Photocopy and Use Authorization

In presenting this thesis in partial fulfillment of the requirements for an advanced degree at Idaho State University, I agree that the Library shall make it freely available for inspection. I further state that permission for extensive copying of my thesis for scholarly purposes may be granted by the Dean of the Graduate School, Dean of my academic division, or by the University Librarian. It is understood that any copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Signature ____________________________________

Date ____

Effects of Student Response System in

University Foundation Courses

by

Grace M. Tuttle

A dissertation

submitted in partial fulfillment

of the requirements for the degree of

Doctor of Education in the Department of

School Psychology and Educational Leadership

Idaho State University

Spring 2021

To the Graduate Faculty:

The members of the committee appointed to examine the dissertation of GRACE M. TUTTLE find it satisfactory and recommend that it be accepted.

John H. Curry, Ph.D.
Major Advisor

Carl F. Siebert, Ph.D.
Committee Member

Sheldon Eakins, Ph.D.
Committee Member

Cho Hyun Park, Ph.D.
Committee Member

Beverly Ray, Ph.D.
Graduate Faculty Representative

Idaho State University

March 8, 2020

Grace Tuttle
Learning Technology Solutions
Boise State University
Boise, ID 83725

Dear Ms. Tuttle,

The Institutional Review Board of Idaho State University (Human Subjects Committee) accepts the review of the IRB of Boise State University for your project titled, "Effect of Student Response System in UF 100 Courses". No separate submission to the Idaho State University Human Subjects Committee is required for this project.

Please note that the IRB BSU is the IRB of record for this project. All adverse events, unexpected problems, deviations from protocol, etc. must be submitted to that committee in accordance with its procedures and requirements.

Sincerely,

Tom Bailey
Coordinator, ISU Human Subjects Committee

Office for Reseach - Research Outreach & Compliance
921 South 8th Ave, Stop 8386 | Pocatello, ID 83209-8286 | (208) 282-1336 | isu.edu/research

DEDICATION

I dedicate this to my parents, Serafin and Leonora, who are not here to witness this accomplishment. I always remember your words of wisdom that I can do anything I set my mind to it, that education is a path to upward mobility, and that no one can take away this education from me.

You always encouraged me to always think outside the box. I love you and I miss you, Ma and Tang. Thank you for choosing me and guiding me.

ACKNOWLEDGEMENTS

I would like to give my sincere thanks to my committee: Dr. John Curry, Dr. Carl Siebert, Dr. Beverly Ray, Dr. Sheldon Eakins, and Dr. Cho Hyun Park for helping me with my research, your well-intended questions and feedback, and for challenging me to be a better researcher.

Thank you to Boise State Writing Center for proofreading my paper. I appreciate what you do for students and staff.

Above all, thank you to my number-one fan, my husband, Tim. You have been the Director of Operations and always support me with all my crazy ideas and encourage me to be my best self. I would not have been able to finish this well without your undying support. I love you, Sunshine. You are a rock star.

TABLE OF CONTENTS

List of Tables x

Abstract xii

CHAPTER I: Introduction 1

- Problem Statement 2
- Purpose of the Study 3
- Operational Definitions 4
- Research Questions 5
- Theoretical Framework 5
- Assumptions 6
- Significance of the Study 6
- Researcher Positionality 7

CHAPTER II: Literature Review 9

- Introduction 9
- Research on SRS 9
- Student Participation 11
- Attendance 13
- Active Learning 14
- Cognitive Load Theory 15
- Gender Differences 17
- Impediments to the Use of SRS in the Classroom 18
- Conclusion 21

CHAPTER III: Methodology 22

Purpose of the Study 22

Research Questions 22

Research Design..22

Participants 22

Research Site 23

Data Collection 23

Treatment 24

Variables 25

Coding Variables...25

Data Cleaning...26

Pre-Analysis 26

Data Analysis 26

Data Protection..29

CHAPTER IV: Results...………… 30

Assumption of Normality...33

Independent Sample T-test Analysis...34

Correlation Analysis 40

Regression Analyses: Multivariate Tests of Relationships Predicting UF 100 Final Grades……………………………………………………..…..……..…………………40

