of the study.

Data Analysis and Display Procedure

In the following chapter, descriptive statistics for demographic information, questionnaires, and test and quiz scores will be presented in tables. It was thought unlikely that distributions would be markedly non-normal, but this was checked. A few incidental statistics, for example, the correlation of GPA and course performance, were also thought to be of interest in describing the sample or clarifying analyses. For statistical significance, an alpha level of .05 was chosen as the cut-off. “An alpha level of less than .05 is accepted in most social science
fields as statistically significant, and this is the most common alpha level used” (Zint, 2012, para. 1).

**Statistical Analysis of Research Questions**

Research questions were analyzed as follows.

Q1 was whether the two sections differed in students’ course quiz and test scores. Overall combined quiz and test scores were compared between the two classes by \( t \) test, equivalent to a 2-group one-way ANOVA (\( F \) test). Either of these analyses is appropriate as they compare mean scores between two independent groups (Fraenkel & Wallen, 2007). It was predicted that scores would be higher, on average, in the class using ERS, and that this difference would be statistically significant. This prediction was based on several anecdotal reports (e.g., Sprague & Dahl, 2010) and a few experimental studies (e.g., Holderied, 2011), indicating that ERS use improves student performance.

Q2 was whether the difference between sections, if any, varied by gender. An analysis of variance (ANOVA, \( F \) test) was performed with course section and gender as factors and overall total quiz and test point score on which the course grade is based as the main outcome measures. These analyses were followed by parallel analyses using secondary outcome measures (individual quiz scores, for example). A 2 × 2 ANOVA is appropriate as the two predictor variables (course section and gender) were dichotomous and crossed—proportions of males and females were roughly equal in the two sections (Fraenkel & Wallen, 2007). A significant condition \( \times \) gender interaction would indicate that the effect of the manipulation did differ for men and women. That is, that men and women responded differently in the two conditions. Furthermore, the main effects of the interaction were examined to determine if the genders differed in their performance within each section separately. No prediction of a direction (for
example, that women would do better in the ERS section, compared to men, than in the control section) was made because there is very little research on this topic to suggest a likely outcome.

Q3 was whether the difference between sections, if any, varied by academic ability as measured by self-reported GPA. As noted above, any difference between sections could be affected by a number of factors in addition to the manipulation, including differences in academic ability between the student groups at the beginning of the semester. Therefore analyses of covariance (ANCOVAs) were performed, with self-reported GPA used as a covariate. This analysis was appropriate because the independent variable (section) was categorical, outcome measures (exam scores) were continuous, and a third variable that was expected to correlate highly with the outcome variables (GPA) was also continuous (Fraenkel & Wallen, 2007).

A main effect of section could be significant in this analysis even if it was not in the analysis for Q1, as using GPA as a covariate would control for any possible influence on exam scores due to a general tendency to do better academically. In effect, a potential source of noise can be accounted for, improving the power of finding a significant main effect (Fraenkel & Wallen, 2007). In addition, a significant section × GPA interaction would indicate that ERS affected student performance differently for students of different academic abilities. No prediction was made for these analyses as the few studies previously addressing this (e.g., Kang et al., 2012; Newmark, et al., 2011) have shown mixed results. Finally, scores from the 38 assignments, quizzes, and exams were used in repeated-measures ANCOVAs with GPA as the covariate. This analysis was to indicate whether students in one section steadily and consistently improved their performance compared to those in the other section. This analysis was of interest because of the findings by Karaman (2011) that improvement in the group that used ERS was not maintained over the semester.
Q4 was whether the difference between sections, if any, varied by gender and academic ability combined. This question was essentially a combination of Q2 and Q3. To analyze this question, 2 × 2 ANCOVAs were performed, with section and gender as factors and GPA as covariate, for reasons explained above.

Q5 was whether student perceptions of ERS differed by whether or not they had used ERS previously. The latter information was measured by two Yes-No questions: “Have you ever used an Electronic Response System (clicker) in a college class?” and “Have you ever used an Electronic Response System (clicker) in school at any time during kindergarten through twelfth grade?” The appropriate analysis depended on the distribution of participants on these questions. Since roughly ¼ of participants fell into each of the four possible patterns (Yes-Yes, Yes-No, No-Yes, and No-No), a 2 × 2 ANOVA with overall positivity of perception as the dependent variable was appropriate (Fraenkel & Wallen, 2007). This analysis was repeated with the six other questions on the Student Perception Questionnaire. This was to analyze the main effects of both types of prior experience, as well as their interaction. No predictions of effects were proposed, as a case could be made in either direction—that is, it is possible that those with experience might feel more positively or negatively about ERS, compared to those whose perceptions are based on second-hand information.

Prior to analyses being conducted, statistical assumptions were tested by means of the SPSS Explore function. By both visual inspection of plots and statistical values (e.g., skewness and kurtosis), very few and minor deviations from statistical assumptions were found, both in overall distributions and across subpopulations (in particular, students in the two classes.)
Exploratory Analyses

Additional analyses were performed on (a) data obtained that had not been anticipated (pre-test/post-test change in knowledge and change in opinions of ERS); (b) change in test scores over time, to assess for changes in ERS effects; and (c) an attempt to find other variables beyond gender and GPA that might shed light on ERS effects (including school year, age, and experience with personal electronic devices).

Dr. Smith routinely administered a pre-test early in the semester that was also used as a final exam (though counting as only 5% of the course grade). This constituted the only direct measure of learning, in the sense of knowledge gained over the semester. The post-test and difference scores were used in analyses like other measures of performance.

Since gender and GPA proved to have no effect on results, school year and age were also used as covariates in ANCOVAs. It was also thought that experience with personal electronic devices might make a difference in ERS effects. Thus total device use and attitude were used as additional covariates in ANCOVAs.

The pattern of outcome measure scores over the semester was also examined, simply by generating graphs. As there were no obvious patterns, no statistical analyses were conducted.

Finally, since Dr. Smith had decided to re-administer the Student Perception Questionnaire at the end of the semester, changes in opinions were compared across the two classes using repeated-measures ANOVAs. In addition, pre-post changes were analyzed within each class by repeated-measures t tests.

Power Analysis

Although the N of participants (originally estimated to be approximately 88) was determined by enrollment, it was of interest to estimate the effect that could be reliably detected
with the proposed design. For the main analysis of Q1 (t test), with Ns of 45 and 43 in the two conditions, 1-tailed alpha set at $p = .05$, and power at 90%, a mean difference of $.63 \sigma$ would be required for significance according to G*power (Faul, Erdfelder, Lang, & Buchner, 2007). This is close to Cohen’s (1992) “medium” effect size of $d = .50$, compared to a “large” effect size of $d = .80$. On the other hand, there would be a 50-50 chance (power = 50%) of detecting a difference as small as $d = .35$. Thus, a moderately large effect would have to be evident in order to find significance with this analysis, although this was among the lowest-power tests proposed for the analyses.

Summary

Following a review of the purpose of the proposed study, the first section of this chapter was “Participants.” This section discussed how access was gained to the sample of students and explained human subjects and IRB considerations. The following section, “Equipment Used,” described the ERS equipment. The next section, “Measures,” presented the measures used to gather data on demographics, student perceptions of ERS, and performance in the course. The fourth section, “Research Design,” provided a rationale for the type of design and listed factors that limit the design from being a true experiment. This was followed by “Procedures,” on recruitment of participants, informed consent, assignment to the manipulation, and how ERS was to be used in the ERS class. Finally, a section on “Data Analysis and Display Procedure” discussed how data was to be presented and analyzed and described a power analysis.
CHAPTER FOUR: RESULTS

The current study was designed to investigate whether use of Electronic Response Systems (ERS) in an introduction to Biblical Studies course at a small, private, evangelical midwestern university would make a difference in student performance. One course section was conducted using ERS, the other, a control group, was not. The research questions asked were as follows:

Q1: Is there a significant difference between student assessment performance based on use of ERS?

Q2: Is there a significant difference between student assessment performance based on use of ERS with gender added?

Q3: Is there a significant difference between student assessment performance controlling for the influence of GPA?

Q4: Is there a significant difference between student assessment performance controlling for the influence of GPA with gender added?

Q5: Is there a significant difference in student perceptions in the use of an ERS based on their use of ERS?

This chapter begins with general descriptive statistics, including participant characteristics such as age and prior experience with ERS, and summaries of outcome measures. The following section reports analyses of the five research questions in order. This discussion is followed by exploratory analyses in an effort to shed light on the negative results of analyses of
research questions. These analyses include pre-test—post-test change scores, the differences related to school year, age, and prior experience with personal devices, and change over time. Finally, change in perception of ERS is analyzed. The chapter concludes with a summary.

**Descriptive Statistics**

**Participant Characteristics**

A total of 88 students signed informed consent forms, although three (one in the control class and two in the ERS class) were under age 18 and consequently their data was dropped from the study, and two students dropped the course, leaving 83 participants. A single student missed the course pre-test, so that score is missing. Apart from this, there was no missing data.

The 83 students were nearly equally divided between the two sections, with 42 in the Monday, Wednesday, Friday control group, and 41 in the Tuesday, Thursday ERS class. Student demographics were very similar in the two sections of the Biblical Studies course, with any differences in gender, school year, and age not approaching significance. Overall, 35 (42.2%) were males, 48 (57.8%) were females. The majority of participants, 62 (74.7%), were freshmen; there were 19 (22.9%) sophomores, and there were two (2.4%) juniors. Age distribution of participants included 32 (38.6%) 18-year olds, 35 (42.2%) 19-year olds, 9 (10.8%) 20-year olds, and 4 (4.8%) 21-year olds, with one student each (1.2% each) at ages 22, 23, and 38.

Self-reported grade point average (GPA) ranged between 1.7 and 4.9, with a mean of 3.57 ($SD = 0.43$). (The unusual GPA of 4.9 was rechecked, and this is what the student reported. Although the university uses a 4.0 scale, it is possible that this student had transferred from another college using a different scale.) Students had been asked to report their experience with personal electronic devices, as a number of prior researchers (Baker et al., 2007; Guthrie &
Carlin, 2005; McCurry & Hunter-Revell, 2011) had claimed that such devices were nearly ubiquitous among current students, and a high level of electronic device use was a major justification for introducing ERS into the classroom. Results are presented in Table 1.

Table 1  
*Reports of Experience with Personal Electronic Devices*

<table>
<thead>
<tr>
<th>Compared to other people my age, I probably use</th>
<th>Never</th>
<th>Less than most</th>
<th>About average</th>
<th>More than most</th>
<th>Much more than most</th>
</tr>
</thead>
<tbody>
<tr>
<td>video games:</td>
<td>34</td>
<td>27</td>
<td>14</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>(41.0%)</td>
<td>(32.5%)</td>
<td>(16.9%)</td>
<td>(7.2%)</td>
<td>(2.4%)</td>
</tr>
<tr>
<td>computers:</td>
<td>0</td>
<td>9</td>
<td>56</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>(0.0%)</td>
<td>(10.8%)</td>
<td>(67.5%)</td>
<td>(18.1%)</td>
<td>(3.6%)</td>
</tr>
<tr>
<td>a cell phone:</td>
<td>0</td>
<td>31</td>
<td>44</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>(0.0%)</td>
<td>(37.3%)</td>
<td>(53.0%)</td>
<td>(9.6%)</td>
<td>(0.0%)</td>
</tr>
<tr>
<td>an iPod/MP3 player:</td>
<td>6</td>
<td>28</td>
<td>38</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>(7.2%)</td>
<td>(33.7%)</td>
<td>(45.8%)</td>
<td>(13.3%)</td>
<td>(0.0%)</td>
</tr>
<tr>
<td>In my opinion, the kinds of devices mentioned above affect people and/or society in the following way:</td>
<td>Are harmful</td>
<td>Some negatives, in general harmless</td>
<td>Are neutral</td>
<td>Are mostly positive</td>
<td>Are extremely positive</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>52</td>
<td>16</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(3.6%)</td>
<td>(62.7%)</td>
<td>(19.3%)</td>
<td>(13.3%)</td>
<td>(1.2%)</td>
</tr>
</tbody>
</table>

Students also reported their perceptions of ERS (called “clickers” in the questionnaire) on a 5-point scale in which 1 = *strongly disagree*, 2 = *disagree*, 3 = *neutral*, 4 = *agree*, and 5 = *strongly agree*. Means and *SD*s were as follows for the seven questions:
“Using clickers in this class would improve my grade in the course”: $M = 2.93, SD = 0.71$.

“Using clickers in this class would improve my understanding of the course subject content”: $M = 3.01, SD = 0.72$.

“Using clickers in this class would increase my feeling of belonging in this course”: $M = 2.75, SD = 0.82$.

“Using clickers in this class would increase my interaction with the instructor”: $M = 3.27, SD = 0.89$.

“Using clickers in this class would increase my interaction with other students”: $M = 2.95, SD = 0.80$.

“I would enjoy using clickers in this class”: $M = 3.31, SD = 0.98$.

“I would recommend using clickers in class in this course”: $M = 3.17, SD = 0.79$.

In addition, students reported whether or not they had previously used ERS in college or in kindergarten through 12th grade. On the former, 49 (59.0%) reported that they had, and 34 (41.0%) that they had not. On the latter, 25 (30.1%) reported that they had used ERS in classes before college, and 58 (69.9%) that they had not.

**Outcome Measures**

Most of the outcome measures consisted of graded assignments, quizzes, and tests, as well as the overall course grade. Table 2 summarizes the scores for the main graded activities. Figure 2 shows the distribution of final course scores. As is usually the case with achievement scores, these scores and other outcome measures were near-normally distributed, hence met statistical assumptions (Glass & Hopkins, 1984). This was also true of responses to questions on experience with electronic devices and perceptions of ERS.
Table 2
*Summary of Main Outcome Measures (Graded Assignments and Tests)*

<table>
<thead>
<tr>
<th>Outcome Measure</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Grade</td>
<td>63.5</td>
<td>100.2</td>
<td>89.1</td>
<td>7.7</td>
</tr>
<tr>
<td>Quiz Total</td>
<td>13.8</td>
<td>100.0</td>
<td>91.4</td>
<td>10.4</td>
</tr>
<tr>
<td>Exam Total</td>
<td>57.3</td>
<td>100.3</td>
<td>87.4</td>
<td>9.1</td>
</tr>
<tr>
<td>Journal Total</td>
<td>2.1</td>
<td>10.0</td>
<td>9.4</td>
<td>1.2</td>
</tr>
<tr>
<td>Reading Total</td>
<td>67.7</td>
<td>100.0</td>
<td>95.9</td>
<td>6.6</td>
</tr>
<tr>
<td>Pre-test</td>
<td>23.0</td>
<td>100.0</td>
<td>53.3</td>
<td>12.3</td>
</tr>
<tr>
<td>Post-test</td>
<td>46.0</td>
<td>100.0</td>
<td>83.5</td>
<td>12.2</td>
</tr>
</tbody>
</table>

*Note.* Scores were based on 100 points per measure (10 points for journal total), with some extra points added.

![Distribution of final course grade scores.](image-url)

*Figure 2.* Distribution of final course grade scores.
Analyses of Research Questions

The overall question guiding this study was: What is the effect of ERS use within a small introduction to Biblical Studies course? In this section, the five research questions will be addressed. In most cases, the main analyses, as originally proposed, will be presented, followed by similar exploratory analyses in an attempt to shed light on the main results. In all tables, figures, and statistics reported in text, \( N = 83 \), except for course pre-test, for which \( N = 82 \) because one student missed the pre-test.

**Q1: Is there a significant difference between student assessment performance based on use of ERS?**

Table 3 displays the comparisons between the groups (control class and ERS class) on the principal performance evaluation assessments. None of the six main sets of scores (overall course grade and exam, quiz, journal, reading totals, and post-test) showed a significant difference between the groups. Furthermore, of individual exam and quiz scores, none were significant.

Table 4 shows similar analyses on secondary performance scores: scripture memorization, journal entries, and reading. Only a single analysis (for Journal 1) proved significant, such that the control group scored better on average. Out of 21 analyses, one would be expected to be significant due to chance, so this result can be discounted (Fraenkel & Wallen, 2007).
Table 3  
*Comparison between Control and ERS Student Performance, Main Assessments*

<table>
<thead>
<tr>
<th>Stu. Assessment</th>
<th>Control (n=42)</th>
<th>ERS (n=41)</th>
<th>Difference</th>
<th>(t_{(df=81)})</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Course Grade</td>
<td>89.0</td>
<td>7.1</td>
<td>89.1</td>
<td>8.3</td>
</tr>
<tr>
<td>Exam Total</td>
<td>86.9</td>
<td>8.7</td>
<td>87.9</td>
<td>9.5</td>
</tr>
<tr>
<td>Quiz Total</td>
<td>92.1</td>
<td>6.0</td>
<td>90.7</td>
<td>13.3</td>
</tr>
<tr>
<td>Journal Total</td>
<td>9.5</td>
<td>0.9</td>
<td>9.2</td>
<td>1.4</td>
</tr>
<tr>
<td>Reading Total</td>
<td>96.7</td>
<td>5.5</td>
<td>95.0</td>
<td>7.5</td>
</tr>
<tr>
<td>Post-test</td>
<td>82.0</td>
<td>12.9</td>
<td>85.0</td>
<td>11.3</td>
</tr>
<tr>
<td>Exam 1</td>
<td>89.1</td>
<td>9.5</td>
<td>91.2</td>
<td>8.4</td>
</tr>
<tr>
<td>Exam 2</td>
<td>90.7</td>
<td>8.9</td>
<td>88.8</td>
<td>9.5</td>
</tr>
<tr>
<td>Exam 3</td>
<td>80.9</td>
<td>12.8</td>
<td>83.8</td>
<td>15.4</td>
</tr>
<tr>
<td>Quiz 0</td>
<td>100.0</td>
<td>0.0</td>
<td>97.7</td>
<td>15.6</td>
</tr>
<tr>
<td>Quiz 1</td>
<td>73.8</td>
<td>35.2</td>
<td>64.5</td>
<td>38.9</td>
</tr>
<tr>
<td>Quiz 2</td>
<td>32.9</td>
<td>38.5</td>
<td>49.9</td>
<td>41.8</td>
</tr>
<tr>
<td>Quiz 3</td>
<td>68.1</td>
<td>40.3</td>
<td>63.9</td>
<td>40.6</td>
</tr>
<tr>
<td>Quiz 4</td>
<td>80.5</td>
<td>32.6</td>
<td>76.3</td>
<td>39.3</td>
</tr>
<tr>
<td>Quiz 5</td>
<td>69.0</td>
<td>40.0</td>
<td>73.7</td>
<td>36.6</td>
</tr>
<tr>
<td>Quiz 6</td>
<td>56.7</td>
<td>42.6</td>
<td>60.1</td>
<td>41.2</td>
</tr>
<tr>
<td>Quiz 7</td>
<td>48.6</td>
<td>42.9</td>
<td>61.3</td>
<td>43.9</td>
</tr>
<tr>
<td>Quiz 8</td>
<td>45.2</td>
<td>42.8</td>
<td>28.1</td>
<td>41.0</td>
</tr>
<tr>
<td>Quiz 9</td>
<td>76.7</td>
<td>32.7</td>
<td>64.4</td>
<td>40.7</td>
</tr>
<tr>
<td>Quiz 10</td>
<td>72.4</td>
<td>38.2</td>
<td>59.7</td>
<td>46.8</td>
</tr>
<tr>
<td>Quiz 11</td>
<td>70.0</td>
<td>41.0</td>
<td>59.2</td>
<td>46.3</td>
</tr>
<tr>
<td>Quiz 12</td>
<td>54.3</td>
<td>46.2</td>
<td>65.9</td>
<td>41.2</td>
</tr>
</tbody>
</table>
Table 4
Comparison between Control and ERS Student Performance, Secondary Assessments

<table>
<thead>
<tr>
<th>Stu. Assessment</th>
<th>Class</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>t_{(df=81)}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control (n=42)</td>
<td>ERS (n=41)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrip Memoriz 1</td>
<td>89.7</td>
<td>26.1</td>
<td>88.3</td>
<td>26.8</td>
<td>0.23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrip Memoriz 2</td>
<td>97.8</td>
<td>3.9</td>
<td>94.7</td>
<td>15.9</td>
<td>1.22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrip Memoriz 3</td>
<td>93.0</td>
<td>21.3</td>
<td>88.1</td>
<td>29.5</td>
<td>0.87</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrip Memoriz 4</td>
<td>88.8</td>
<td>29.3</td>
<td>94.4</td>
<td>16.1</td>
<td>-1.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrip Memoriz 5</td>
<td>93.6</td>
<td>21.3</td>
<td>92.8</td>
<td>21.8</td>
<td>0.18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrip Memoriz 6</td>
<td>81.9</td>
<td>37.2</td>
<td>89.8</td>
<td>26.5</td>
<td>-1.12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Journal 1</td>
<td>9.6</td>
<td>0.5</td>
<td>9.1</td>
<td>1.3</td>
<td>2.47*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Journal 2</td>
<td>9.7</td>
<td>0.4</td>
<td>9.1</td>
<td>2.2</td>
<td>1.84</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Journal 3</td>
<td>9.4</td>
<td>1.7</td>
<td>9.1</td>
<td>2.3</td>
<td>0.73</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Journal 4</td>
<td>9.5</td>
<td>1.6</td>
<td>9.6</td>
<td>0.9</td>
<td>-0.43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Journal 5</td>
<td>9.7</td>
<td>1.6</td>
<td>9.7</td>
<td>1.6</td>
<td>-0.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Journal 6</td>
<td>9.4</td>
<td>2.2</td>
<td>9.2</td>
<td>2.6</td>
<td>0.35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Journal 7</td>
<td>9.8</td>
<td>0.4</td>
<td>9.0</td>
<td>2.6</td>
<td>1.96</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Journal 8</td>
<td>9.5</td>
<td>1.7</td>
<td>9.4</td>
<td>2.2</td>
<td>0.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Journal 9</td>
<td>9.6</td>
<td>0.8</td>
<td>9.2</td>
<td>2.3</td>
<td>1.14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Journal 10</td>
<td>9.0</td>
<td>2.3</td>
<td>9.4</td>
<td>2.2</td>
<td>-0.79</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Journal 11</td>
<td>9.4</td>
<td>1.9</td>
<td>8.8</td>
<td>3.3</td>
<td>1.04</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Journal 12</td>
<td>9.5</td>
<td>2.2</td>
<td>9.2</td>
<td>2.6</td>
<td>0.53</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading 1</td>
<td>94.7</td>
<td>11.4</td>
<td>94.2</td>
<td>8.5</td>
<td>0.23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading 2</td>
<td>97.5</td>
<td>4.3</td>
<td>95.2</td>
<td>8.9</td>
<td>1.51</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading 3</td>
<td>98.0</td>
<td>4.5</td>
<td>95.8</td>
<td>8.9</td>
<td>1.45</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. Significant results are shown in bold italics.*

*p < .05, 2-tailed.
Q2: Is there a significant difference between student assessment performance based on use of ERS with gender added?

This question was analyzed with a series of $2 \times 2$ ANOVAs with gender and class as factors. In addition, the main effects of interactions were examined to determine whether there were gender differences within the two classes. Table 5 condenses the results of seven ANOVAs with outcome measures including course grade, exam and quiz totals, the three exams, and post-test. The first columns show the main effects of gender and class, respectively. These two columns are followed by the analysis of the interaction of gender and class. Finally, the last columns display the results of planned comparisons between males and females within the control class and within the ERS class. As Table 5 shows, none of the analyses were significant.

Table 5
Summary of ANOVAs for the Effects of Gender and Class on Main Student Assessments

<table>
<thead>
<tr>
<th>Student assessment</th>
<th>Gender</th>
<th>Class</th>
<th>Gender × Class</th>
<th>Gender in Control</th>
<th>Gender in ERS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$F_{(1,82)}$</td>
<td>$p$</td>
<td>$F_{(1,82)}$</td>
<td>$p$</td>
<td>$F_{(1,82)}$</td>
</tr>
<tr>
<td>Course Grade</td>
<td>0.44</td>
<td>.51</td>
<td>0.01</td>
<td>.92</td>
<td>2.80</td>
</tr>
<tr>
<td>Exam Total</td>
<td>0.64</td>
<td>.42</td>
<td>0.17</td>
<td>.68</td>
<td>2.00</td>
</tr>
<tr>
<td>Quiz Total</td>
<td>0.13</td>
<td>.71</td>
<td>0.52</td>
<td>.47</td>
<td>0.87</td>
</tr>
<tr>
<td>Exam 1</td>
<td>0.79</td>
<td>.38</td>
<td>1.00</td>
<td>.32</td>
<td>1.68</td>
</tr>
<tr>
<td>Exam 2</td>
<td>0.60</td>
<td>.44</td>
<td>0.96</td>
<td>.33</td>
<td>1.05</td>
</tr>
<tr>
<td>Exam 3</td>
<td>0.23</td>
<td>.63</td>
<td>0.63</td>
<td>.43</td>
<td>1.52</td>
</tr>
<tr>
<td>Post-test</td>
<td>0.65</td>
<td>.42</td>
<td>0.88</td>
<td>.35</td>
<td>0.08</td>
</tr>
</tbody>
</table>
Table 6 is similar and shows the results of analyses on the 13 quizzes. Of the 65 analyses, four were significant. On Quiz 8, both gender and class showed main effects. These main effects were such that the control class scored higher (as shown in Table 3), and males also scored higher \( (M = 48.06, SD = 46.87) \) than females \( (M = 28.56, SD = 37.51) \). On Quiz 9, there was a significant main effect of class (similar to the non-significant difference shown in Table 3), and also a gender difference in the ERS class. This gender difference was such that in the ERS class, females scored higher on Quiz 9 \( (M = 75.76, SD = 33.43) \) than did males \( (M = 52.40, SD = 44.89) \).
Table 6
Summaries of ANOVAs for the Effects of Gender and Class on Quiz Scores

<table>
<thead>
<tr>
<th>Student assessment</th>
<th>Gender (1,82)</th>
<th>p</th>
<th>Gender × Class</th>
<th>Gender in Control (1,82)</th>
<th>p</th>
<th>Gender in ERS (1,82)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quiz 0</td>
<td>1.03</td>
<td>.31</td>
<td>1.03</td>
<td>.31</td>
<td>0.00</td>
<td>2.13</td>
<td>.15</td>
</tr>
<tr>
<td>Quiz 1</td>
<td>0.05</td>
<td>.82</td>
<td>1.45</td>
<td>.23</td>
<td>0.18</td>
<td>0.67</td>
<td>.21</td>
</tr>
<tr>
<td>Quiz 2</td>
<td>0.57</td>
<td>.45</td>
<td>3.66</td>
<td>.06</td>
<td>0.15</td>
<td>0.79</td>
<td>.67</td>
</tr>
<tr>
<td>Quiz 3</td>
<td>0.82</td>
<td>.37</td>
<td>0.19</td>
<td>.66</td>
<td>0.85</td>
<td>0.99</td>
<td>1.72</td>
</tr>
<tr>
<td>Quiz 4</td>
<td>0.00</td>
<td>.95</td>
<td>0.25</td>
<td>.62</td>
<td>0.00</td>
<td>0.95</td>
<td>0.00</td>
</tr>
<tr>
<td>Quiz 5</td>
<td>2.42</td>
<td>.12</td>
<td>0.07</td>
<td>.79</td>
<td>0.19</td>
<td>1.91</td>
<td>.17</td>
</tr>
<tr>
<td>Quiz 6</td>
<td>0.69</td>
<td>.41</td>
<td>0.08</td>
<td>.77</td>
<td>1.35</td>
<td>0.25</td>
<td>.82</td>
</tr>
<tr>
<td>Quiz 7</td>
<td>1.98</td>
<td>.16</td>
<td>1.43</td>
<td>.23</td>
<td>0.19</td>
<td>0.67</td>
<td>.50</td>
</tr>
<tr>
<td>Quiz 8</td>
<td><strong>5.87</strong></td>
<td>.02</td>
<td><strong>4.96</strong></td>
<td><strong>0.03</strong></td>
<td>0.09</td>
<td>3.60</td>
<td>.06</td>
</tr>
<tr>
<td>Quiz 9</td>
<td><strong>7.22</strong></td>
<td>&lt;.01</td>
<td>1.49</td>
<td>.23</td>
<td>0.05</td>
<td>2.93</td>
<td>.09</td>
</tr>
<tr>
<td>Quiz 10</td>
<td>1.47</td>
<td>.23</td>
<td>1.63</td>
<td>.21</td>
<td>0.51</td>
<td>0.48</td>
<td>.12</td>
</tr>
<tr>
<td>Quiz 11</td>
<td>0.23</td>
<td>.63</td>
<td>0.85</td>
<td>.36</td>
<td>0.46</td>
<td>0.50</td>
<td>.42</td>
</tr>
<tr>
<td>Quiz 12</td>
<td>0.02</td>
<td>.90</td>
<td>1.33</td>
<td>.25</td>
<td>0.03</td>
<td>0.85</td>
<td>.97</td>
</tr>
</tbody>
</table>

Note. Significant results are shown in **bold italics**.

Tables 7 and 8 display similar results for secondary measures of student performance. In Table 7 it can be seen that only a single analysis was significant. This analysis was for the second scripture memorization assignment, in which the genders differed in the ERS class. The
difference was such that females scored slightly higher ($M = 98.38$, $SD = 2.25$) than males ($M = 90.85$, $SD = 22.24$). Here it might be noted that this relatively small mean difference was significant because of the very small $SD$ among the females. This presumably resulted from most of the 22 females in the class scoring 100%.

Table 8 shows that there were significant differences on the ANOVAs on the total journal assignment score and on Journal 1. The former was a significant interaction between gender and class, such that in the ERS class, females did better than males (females: $M = 9.55$, $SD = 1.01$; males: $M = 8.92$, $SD = 1.77$), whereas the opposite was true in the control class (females: $M = 9.35$, $SD = 1.03$; males: $M = 9.82$, $SD = 0.22$). Finally, three of the five analyses were significant for Journal 1. These analyses were: An overall difference in class, such that the control group did better, as shown in Table 4; a gender $\times$ class interaction; and a gender difference in the ERS class. The gender $\times$ class interaction was similar to that for journal total scores, such that in the ERS class, females did better than males (females: $M = 9.52$, $SD = 0.75$; males: $M = 8.65$, $SD = 1.56$), whereas the opposite was true in the control class (females: $M = 9.52$, $SD = 0.55$; males: $M = 9.80$, $SD = 0.32$). Finally, in the ERS class by itself, the females’ mean of 9.52 (see above) was significantly higher than the males’ average score of 8.65.
Table 7  
*Summaries of ANOVAs for the Effects of Gender and Class on Scripture Memorization and Reading*

<table>
<thead>
<tr>
<th>Gender</th>
<th>Class</th>
<th>Gender × Class</th>
<th>Gender in Control</th>
<th>Gender in ERS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student assessment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$F_{(1,82)}$</td>
<td>$p$</td>
<td>$F_{(1,82)}$</td>
<td>$p$</td>
</tr>
<tr>
<td>Script Mem 1</td>
<td>0.17</td>
<td>.68</td>
<td>0.09</td>
<td>.77</td>
</tr>
<tr>
<td>Script Mem 2</td>
<td>1.47</td>
<td>.23</td>
<td>1.76</td>
<td>.19</td>
</tr>
<tr>
<td>Script Mem 3</td>
<td>0.26</td>
<td>.61</td>
<td>1.09</td>
<td>.30</td>
</tr>
<tr>
<td>Script Mem 4</td>
<td>0.65</td>
<td>.42</td>
<td>1.38</td>
<td>.24</td>
</tr>
<tr>
<td>Script Mem 5</td>
<td>2.31</td>
<td>.13</td>
<td>0.02</td>
<td>.90</td>
</tr>
<tr>
<td>Script Mem 6</td>
<td>0.46</td>
<td>.50</td>
<td>0.93</td>
<td>.34</td>
</tr>
<tr>
<td>Reading Total</td>
<td>0.02</td>
<td>.90</td>
<td>1.92</td>
<td>.17</td>
</tr>
<tr>
<td>Reading 1</td>
<td>0.05</td>
<td>.82</td>
<td>0.14</td>
<td>.71</td>
</tr>
<tr>
<td>Reading 2</td>
<td>0.07</td>
<td>.79</td>
<td>2.82</td>
<td>.10</td>
</tr>
<tr>
<td>Reading 3</td>
<td>0.18</td>
<td>.67</td>
<td>2.79</td>
<td>.10</td>
</tr>
</tbody>
</table>

*Note.* Significant results are shown in *bold italics.*
Table 8
Summaries of ANOVAs for the Effects of Gender and Class on Journals

<table>
<thead>
<tr>
<th></th>
<th>Gender</th>
<th>Class</th>
<th>Gender × Class</th>
<th>Gender in Control</th>
<th>Gender in ERS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student assessment</td>
<td>$F_{(1,82)}$</td>
<td>$p$</td>
<td>$F_{(1,82)}$</td>
<td>$p$</td>
<td>$F_{(1,82)}$</td>
</tr>
<tr>
<td>Journal Total</td>
<td>0.10</td>
<td>.75</td>
<td>1.81</td>
<td>.18</td>
<td><strong>4.48</strong></td>
</tr>
<tr>
<td>Journal 1</td>
<td>2.07</td>
<td>.15</td>
<td><strong>7.74</strong></td>
<td><strong>&lt;.01</strong></td>
<td><strong>7.88</strong></td>
</tr>
<tr>
<td>Journal 2</td>
<td>0.04</td>
<td>.83</td>
<td>3.59</td>
<td>.06</td>
<td>0.76</td>
</tr>
<tr>
<td>Journal 3</td>
<td>0.17</td>
<td>.68</td>
<td>0.91</td>
<td>.34</td>
<td>1.49</td>
</tr>
<tr>
<td>Journal 4</td>
<td>0.01</td>
<td>.91</td>
<td>0.04</td>
<td>.84</td>
<td>2.45</td>
</tr>
<tr>
<td>Journal 5</td>
<td>0.03</td>
<td>.87</td>
<td>0.03</td>
<td>.87</td>
<td>2.37</td>
</tr>
<tr>
<td>Journal 6</td>
<td>0.01</td>
<td>.93</td>
<td>0.28</td>
<td>.60</td>
<td>1.31</td>
</tr>
<tr>
<td>Journal 7</td>
<td>0.82</td>
<td>.37</td>
<td>3.74</td>
<td>.06</td>
<td>0.82</td>
</tr>
<tr>
<td>Journal 8</td>
<td>0.51</td>
<td>.48</td>
<td>0.15</td>
<td>.70</td>
<td>3.33</td>
</tr>
<tr>
<td>Journal 9</td>
<td>0.18</td>
<td>.67</td>
<td>1.43</td>
<td>.24</td>
<td>0.80</td>
</tr>
<tr>
<td>Journal 10</td>
<td>0.21</td>
<td>.65</td>
<td>0.35</td>
<td>.56</td>
<td>2.51</td>
</tr>
<tr>
<td>Journal 11</td>
<td>0.08</td>
<td>.78</td>
<td>1.51</td>
<td>.22</td>
<td>1.31</td>
</tr>
<tr>
<td>Journal 12</td>
<td>0.06</td>
<td>.81</td>
<td>0.52</td>
<td>.47</td>
<td>1.26</td>
</tr>
</tbody>
</table>

Note. Significant results are shown in **bold italics.**
Q3: Is there a significant difference between student assessment performance controlling for the influence of GPA?

Question 3 was addressed using a series of ANCOVAs with self-reported GPA used as a covariate and class as a factor. First, it may be of interest to note that GPA and course performance were strongly correlated, indicating that better students did better in this course. GPA correlated at $r = .62$ with course grade, $r = .46$ with quiz total, and $r = .55$ with exam total (all $N = 83$, $p < .001$). These correlations did not differ significantly between the two groups, by analyses presented in Glass and Hopkins (1984). In addition, GPAs of the students in the two classes were almost identical (control: $M = 3.55$, $SD = 0.52$; ERS: $M = 3.56$, $SD = 0.36$, ns by t-test).

All 43 student performance measures were analyzed by ANCOVA. Of these analyses, two showed results in which class was a significant factor once the effect of GPA had been taken into account. These were: Journal 1 ($F_{(1,80)} = 7.34$, $p < .01$), and Journal 7 ($F_{(1,80)} = 4.08$, $p < .05$). Estimated marginal means revealed that, with the effect of GPA removed, means were higher in the control class for both.

Q4: Is there a significant difference between student assessment performance controlling for the influence of GPA with gender added?

Analyses similar to those for Q3 were used to answer this question, with ANCOVAs including GPA as covariate and both class and gender as factors. The principal additional information beyond the previous analyses provided by these additional analyses is the effect of the gender × class interaction after accounting for the effect of GPA. Of the 43 analyses, only two included significant gender × class interactions. These analyses were for Journal Total and Journal 1. The results repeated the findings already displayed in Table 8, and in the same
direction: females had higher scores on these measures in the ERS class, while the opposite was true in the control class. That is, the addition of GPA as a covariate did not change the results shown in Table 8.

Q5: Is there a significant difference in student perceptions in the use of an ERS based on their use of ERS?

Question 5 was addressed by comparing student perceptions of ERS to students’ prior experience with ERS. The latter was measured by responses to two questions, one on use in a college class, the other on use in earlier classes. As noted in Chapter Three, the appropriate analysis depends on the distribution of responses to these two questions. Table 9 shows the results of cross tabulation of these questions. Use in earlier grades was unrelated to use in college ($\chi^2(1) = 0.11, p = .736$), and the minimum cell frequency was 10, so a $2 \times 2$ ANOVA was appropriate for this analysis.

Table 9
Use of ERS in Kindergarten Through 12th Grade and in College

<table>
<thead>
<tr>
<th>Used ERS K-12</th>
<th>Used ERS in college</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>No</td>
<td>25 (42.4%)</td>
</tr>
<tr>
<td>Yes</td>
<td>10 (38.5%)</td>
</tr>
</tbody>
</table>

The ANOVA was repeated for each of the seven questions on the Student Perception Questionnaire (see Appendix D). The only significant effects were main effects of use in college for Question 2 (“Using clickers in this class would improve my understanding of the course subject content”), Question 6 (“I would enjoy using clickers in this class”) and Question 7 (“I
would recommend using clickers in class in this course"). In each case, those who reported having used ERS in college were more favorable (Q2: $M = 3.20$ ($SD = 0.73$) vs. $M = 2.71$ ($SD = 0.62$), $F_{(1,81)} = 8.03, p < .01$; Q6: $M = 3.50$ ($SD = 0.86$) vs. $M = 3.03$ ($SD = 1.07$), $F_{(1,81)} = 4.57$, $p < .05$; Q7: $M = 3.38$ ($SD = 0.81$) vs. $M = 2.86$ ($SD = 0.65$), $F_{(1,81)} = 10.00, p < .01$).

**Exploratory Analyses**

A number of variables were measured in addition to those referred to in the research questions. For most of these exploratory analyses, only the six main measures of student performance (course grade, post-test, and total scores on quizzes, exams, journals, and reading) will be used to measure student performance.

**Pre-test and Post-test Scores**

It was Dr. Smith’s practice to administer a pre-test at the outset of the semester that was identical to the final exam (which counted as only 5% of the course grade) in order to assess student knowledge. This early semester assessment is referred to here as “course pre-test.” The final exam constituted the post-test. The difference scores could be regarded as an additional measure of student performance, although they were not included in students’ grades. Like most of the other measures, difference (improvement) scores did not differ between the control and ERS classes ($t_{(80)} = 0.22, ns$). They did, however, reflect the grades, such that students who did well on the post-test and improved more on the test received higher scores on most of the other graded measures (see Table 10). It may be observed, however, that students who came into the course knowing more about the subject did even better than those who improved their knowledge a great deal.
Table 10
*Correlations between Student Performance and Pre-test, Post-test, and Difference Scores*

<table>
<thead>
<tr>
<th>Student performance</th>
<th>Pre-test (N=82)</th>
<th>Post-test (N=83)</th>
<th>PrePost Difference (N=82)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Grade</td>
<td>(r= .404^{***})</td>
<td>(r= .726^{***})</td>
<td>(r= .341^{**})</td>
</tr>
<tr>
<td>Quiz Total</td>
<td>(r= .366^{***})</td>
<td>(r= .385^{***})</td>
<td>(r= .251^{*})</td>
</tr>
<tr>
<td>Exam Total</td>
<td>(r= .410^{***})</td>
<td>(r= .721^{***})</td>
<td>(r= .290^{**})</td>
</tr>
<tr>
<td>Journal Total</td>
<td>(r= .008)</td>
<td>(r= .202)</td>
<td>(r= .223^{*})</td>
</tr>
<tr>
<td>Reading Total</td>
<td>(r= -.139)</td>
<td>(r= .017)</td>
<td>(r= .145)</td>
</tr>
</tbody>
</table>

* \(*p < .05, **p < .01, ***p < .001, all 2-tailed.*

**School Year and Age**

As noted in the Descriptive Statistics section, 74% of students were freshmen, and all but two of the rest were sophomores, so there was little variation in school year. Similarly, all but seven were between 18 and 20 years of age. School year correlated significantly and negatively with all the measures of performance except Reading Total. Correlations were: Course Grade, \(r = -.356, p < .001\); Quiz Total, \(r = -.408, p < .001\); Exam Total, \(r = -.247, p < .05\); Journal Total, \(r = -.325, p < .01\); Reading Total, \(r = -.035, ns\); Post-test, \(r = -.241, p < .05\). Thus, higher-level students did more poorly in the class than freshmen. Age did not correlate significantly with any of the measures.

The school year and age variables were included separately as covariates in ANCOVAs, with class as the factor. Despite the significant relationship between school year and most of the scores, correcting for school year and age did not make a difference with the lack of effect of class, as none of the analyses showed a significant effect of class after correcting for the effects of school year or age.
Experience with Personal Electronic Devices

As shown in Table 1, experience with personal electronic devices varied considerably across participants. With responses scored from 1 through 5, these variables, plus the sum of scores across the four types of devices, were correlated with the six main measures of student performance. Of the 24 (6 measures × 4 devices) correlations with individual device categories, only one was significant: course grade × computer use: $r = -.224, p < .05$. However, with the total score across all devices, three of the five analyses were significant: course grade: $r = -.284, p < .01$; quiz total: $r = -.234, p < .05$; exam total: $r = -.251, p < .05$. As might be expected, the response to the question on whether such devices were harmful or positive correlated significantly with total use: $r = .346, p < .01$. It also was related to quiz total: $r = -.268, p < .05$. Here it might be noted that since all relevant correlations were negative, students who used these devices more did more poorly in class.

When total device use and attitude were entered (separately) as covariates in ANCOVAs with the six main measures of performance as dependent variables and class as the factor, none of the analyses were significant.

Change Over Time

It was thought possible that, despite the lack of overall significant difference between the classes, there might have been a pattern over time, such that students in the ERS class might have done better than those in the control class at some times over the course of the semester but not others. Therefore, graphs were produced to compare the patterns over time on the five main outcome measures. The graphs are shown in Figures 3-7. There does not appear to be any obvious pattern across time between the classes.
Figure 3. Comparison between classes on exams.
Figure 4. Comparison between classes on quizzes.

Figure 5. Comparison between classes on scripture memorization.
Figure 6. Comparison between classes on journal scores.
*These differed significantly at $p < .05$.

Figure 7. Comparison between classes on reading scores.
Changes in Perception of ERS

Professor Smith was interested in whether the students who were exposed to ERS would feel more positively or less positively toward using ERS after experiencing them in his class. Therefore, the Student Perception Questionnaire was repeated near the end of the semester. Differences between the classes on the seven items in the questionnaire were analyzed by repeated measures ANOVAs. In all seven analyses, there was a significant interaction of change in perception and class. For six of the items, the interaction was significant at \( p < .001 \) (the exception was for question 4, “Using clickers would/did increase my interaction with the instructor,” which was significant at \( p < .05 \)).

Figures 8 through 14 show that in each case, the interaction was such that the ERS class increased strongly in their opinions. (Perceptions were rated on a 5-point scale with 1: \textit{strongly disagree} to 5: \textit{strongly agree}.）Interestingly, for many items it was evident that the significant interactions were due as much to a decline in perceptions in the control class as an increase in the ERS class.

It might be argued that if the above effects were due to the combined effects of the two classes, they might not hold for either one separately, or might not reflect differences at the end of the semester. Therefore, the data was analyzed further. Comparing only the end-of-semester perceptions between the two classes by \( t \) tests, it was found that all seven questions differed significantly and strongly at \( p < .001 \), such that (as Figures 8 through 14 show), the ERS students were more positive in their evaluations. Assessing the classes separately for the changes over time, with matched-pairs \( t \) tests, the control class showed significant declines on Questions 1 and 2 at \( p < .001 \), Question 3 at \( p < .01 \), and Question 7 at \( p < .05 \), all such that evaluations declined significantly over the semester. On the other hand, in the ERS group, all but one of the
evaluations were significantly more positive at the end of the course: Questions 3, 5, 6, and 7 at $p < .001$, Question 4 at $p < .01$, and Question 2 at $p < .05$. The remaining question, number 1, was marginal, at $p = .051$, 2-tailed.

*Figure 8.* Change in perceptions of ERS between beginning and end of semester in the two classes on question “Using clickers in this class would improve my grade in the course.”

*Figure 9.* Change in perceptions of ERS between beginning and end of semester in the two classes on question “Using clickers in this class would improve my understanding of the course subject content.”
Figure 10. Change in perceptions of ERS between beginning and end of semester in the two classes on question “Using clickers in this class would increase my feeling of belonging in this course.”

Figure 11. Change in perceptions of ERS between beginning and end of semester in the two classes on question “Using clickers in this class would increase my interaction with the instructor.”
Figure 12. Change in perceptions of ERS between beginning and end of semester in the two classes on question “Using clickers in this class would increase my interaction with other students.”

Figure 13. Change in perceptions of ERS between beginning and end of semester in the two classes on question “I would enjoy using clickers in this class.”
Summary

The current chapter reports the results of a study in which one section of an introductory Biblical Studies course at a small, private, evangelical, midwestern university used ERS and another did not. The 83 student participants were divided between the two classes ($n = 42$ and $41$ for control and ERS classes, respectively), and the classes were very similar on characteristics such as gender, age, and GPA.

The first four research questions addressed whether student performance differed in the sections. Overall, they did not. Specifically, average scores did not differ for any of the main assessments of performance, and for only one of the secondary assessments. Thus, across 43 statistical analyses, only one was significant, fewer than would have been expected purely by chance.

Furthermore, the inclusion of gender, self-reported GPA, and the combination of these variables made essentially no difference to the result. That is, taking into account variations in performance due to these factors did not affect the overall lack of difference between the sections.
The fifth research question addressed whether having had experience with ERS was related to students’ opinions on ERS. Opinions on seven questions did not differ significantly based on whether the student had used ERS before college, and differed on only three questions based on whether the student had used ERS in a college class. The three significant results indicated that students with ERS experience thought it more likely that the devices would improve their understanding and enjoyment of the class, and recommended their use.

Exploratory analyses compared pre-test, post-test, and pre-post difference scores to other measures. It was found that students who already knew the material at the beginning of the class tended to do very well on most measures of student performance, somewhat better even than those who improved more between the pre-test and post-test. Experience with personal electronic devices was compared to student performance. Results showed that several of the performance measures were related to total use of such devices, such that students who reported high levels of use in total, and for computers, tended to do more poorly in the course than others. Experience with personal electronic devices was, however, not related to any differences between the sections.

A number of other analyses were performed to see if any might be related to the lack of difference between the ERS class and the control class. School year and age of students did not affect their responses to the different teaching methods. An examination of changes over time also did not reveal any obvious patterns of difference between the two groups. Finally, changes in perception of ERS were compared over the course of the semester. Here there were distinct differences between the two sections. Over all seven items on the questionnaire adapted from Martyn (2007), opinions diverged strongly between students in the groups, such that opinions increased in the ERS section and declined in the control section.
Chapter Five will summarize and discuss the findings. In an attempt to gain insight into the unexpected results, comparable studies will be re-examined. Possible reasons for these results will be considered. A conclusion will be drawn, and recommendations made for future research.
CHAPTER FIVE: SUMMARY AND CONCLUSIONS

This quantitative study was designed to determine the effect of an Electronic Response System (ERS) on students’ course performance. A second goal of the study was to see how student perception of ERS was related to performance. Most previous studies in this area have been conducted in technical courses in large research universities. In contrast, the current study was carried out in an introductory Biblical Studies course at a small, private, evangelical midwestern university. Two course sections were used: one randomly assigned to be a control group, the other to use ERS. The classes were otherwise taught in as similar a fashion as possible.

This chapter will begin with a summary of how the study was conducted, and will review the results. Contrary to expectations, no evidence of superior performance in the ERS class was found. Most of the chapter will be taken up with a discussion of possible reasons for why the current results did not replicate previous work. This discussion will focus on a close examination of prior work in an effort to determine what factors were and were not associated with ERS effects, and how limitations and delimitations of the current study may have affected results. The chapter will conclude with recommendations for future research.

Summary of study. The main research question was:

What is the effect of ERS use within a small introduction to Biblical Studies course?

This question was broken down into several sub-questions:
Q1: Is there a significant difference between student assessment performance based on use of ERS?

Q2: Is there a significant difference between student assessment performance based on use of ERS with gender added?

Q3: Is there a significant difference between student assessment performance controlling for the influence of GPA?

Q4: Is there a significant difference between student assessment performance controlling for the influence of GPA with gender added?

Q5: Is there a significant difference in student perceptions in the use of an ERS based on their use of ERS?

On the first day of class, students were given a demographic questionnaire and a questionnaire that assessed students’ perceptions and opinions on the use of the ERS. The students also completed a pre-test about their knowledge of the Biblical literature concepts that would be taught in the course during the semester. Professor Smith then began using ERS in one section of the course, randomly determined, but not in the control group, for reading quizzes and discussion starters. At the end of the semester, at Professor Smith’s request, students again were given the ERS perception questionnaire in both the control group and ERS section of the course. They also took a post-test, which was identical to the pre-test given at the beginning of the semester. Student assessment performance was measured primarily by course grade, quiz total, exam total, journal total, reading total, and post-test score. In addition, scores on three exams, 13 quizzes, six scripture memorization assignments, 12 journal entries, and three reading scores were used as outcome measures.
Summary of results. A total of 83 students, 41 in one class and 42 in another, participated in the study. In all demographic characteristics, such as GPA, gender distribution, and age, both classes were nearly identical.

Results showed that, overall, there was not a significant difference between student assessment performance between the two course sections. This lack of difference was not modified by inclusion of gender, GPA, or the combination of gender and GPA in the analyses.

Therefore, contrary to expectations, students in the ERS class did not differ from those in the control class in most measures of student performance. The significant results were so few as to be best explained as chance effects. One interesting result was that, despite the complete lack of superior performance in the ERS class, those students on average increased their opinions on clickers following the course. These increased opinions included questions specifically related to their performance in the course. Thus, while the students gained no apparent benefits from using ERS, they believed that they had.

Although there was not a significant difference in student perceptions in the use of an ERS based on their experience with ERS prior to college, students who reported that they had used ERS in college courses were more favorable towards it on three of the seven perception questions. That is, students with college ERS experience thought it more likely that the ERS would improve their understanding and enjoyment of the class, and recommended its use. This positive opinion expressed by students with more ERS experience will be addressed, with citations, in the Implications of Results section below.
Conclusion and Discussion

The current study found no significant difference in student assessment performance related to ERS use in the college classroom. This lack of difference was not modified by inclusion of gender, GPA, or the combination of gender and GPA in the analyses. This conclusion is supported by the data in Tables 3-9 and Figures 3-7. Thus, the current study joined the smaller group of reported studies (e.g., Karaman, 2011; Martyn, 2007) that found no significant difference in student performance related to use of ERS.

Implications of Results

Overall, results were unexpected, as the current study did not offer any support for the expectation that use of ERS would improve student academic performance. It is possible this lack of difference between the classes was due to the many limitations of the study, including limited use of ERS and a single teaching style that may not have been conducive to ERS. The most surprising and interesting finding was the fact that despite this lack of objective support for improved student performance, students in the ERS group reported at the end of the semester that they believed that ERS use had had many positive benefits including improving their grade, as well as improving their understanding, feeling of belonging, interaction with the instructor and other students, and how enjoyable the course was. This result demonstrated that satisfaction with ERS and a high opinion of it does not necessarily relate to actual improved performance. It suggests that student opinion, even retrospectively, may not be a good indicator of ERS’s effects. Instead, objective evidence of performance should be used. This lack of correspondence between opinions and fact in the course taught should be kept in mind not only in the following sections, but in any general consideration of the question of whether there is compelling evidence for the effectiveness of ERS use. If this effect was present in previous studies that only surveyed
opinions, it may be that perhaps some of them have just been reporting an illusion of improvement.

Most of the studies cited in previous chapters as supporting the use of ERS used student opinions or retrospective evaluations as their principal or sole measure of ERS effectiveness. For example, students in Skinner’s (2009) course took a survey asking their opinion of ERS. They liked the devices, found them enjoyable, and recommended that the technology be used in other courses. Eastman et al. (2009) examined students’ attitudes toward ERS. The study used pre- and post-tests to measure the students’ attitudes toward ERS on a five point Likert scale, and found that they had improved over the semester. Guthrie and Carlin (2005) reported that students who use ERS agree that they interacted more with their classmates when the system was used. Students in the current study reported similar positive responses, despite there clearly being no actual performance advantage in the ERS section.

The lack of difference between class performance is not to say that using ERS in a class has no effect. For practical purposes, it may function as a placebo, in that students who receive it may feel they have benefited from it, whether or not they actually have. Unfortunately, a limitation of this study was that it was not possible to compare student course evaluation scores between the two groups. If, as has been demonstrated in prior research (e.g., Carnaghan & Webb, 2005; Cummings & Hsu, 2007; Judson & Sawada, 2002), the students gave higher course evaluations to the ERS class than the standard one, the current findings would also undercut the presumption that such evaluations are a good proxy for teaching quality. Nonetheless, it is possible that an instructor aware of the effect might use ERS solely to improve his or her course evaluations.
Finally, it was interesting that not only did the ERS students increase their opinions of clickers over the course of the semester, but the control students’ opinions declined. This decline might perhaps be attributed to sour grapes, in that those students rejected the notion that ERS might have been a positive influence on their performance.

**Interpretation of Results by Review of Comparable Studies**

Given the unexpected results in which students appear not to have gained any advantage by using ERS, yet believed that they had, it was thought important to re-examine the 20 studies cited in the Review of Literature that had directly compared academic achievement between separate similar classes in which some had used ERS and others had not (or in a few studies, in which comparisons were made between the techniques within the same class). Table 11 summarizes salient characteristics of these studies. Of the 20 studies, ten reported unequivocal support for the hypothesis that ERS use would result in greater command of course material. Five more reported weak or probable support, three others reported ERS advantages only for some students or mixed results, while only two, both on small classes, found no support.
Table 11
*Summary of Studies in which ERS Classes (or Groups within Classes) Were Compared to Controls*

<table>
<thead>
<tr>
<th>Study</th>
<th>Institution</th>
<th># stus$^a$</th>
<th>Subject</th>
<th>Perceptions</th>
<th>Performance difference?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karaman (2011)</td>
<td>University</td>
<td>22</td>
<td>Info Tech</td>
<td>Enjoyed, helpful, learned more</td>
<td>No</td>
</tr>
<tr>
<td>Martyn (2007)</td>
<td>Small coll</td>
<td>23</td>
<td>Comp Sci</td>
<td>* No difference</td>
<td>No</td>
</tr>
<tr>
<td>Kennedy &amp; Cutts (2005)</td>
<td>University</td>
<td>241</td>
<td>Comp Sci</td>
<td>Not assessed</td>
<td>Better stus only</td>
</tr>
<tr>
<td>King &amp; Joshi (2008)</td>
<td>University</td>
<td>370</td>
<td>Chem</td>
<td>Not assessed</td>
<td>Active stus only</td>
</tr>
<tr>
<td>Bullock et al. (2002)</td>
<td>University</td>
<td>200</td>
<td>Physics</td>
<td>Not assessed</td>
<td>Yes</td>
</tr>
<tr>
<td>Kang et al. (2012)</td>
<td>Various</td>
<td>142</td>
<td>Biology</td>
<td>“Generally positive”</td>
<td>Weak support</td>
</tr>
<tr>
<td>Ribbens (2007)</td>
<td>University</td>
<td>120</td>
<td>Biology</td>
<td>Engaging, better prep, better understanding</td>
<td>Probably$^b$</td>
</tr>
<tr>
<td>El-Rady (2006)</td>
<td>University</td>
<td>111</td>
<td>Biology</td>
<td>“Generally praised”</td>
<td>Weak support</td>
</tr>
<tr>
<td>Preszler et al. (2007)</td>
<td>University</td>
<td>134</td>
<td>Biology</td>
<td>Improve interest &amp; understanding</td>
<td>Yes</td>
</tr>
<tr>
<td>Holderied (2011)</td>
<td>University</td>
<td>15</td>
<td>English</td>
<td>* Better engagement/enjoyment with ERS</td>
<td>Yes</td>
</tr>
<tr>
<td>Shapiro (2009)</td>
<td>University</td>
<td>210</td>
<td>Psychology</td>
<td>“Positive” (informal assessment)</td>
<td>Yes</td>
</tr>
<tr>
<td>Edmonds &amp; E (2008)</td>
<td>University</td>
<td>91</td>
<td>Accounting</td>
<td>Not assessed</td>
<td>Yes, esp weaker stus</td>
</tr>
<tr>
<td>Kaleta &amp; Joosten (2007)</td>
<td>University</td>
<td>Various</td>
<td>Various</td>
<td>Positive</td>
<td>Yes</td>
</tr>
<tr>
<td>Berry (2009)</td>
<td>University</td>
<td>65</td>
<td>Nursing</td>
<td>Positive</td>
<td>Weak support</td>
</tr>
<tr>
<td>McCurry &amp; H-R (2011)</td>
<td>University</td>
<td>32</td>
<td>Nursing</td>
<td>Not assessed</td>
<td>Weak support</td>
</tr>
<tr>
<td>Pradhan et al. (2005)</td>
<td>Med Sch</td>
<td>8</td>
<td>OB/GYN</td>
<td>* Positive, no difference between groups$^c$</td>
<td>Yes</td>
</tr>
<tr>
<td>Schackow et al. (2004)</td>
<td>Med Sch</td>
<td>12</td>
<td>Fam Med</td>
<td>Not assessed</td>
<td>Yes, but…$^d$</td>
</tr>
<tr>
<td>Slain et al. (2004)</td>
<td>Doctoral</td>
<td>66</td>
<td>Pharmacy</td>
<td>* ERS more enjoyable; most oth quests ns</td>
<td>Yes</td>
</tr>
<tr>
<td>Kyei-Blankson (2009)</td>
<td>Grad Edu</td>
<td>15</td>
<td>Meth/Stats</td>
<td>Engaging, helpful, learned more</td>
<td>Yes</td>
</tr>
<tr>
<td>Horowitz (1988)</td>
<td>IBM</td>
<td>Not given</td>
<td>Mgr Train</td>
<td>* Strong preference for ERS</td>
<td>Mixed</td>
</tr>
</tbody>
</table>

*Indicates studies in which perceptions were compared between ERS and control classes.

$^a$ Average per class or group within class.

$^b$ Statistical significance not reported.

$^c$ Not significant, but ceiling effect. ERS: 8/8 positive, Control: 6/9 positive.

$^d$ No better than interactive lecture.
Fourteen of the 20 studies also reported student perceptions of ERS. Of these 14 studies, only five reported comparisons between the groups. Martyn (2007) found no difference in opinions between students in the ERS classes and those in control classes. This lack of difference may or may not have been related to the fact that the ERS students did not do better academically. Holderied (2011) found that students in the ERS class, which did better on exams, reported being more engaged in the course and enjoying it more. Pradhan et al. (2005) found that both classes had positive opinions on ERS, rated simply as positive or negative. Although all eight in the ERS class were positive, three of the nine in the control class were negative. This difference in proportions did not quite reach statistical significance by $\chi^2$ test ($p = .072$, 2-tailed). Horowitz (1988) reported that among the IBM managers who experienced both ERS and regular classes, there was a strong preference for ERS.

Slain et al. (2004) was the only study, prior to the current one, to compare in detail student perceptions following a semester of either ERS or control classes. Interestingly, of the 13 questions, only three showed significant differences (all in the direction of the ERS class being more positive). These three questions were:

“I enjoyed the teaching/learning format used in the course” ($p = .002$); “The questions I had about the material were answered during class sessions” ($p = .042$); and “I felt comfortable asking questions during class about material I didn’t understand” ($p = .018$).

The other questions did not show a significant difference between classes:

“The class format encouraged active learning on the part of the students.” “The instructors obtained sufficient feedback from students during class to assess student understanding of the class materials.” “The instructor often moved through concepts faster than I could understand them.” “A sufficient number of clinical examples or case
studies were used to emphasize important concepts.” “I am confident in my ability to
evaluate and recommend drug therapy as a result of the material covered.” “The amount
of material covered in these areas was appropriate.” “I completed the required reading
assignments before coming to class” “I was an active participant in class.” “I had
difficulty paying attention in class.” “I had a good understanding of the material as it was
being discussed in class.”

Possible Reasons for Unexpected Results

Given the mixed but mostly positive results for ERS use found in the literature, the
question is not so much whether ERS is helpful or not, but rather under what circumstances and
in what ways ERS might improve performance. A reconsideration of prior studies in light of the
current results suggests that three main categories of variables should be considered. These
include: (a) study method characteristics, including differences between ERS and control classes;
(b) class characteristics; and (c) student characteristics.

Methodological issues. This section examines differences between previous research and
the study reported here. It includes characteristics of the studies such as whether the same or
different instructors taught ERS and control classes, whether these classes were comparable, and
various specifics regarding how the ERS was implemented.

Some studies were conducted using the same instructors to teach ERS and control
sections, others were not. Holderied (2011) conducted a study that compared the use of ERS with
discussion vs. lecture, which was similar to the current study in most ways. However, the studies
had some marked differences. Professor Smith taught both the control group and the ERS group,
but the classes in Holderied’s study had different instructors. While Holderied found increased
student performance for the ERS group compared to the control group, this difference was not
seen in Professor Smith’s classes. Edmonds and Edmonds (2008) investigated whether or not the use of ERS technology increases student performance. All of the classes were also taught by the same professor. There also was a control group that answered questions on paper, while the other group answered them using the ERS system. Both groups also had the same homework, course content, and tests. However, this study’s results differed from the current one. Edmonds and Edmonds found that the students in the ERS course performed better than those in the non-ERS course, but this superior performance was not the case in Professor Smith’s courses.

McCurry and Hunter-Revell (2011) studied small nursing research courses in which ERS was used for both test and quiz questions. Different instructors also taught the control group and the ERS group. Those researchers discovered significant differences between the control group and the ERS groups on assessed material.

It is possible that instructors who used ERS may have differed from those who did not, such that the former happened to be better teachers. In fact, if some other studies had found that control groups were equal or even superior to ERS groups, it might have been attributed to instructor differences and results might never have been published (the “file drawer effect,” Rosenthal, 1979).

A second source of differences between results may be faculty familiarity with ERS. The degree of familiarity of using ERS varies considerably across studies. Studies (e.g., Kenwright, 2009; Premkumar & Coupal, 2008) have also noted that technical problems and awkward use hinder student satisfaction. Guthrie and Carlin (2005) and Gok (2011) found that instructor experience with ERS was positively related to students’ liking of the course. A delimitation of the current study was that Professor Smith had had extensive experience with the devices. On the other hand, if an instructor is using ERS for the first time, he/she might show greater enthusiasm
for the system than one for whom the practice is routine, and this enthusiasm might be communicated to students. This effect might have occurred in the Holderied (2011) study, for example, in which different instructors taught control and ERS classes. In another report, an analysis of scores on quizzes given to students using ERS compared to those that took them on paper discovered that, over the course of the semester, students exhibited a 20% increase in scores on the quizzes when taking them with clickers (“Classroom clickers make…,” 2012). However, this difference was not seen in the current study. Of course, if instructors work harder or enjoy their teaching more in classes using ERS, this hard work or enjoyment may have true positive effects on their students’ performance, but a positive effect of instructor enthusiasm is not the effect usually attributed to ERS.

A third methodological issue concerns a possible Hawthorne effect. Any time an innovation is introduced, there is a tendency for those being studied to work harder or be more enthusiastic about the innovation. This tendency has been called the Hawthorne effect (Landsberger, 1958). It is possible that early studies on ERS, at least when the technology was new and different, might have shown an effect of ERS use simply because it was innovative, thus encouraging students to expend more effort in that course. Also it should be noted that ERS use is becoming common. Over 70% of current participants, mostly in their first year of college, had had prior experience with it. Thus, it might be speculated that older studies might have found different effects from newer ones. A comparison between the nine studies shown in Table 11 published before 2007 and the seven published after 2007 showed no clear trend either way. The newer studies included four with unequivocal support, four with weak or mixed results, and one that found no effect. The older ones included four with strong support, and three with weak or mixed support.
Comparability of the control group is a fourth consideration. A number of influential studies, such as those by Sprague and Dahl (2010) and Eastman et al. (2009), did not have a control group not using ERS. Given the lack of relationship between student opinions and actual performance shown in the current study, it is likely that only a comparison between academic performance in very similar classes, with and without ERS, can definitively show the effects of the device. The use of very similar ERS and control classes was a strength of the current study, although it may have been outweighed by its limitations.

A fifth methodological concern is ways in which ERS is used. It is possible that the negative results occurred in the current study because Professor Smith used the clickers differently from their use in studies that did show an effect. Professor Smith asked discussion starter questions, where the students were asked an opinion question, and the responses were projected onto the screen in front of the classroom. Kyei-Blankson (2009) also used this procedure. In both classes, the students reported satisfaction with the use of ERS, although Kyei-Blankson also found higher exam scores in the ERS class. Sprague and Dahl (2010) discussed experiences in a classroom where ERS was used only for the purposes of quizzes and class discussions, just as Professor Smith used the devices. In their study, they found students reported that ERS helped their performance, also as in the current study, although they did not assess actual achievement. The use of ERS only for short discussion starters and quizzes may have been a serious limitation.

In addition, McCurry and Hunter-Revell (2011) reported that student exam performance tends to be best on specific topics covered using ERS, and does not generalize well to other topics. McCurry and Hunter-Revell’s finding suggests that ERS may be best for teaching specific facts rather than the more conceptual material covered in the current study.
A sixth methodological concern is frequency of use. Perhaps the current results occurred because ERS was not used often enough in class (only two to four times a week). Ribbens (2007) and El-Rady (2006) as well as Kyei-Blankson (2009) used ERS to answer several questions during each lecture, more frequently than did Professor Smith. As Table 11 shows, the first two studies found only moderate or weak differences between classes, although the third showed a strong effect.

Type of feedback constitutes a seventh methodological concern. Regarding active learning, Bransford et al. (2004) pointed out that feedback is important, not only for the instructors but also for the students, in the context of the classroom rather than after the final exam. In the ERS class in the current study, the students took quizzes using the clickers but did not know instantly how they did on them, a possible limitation of the study that may have reduced ERS’s effectiveness.

The eighth concern is level of interaction. Active learning occurs when students consistently interact with the instructor and each other (FitzPatrick et al., 2011; Madigan, 2006). The devices were not used constantly in class to promote active learning in this study. The majority of the students’ grade was based on passive activities, such as taking tests, completing reading assignments, and writing journal entries online.

Finally, anonymity can vary between studies. The decision as to whether or not to keep the responses to the ERS questions anonymous is made by the professors (White et al., 2011). Professor Smith chose to keep the responses anonymous when he asked the students’ opinions to start the daily in-class discussions. In order to achieve this anonymity in the control class, he did not use voting by hand--raising. It has been assumed that anonymity is less intimidating than allowing all students to see each other’s answers, but it also may be less motivating.
Holderied’s (2011) study compared the use of ERS with discussion vs. lecture. Discussion questions were asked orally in both the control group and the ERS group, with the control group raising their hands to answer the question, and the ERS group using the clickers to answer them. However, Holderied’s study found increased performance for the ERS group than for the control group.

**Class characteristics.** It is possible that ERS is effective in some classroom situations but not others. This section considers course and class characteristics that might bear on this issue.

Class size was one characteristic that varied across studies. If ERS works by getting students more involved in the class, it would be reasonable to expect to see its effects differing depending on class size. A study of small classes that used ERS was conducted (Hatch et al., 2005), and it also found that students reported benefits to the technology, which is what this study discovered as well.

Table 11 shows that six studies were conducted with classes averaging 23 students or fewer, while four used classes of 200 or more. The small class studies included four with strong support for the hypothesis that ERS would improve performance and two with no support. The studies conducted in large classes included two with strong support and two with mixed results. Studies in the middle range (32-142 students on average per class) included four with strong results and four with weak support. Thus, class size does not appear to be a factor in past studies.

The type of college or university is a second consideration. Most research on ERS has been conducted in large research-oriented universities. There was only a single previous study (Martyn, 2007) that compared academic achievement between ERS and control classes in a small college. That study, like the current one, also found no difference in course performance,
although the author partly attributed this lack of difference to the minimal use of ERS in the class and her inexperience in using the system.

A third characteristic is course subject. One of the most striking differences among studies investigating the effects of ERS is the variation in course subjects in which the devices were used. The majority of studies on ERS have been in science or mathematics-based subject areas (Kay & LeSage, 2009). The current results might have been due to ERS not being as effective in liberal arts courses as they are in science and engineering courses. For example, Hatch et al.’s (2005) study was conducted in small classes, but the study was done in an environmental science course and not a humanities course like the one used for this study.

Sprague and Dahl’s (2010) study used ERS in a large Introductory Marketing course and not a small humanities class, as to which the current study was limited. Eastman et al.’s (2009) study also differed in that it was conducted in a Consumer Behavior course, not a Biblical Studies one. Among previous reports that compared actual performance (Table 11), only three studies (Holderied, 2011; Horowitz, 1988; Shapiro, 2009) were conducted with subjects that were clearly not technical or mathematical. All three studies showed at least mixed results, though. However, it is difficult to know whether the various studies used ERS for factual vs. conceptual learning. Possibly ERS effectiveness is a matter of memorization vs. interpretation. It seems likely that ERS effects, if any, come from increased attention, so perhaps increased attention is more important for retaining information than for learning how to think.

**Student characteristics.** As with classroom characteristics, it is possible that ERS improves performance for some groups of students but not others. There is already evidence that level of prior knowledge matters, and level of prior knowledge effects might extend to other characteristics such as students’ ability or gender, and especially to their experience with ERS.
Level of knowledge varied a great deal across studies. An effect, known as the “expertise reversal effect,” says that less guidance (or none at all) is needed for learners who already have a solid grounding of facts and principles in the field (Kalyuga, Ayres, Chandler, & Sweller, 2003). In the current study, the fact that students who already knew a lot about the topic at the beginning of the semester did better in both classes than those who did not enter the classroom with preexisting knowledge reinforces this concept. Possibly, they did not need the ERS exercises led by Professor Smith to guide their learning since they knew the material. On the other hand, as Table 11 shows, the four studies conducted in graduate courses all found significantly greater performance in classes using ERS. Thus, this issue remains unclear.

Similarly, level of ability varied. Edmonds and Edmonds (2008) determined that the ERS technology served the greatest benefit to students with the lowest prior GPAs. However, Kennedy and Cutts (2005) and King and Joshi (2008) found that only better and more active students, respectively, benefited. In Professor Smith’s course, GPA did not make a difference.

Gender is a third student characteristic that differed across studies. A few studies have been conducted in classes with mostly or exclusively a single gender or have found gender differences. Berry’s (2009) and McCurry and Hunter-Revell’s (2011) nursing students were mainly women, and both found only weak effects. A study by King et al. (2012) found a gender difference with using ERS. In it, women performed better using the ERS. However, the study in Professor Smith’s class did not yield any significant gender differences with the use of ERS.

Finally, student presumptions regarding ERS varied. Despite the Hawthorne effect noted earlier, there is the possibility that, since students seem to have expected that the ERS class would teach them more, the students in that section might have worked less hard. Thus, it is
conceivable that using ERS in this class might have at least saved them effort. A limitation of the current study was that information on student effort was not gathered.

Discussion of review of comparable studies. The results of the current study, in the context of previous literature on the topic, show a surprising level of complexity to answering the question: “Under what conditions does ERS improve student performance?” The present section described 17 different dimensions of methodology and class and student characteristics on which studies have differed. On each, the current study was located on the dimension and compared to previous ones. However, no obvious characteristics were associated with whether or not studies found significant effects of ERS. Thus, certain factors that might be thought to influence ERS effectiveness do not seem to matter. For example, there is little or no evidence that class size or student ability is relevant. On the other hand, some principles that have not been rigorously studied do seem to have anecdotal support. The instructor’s experience with ERS and enthusiasm for the method appear to be important. It also seems plausible that the more often ERS is used in the class to stimulate interest and involvement, the more likely it is to aid performance.

An Alternative Framework for Considering ERS Effectiveness

Overall, neither the current study nor prior research has shed much light on what factors make the difference between ERS being helpful and not. It appears that simply adding ERS to any teaching approach is not helpful. Instead, ERS may interact in complex ways with other factors. Thus, it might be more appropriate to examine the problem in the broader context of the integration of technology in general into teaching. This broader context is exemplified by TPACK, or technological pedagogical content knowledge (Baran, Chuang, & Thompson, 2011; Harris, Mishra, & Koehler, 2009). TPACK is a construct that has emerged for understanding the integration of content, pedagogy, and technology. “Early attempts at technology integration
treated technology as an entity that needed to be learned separately from pedagogy and content” (Baran et al., 2011, p. 370); that is, early attempts took a techno-centric approach.

In contrast, “TPACK is a theoretical framework for understanding teacher knowledge required for effective technology integration…. to emphasize the need to situate technology knowledge within content and pedagogical knowledge” (Baran et al., 2011, p. 371). The approach is intended to encourage research and practice that allows teachers to “act with an intuitive understanding of the complex interplay between the three basic components of knowledge” (p. 371), namely, content knowledge (an understanding of the subject matter being taught), pedagogical knowledge (effective techniques for teaching at an appropriate level), and technological knowledge. The latter includes traditional technologies such as pencil and paper, current technologies including PowerPoint or Googling and presumably ERS, and whatever future technologies may appear.

The study by Baran et al. (2011) examined quantitative and qualitative survey data and concluded that two main themes ran through TPACK. These were modeling (“teachers tend to teach the way they were taught,” p. 374), and the selection of appropriate technology for the students’ level. Admittedly, this study was concerned with early childhood teachers, but it may be that the principles apply equally to all levels of instruction.

A study by Means (2010) attempted to identify technology implementation practices that were associated with test-retest student learning gains. In that sense, it was, like the current study, concerned not only with opinions, but objective evidence of student performance. Means noted that:

In most cases, the basis for recommending the implementation practices is expert opinion or a correlation between the practice and the observed extent of technology use…. Hence, we are urging schools and teachers to implement technology with little or no empirically based guidance on how to do so in ways that enhance student learning. (pp. 287-288)
Furthermore, in parallel with advocates of TPACK, she argued that “we need to get beyond the simplistic ‘what works’ view of learning technology as a ‘pill’ that will have the same effect on outcomes for anyone in any context. We have ample evidence that implementation practices matter” (p. 304).

In her own study, Means (2010) focused on what classroom and school-level practices were associated with higher achievement gains in classrooms (in Grades 1, 4, 6, and high school) in which reading or math software was used. She found that four school-level practices were associated with improved instruction: a consistent instructional vision, the principal’s support for software use, teacher collaboration, and adequate local technical support. In terms of classroom-level practices, she found support for two: reviewing software-generated reports of progress weekly, and effective classroom management. On the other hand, she found no support for many practices commonly recommended, such as teacher training on technology implementation, a high ratio of computers to students, integration of technology with learning goals, and frequent use of technology.

Thus, even with careful research on objective student achievement, there is no consistent picture of what technological practices are associated with successful use in the classroom. From this larger perspective, it can be seen that the specific example of ERS use is not unusual in lacking clear guidelines as to what works and what does not.

Why then, does ERS seem to be effective in some classes and not others? A reasonable conclusion is that the key lies in the idiosyncratic pedagogical practices of some professors. It appears that most research, including the current study, has not adequately specified ways in which instructors integrate the technology with their content and pedagogical practice.
**Recommendations for Future Research**

Even the prospect of a small increase in student performance, if duplicated across many thousands of classes in higher education, can have great advantages. Therefore, despite the confusing and often conflicting results of many studies, including the current one, research on the topic should continue. Future research should be rigorous and designed to avoid some of the pitfalls seen in the past. Most importantly, it should not rely on student comments as evidence of ERS effectiveness. Analyses in the current study suggest that student impressions of the effectiveness of ERS do not necessarily reflect actual performance. A control group comparable to a class using ERS should be included to establish objective effects of ERS on student performance. Furthermore, the same or very similar instructors must teach the different conditions. Ideally, randomly assigned instructors would be trained in the use of ERS, to avoid the possibility that professors who adopt ERS on their own are simply more involved in teaching or motivated to do well.

Findings not just from research on ERS but from the integration of technology in general suggest that whether the technology is effective or not may lie in details of the instructor’s pedagogical practice. To be able to sort out which pedagogical devices work and which do not, studies must be detailed and precise in describing the ways the technology was used.

The instructor in the ERS class should have substantial experience with the devices, to avoid disruptive errors in their use. To ensure a maximum effect, hence a clear difference from the control group, the ERS class should use the clicker devices frequently and they should be a central part of the method of instruction, not merely a substitute for raising hands or answering quiz questions on paper. Assessment of course performance might be done separately on facts vs. concepts, especially facts presented via ERS. Separate assessments could be done simply by
recording subscores (not necessarily reported to the students) on each exam. Exams, of course, should be the same for different classes. Differences by gender and other student characteristics would be easy to check and may prove to be significant.

Evaluation of the effectiveness of ERS should include, but not rely solely on, standardized overall course evaluations. Finally, future studies should ask for the students’ rating of the effort and time they put into the class with ERS or the control, compared to their other classes, to evaluate the possibility that the technique may reduce time spent studying for the course even if actual performance is not improved. As noted above, this effect may be unlikely, but it would be easy to analyze and if demonstrated, would be very interesting.

Ideally, a research project such as the current one ends with a plan for a new study that will definitively answer one or more important questions on the subject. In the present case, an ideal study would be rigorously designed according to the above recommendations and would include variations on important dimensions, including teaching style, motivation and skill of the instructor, and course topic, to see which complement ERS. Such a study would, if successful, provide guidance to instructors as to whether the devices might aid learning in their particular classes. Unfortunately, the ideal study, with complete control over the variables noted above, is not likely to be practical. Therefore it is suggested that researchers at least describe their studies fully and precisely, so that a future reviewer may be able to identify which characteristics are associated with successful use of ERS and which are not. In this way, knowledge may accumulate over time to help guide instructor practices.
Summary

This chapter summarized how the study was conducted, and discussed the results. Study outcomes were unexpected, in that no evidence of superior performance in the ERS class was found. However, this research revealed that student assessments of their performance were not related to actual performance, which has important implications for future research and the interpretation of past research. Much of this chapter was concerned with exploring possible reasons why the current results may have differed from prior studies. In this exercise, it was shown that there are few if any characteristics of method, class, or student that make an obvious difference. This demonstrates that the true differences caused by ERS use are hard to determine. The chapter concluded with recommendations for future research.
REFERENCES


APPENDIX A. Taylor University IRB Approval Letter

Amended Notification of Approval to Conduct Research

December 3, 2012

Julie Keifer
Ball State University
Muncie, IN

Project title: The Effect of Electronic Response Systems: Relationship Between Perceptions and Class Performance, and Difference by Gender and Academic Ability
Category of approval: Exempt

Dear Julie,

This letter is to inform you that the proposed change to your original proposal has been accepted and approved. The approval expires 12 months from the date of the original approval and with the following conditions:

- If your research needs to continue beyond that time you will need to request an extension of the approval.
- If your research design is adjusted or changed again you will need to inform us of the changes and this may necessitate a reconsideration of the approval.
- If an unforeseen event occurs that is outside the scope of this approval you are to notify the IRB immediately. Examples of unforeseen events include but are not limited to: unexpected participation by a minor, adverse reaction of a participant or accidental release of personally identifiable data. Notification should include:
  o Date of the event
  o Nature of the event
  o Steps taken to rectify the issue
  o Additional safeguards implemented to protect against a future event
- Notification when the research project is complete

This approval does not imply any direct or indirect approval of research topics or methodology except as they pertain to the protection of the rights of the human subjects involved in the research.

This document serves as your certification of approval by the IRB and you should keep a file copy in case it might be needed later.

I trust your research project goes well and is very productive! If you should have any questions or concerns please feel free to contact me.

Sincerely,

R. Edwin Welch, Ph.D., Chair
Institutional Review Board
Taylor University
APPENDIX B. Ball State University IRB Approval Letter

Institutional Review Board

DATE: November 29, 2012
TO: Julie Kiefer
FROM: Ball State University IRB
RE: IRB protocol # 402318-1
TITLE: The Effect of Electronic Response Systems: Relationship Between Perceptions and Class Performance, and Difference by Gender and Academic Ability
SUBMISSION TYPE: New Project
ACTION: DETERMINATION OF EXEMPT STATUS
DECISION DATE: November 29, 2012

The Institutional Review Board reviewed your protocol on November 29, 2012 and has determined the procedures you have proposed are appropriate for exemption under the federal regulations. As such, there will be no further review of your protocol, and you are cleared to proceed with the procedures outlined in your protocol. As an exempt study, there is no requirement for continuing review. Your protocol will remain on file with the IRB as a matter of record.

Editorial notes:
1. Approved- Exempt

While your project does not require continuing review, it is the responsibility of the P.I. (and, if applicable, faculty supervisor) to inform the IRB if the procedures presented in this protocol are to be modified or if problems related to human research participants arise in connection with this project. Any procedural modifications must be evaluated by the IRB before being implemented, as some modifications may change the review status of this project. Please contact John Mulcahy at (765) 285-5166 or jmulcahy@bsu.edu if you are unsure whether your proposed modification requires review or have any questions. Proposed modifications should be addressed in writing and submitted electronically to the IRB (http://www.bsu.edu/irb) for review. Please reference the above IRB protocol number in any communication to the IRB regarding this project.

Reminder: Even though your study is exempt from the relevant federal regulations of the Common Rule (45 CFR 46, subpart A), you and your research team are not exempt from ethical research practices and should therefore employ all protections for your participants and their data which are appropriate to your project.
Demographic Questionnaire

Identification No. ________________

Gender
☐ Male ☐ Female

School Year
☐ Freshman ☐ Sophomore ☐ Junior ☐ Senior

Current Age: ________________

What is your cumulative college Grade Point Average (GPA)? ________________

Compared to other people my age, I probably use video games:
☐ Never
☐ Less than most
☐ About average
☐ More than most
☐ Much more than most

Compared to other people my age, I probably use computers:
☐ Never
☐ Less than most
☐ About average
☐ More than most
☐ Much more than most

Compared to other people my age, I probably use a cell phone:
☐ Never
☐ Less than most
☐ About average
☐ More than most
☐ Much more than most
Compared to other people my age, I probably use an iPod/MP3 player:

☐ Never
☐ Less than most
☐ About average
☐ More than most
☐ Much more than most

In my opinion, the kinds of devices mentioned above affect people and/or society in the following way:

☐ Are harmful
☐ Have some negatives, but in general are harmless
☐ Are neutral
☐ Are mostly positive
☐ Are extremely positive
APPENDIX D. Student Perception Questionnaire

Student Perception Questionnaire #1

Identification No. ______________

Please respond to the following statements by completing only one selection for each:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using clickers in this class would improve my grade in the course.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Using clickers in this class would improve my understanding of the course subject content.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Using clickers in this class would increase my feeling of belonging in this course.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Using clickers in this class would increase my interaction with the instructor.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Using clickers in this class would increase my interaction with other students.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I would enjoy using clickers in this class.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I would recommend using clickers in class again in this course.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
Have you ever used an Electronic Response System (clicker) in a college class?

○ Yes
○ No

Have you ever used an Electronic Response System (clicker) in school at any time during kindergarten through twelfth grade?

○ Yes
○ No
APPENDIX E. Dr. Martyn Permission Letter

Approval Granted

From: Margaret Martyn <mmartyn1@ccc.edu>
To: Julie
Subject: Approval Granted
Date: Oct 7, 2012 8:58 PM

Julie,
You may definitely use it and update it. I would love to hear how your research progresses.
Good luck with the rest of your research.
Kind Regards,
Margie

Margie Martyn, Ph.D.
Vice President of Academic Affairs
Herald Washington College, one of the City Colleges of Chicago
30 East Lake Street
Chicago, IL 60601
o: 312-553-5922
c: 312.509-5622

From: Julie [juliesvoyage@earthlink.net]
Sent: Saturday, October 06, 2012 9:52 PM
To: Margaret Martyn
Subject: Clickers in the Classroom article by M. Martyn

Dear Dr. Martyn:

My name is Julie Kiefer, and I am a Ph.D. student at Ball State University in Muncie, IN. My dissertation proposal is about the impact of clickers in the classroom in an introductory Biblical literature course. I found your article on Clickers in the Classroom in the November 2007 issue of Educause Quarterly to be an excellent resource. Would it be alright with you if I used an adapted version of the student perception survey published in the article in conducting my research? I would, of course, cite your article as the source for the pattern of the instrument used.

Thank you for your consideration,

Julie Kiefer
http://webmail.c.earthlink.net/zoom/printable.jsp?regid=1245xe=1993569308

Page 1 of 2
APPENDIX F. Informed Consent Form

TAYLOR UNIVERSITY

INFORMED CONSENT

The Effect of Electronic Response Systems: Relationship Between Perceptions and Class Performance, and Difference by Gender and Academic Ability

Identification No. ______________________

You are invited to participate in a research study of the effects of Electronic Response Systems (ERS), commonly called “clickers,” on academic performance. You were selected as a possible subject because you are enrolled in this course. All students in this course age 18 and over will be invited to participate. We ask that you read this form and ask any questions you may have before agreeing to be in the study. The study is being conducted by Julie Keifer, a doctoral student at Ball State University, and Professor Gregory MaGee, your instructor. It is NOT funded by any outside source.

STUDY PURPOSE
The purpose of this study is to obtain more information about the use of Electronic Response Systems (ERS) in the classroom, specifically whether academic performance is better than in a non-ERS class, whether students’ perceptions of their effects change over the semester and are consistent with their academic performance, and whether perceptions and/or ERS effects differ by gender, year in college, academic ability, and experience with and opinions about digital devices.

NUMBER OF PEOPLE TAKING PART IN THE STUDY:
If you agree to participate, you will be one of approximately 60 subjects who will be participating in this research.

PROCEDURES FOR THE STUDY:
If you agree to be in the study, you will do the following things:
Complete a brief form today requesting information on you such as your gender and year in college, your GPA, and your perceptions of “clickers” and other digital devices, and complete a brief questionnaire on your perceptions of clickers, and give permission for the instructor to use quiz and exam scores and other grading and opinion information for this research. Before the second meeting of this class, it will be randomly determined that one section of this course (either yours or the other section) will be conducted without using ERS, while the other will use ERS as the instructor normally would.

NOTE: It is important to understand that agreeing or declining to participate in the study will NOT make a difference to the way the classes are conducted. Students in the ERS section will all be required to use the clickers, and those in the non-ERS section will not use them. Your consent to participate ONLY allows the researchers to use information provided by you and your quiz/exam etc. scores in this course to be used for research. NO information from outside the class (for example, your SAT scores) will be used.

Following your signing of this informed consent form, your name will not be associated with any data obtained by the primary researcher. That is, your name will not be kept with the data; only the randomly-assigned research identification number will be used. Your instructor will, of course, have access to your grade information, but he will not be able to identify which students responded with which answers to the research questionnaires.
RISKS OF TAKING PART IN THE STUDY:
While on the study, the risks are:

Primarily that there will be a loss of confidentiality or anonymity. That is, it is possible that your name could be inadvertently connected with your responses and your course test grades. However, questionnaire responses will not include any data on especially private or sensitive information. It is possible that you might become upset at answering questions on your opinions on the use of ERS or other digital devices. If so, you will be free to skip answering any questions on the research questionnaires at any time without any penalty whatsoever.

BENEFITS OF TAKING PART IN THE STUDY:

The benefits to participation that are reasonable to expect are: Probably there will be no immediate personal benefits for you. It is hoped that what is learned in the study will help instructors to better understand the benefits and drawbacks of using ERS in the future, so that students in future years (possibly including you) will receive a better education.

ALTERNATIVES TO TAKING PART IN THE STUDY:

Instead of being in the study, you have these options: Decline to complete the questionnaires. Your course information (exam scores, etc.) will not be used in the research.

CONFIDENTIALITY

Efforts will be made to keep your personal information confidential. We cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. Your identity will be held in confidence in reports in which the study may be published.

Organizations that may inspect and/or copy your research records for quality assurance and data analysis include groups such as the study investigator and his/her research associates, the Taylor University Institutional Review Board (IRB) or its designees, the Ball State University IRB, and (as allowed by law) state or federal agencies, specifically the Office for Human Research Protections (OHRP) etc., who may need to access your research records.

COSTS

Taking part in this study may lead to added costs to you or your insurance company. You or your insurance company will be responsible for the following costs: None. You will not be responsible for these study-specific costs: Apart from trivial expenses for paper copies of questionnaires, etc., there are no costs associated with this study.

PAYMENT

You will not receive payment for taking part in this study.

COMPENSATION FOR INJURY

In the event of physical injury resulting from your participation in this research, necessary medical treatment will be provided to you and billed as part of your medical expenses. Costs not covered by your health care insurer will be your responsibility. Also, it is your responsibility to determine the extent of your health care coverage. There is no program in place for other monetary compensation for such
injuries. If you are participating in research which is not conducted at a medical facility, you will be responsible for seeking medical care and for the expenses associated with any care received.

FINANCIAL INTEREST DISCLOSURE

Neither researcher has any financial interest in the use of ERS equipment.

CERTIFICATE OF CONFIDENTIALITY

N/A.

CONTACTS FOR QUESTIONS OR PROBLEMS

For questions about the study or a research-related injury, contact the researcher, Julie Kiefer, at 317-258-2515. She will be available at this number during both business and non-business hours.

VOLUNTARY NATURE OF STUDY

Taking part in this study is voluntary. You may choose not to take part or may leave the study at any time. Leaving the study will not result in any penalty or loss of benefits to which you are entitled. Your decision whether or not to participate in this study will not affect your current or future relations with the University or your professor.

SUBJECT’S CONSENT

In consideration of all of the above, I give my consent to participate in this research study.

I will be given a copy of this informed consent document to keep for my records. I agree to take part in this study.

Subject’s Printed Name: ________________________________

Subject’s Signature: ________________________________ Date: __________

Printed Name of Person Obtaining Consent: ________________________________

Signature of Person Obtaining Consent: ____________________________ Date: __________