Assumption of Multicollinearity 46

CHAPTER V: Conclusions 47

Discussion of Research Findings 47

Limitations 54

Conclusion 55

Implications for Higher Education Administrators and Faculty...57

References..59

List of Tables

Table 4. 1 Demographics Characteristics of Participants 30

Table 4. 2 Descriptive Statistics for High School Academic Performance 32

Table 4. 3 Descriptive Statistics for UF 100 Academic Performance 32

Table 4. 4 Crosstabulation of Entering Characteristics and SRS Use 33

Table 4. 5 Results of Independent Samples t-tests for SRS and Non-SRS 36

Table 4. 6 Results of Welch’s t-tests for SRS and Non-SRS Groups 36

Table 4. 7 Results of Independent Samples t-tests for Gender and Age 37

Table 4. 8 Results of Independent Samples t-tests for Gender and Admission Index 38

Table 4. 9 Results of Welch’s t-tests for Gender and Admission Index 38

Table 4. 10 Results of Independent Samples t-tests for Age and Residency 38

Table 4. 11 Results of Independent Samples t-tests for Admission Index and Residency 39

Table 4. 12 Results of Welch’s t-tests for Residency 39

Table 4. 13 Correlations for Study Variables 40

Table 4. 14 Results of Logistic Regression Between UF Final Grade and SRS 41

Table 4. 15 Results of Logistic Regression Between UF Final Grade and SRS and Admission Index 42

Table 4. 16 Results of Logistic Regression Between UF Final Grade and SRS, Admission Index, and Gender 43

Table 4. 17 Results of Logistic Regression Between UF Final Grade and SRS, Admission Index, Gender, and Residency 43

Table 4. 18 Results of Logistic Regression Between UF Final Grade and SRS, Admission Index, Gender, Residency, and Age 44
Table 4. 19 Results of Logistic Regression Between UF Final Grade and SRS, Admission Index, Gender, Residency, Participation, and Age.. 45

Effects of Student Response System in University Foundation Courses

Dissertation Abstract – Idaho State University (2021)

Classroom technology has become an integral part of the life of students in the 21st century. Students get to be active learners when interactive technologies are utilized in the classroom. The purpose of this research was to expand current research and perform quantitative analysis on student response system use considering relevant measures of the factors including participation and attendance whether they have significant impact on learner's performance based on final course grades, controlling for age, gender, state residency, and admission index. Student academic performance as measured by final grades, was compared between the experimental and control groups. Overall findings show there was a significant difference between students who used student response system and students who did not use student response system. A series of regression analyses was conducted, and six models of regression analyses were employed. In particular, the results revealed there was statistically significant difference in final grades controlling for student response system, admission index, gender, residency, and participation. While gender, favoring female students was the highest predictor for four regression models, students who participated indicated with 1 z-score unit increase in student's participation score would boost their final grades by 1.3 percent.

Key Words: student response system (SRS), student participation, student academic performance

CHAPTER I: Introduction

The student response system (SRS) is one of the technologies that receives a great deal of attention across levels of education for both large and small classrooms (Baumann et al., 2015; Blasco-Arcas et al., 2013; Bojinova & Oigara, 2013; Brady et al., 2013; Bruff, 2009; Buil et al., 2016; Caldwell, 2007; Heaslip et al., 2014; Fuad et al., 2018; Hodges et al., 2017; Keough, 2012; Kortemeyer, 2016; Lee, et al., 2015; Powell et al., 2011; Rana & Dwivedi, 2017; Sarvary & Gifford, 2017; Stagg & Lane, 2010; Stines-Chaumeil et al., 2019; Smith, et al., 2011; Tlhoaele et al., 2014; Unal, et al., 2018). Clickers have different names depending on the vendors or users.

For the sake of simplicity and consistency, the term "Student Response System" and all categories of clicker-based technologies refers to the same clicker principle used in the classroom for polling.

Several studies on SRS can provide teachers an opportunity to improve pedagogy and promote student learning that is applicable to all classroom settings (Armbruster et al., 2009; Baumann et al., 2015; Bonwell & Eison, 1991; Heflin et al., 2016; Liu et al., 2017; Mayer, 2001) and enable students to easily interact and communicate with their classmates (Cheon et al., 2012; Addison et al., 2009). The use of SRS brought some changes to curriculum design and teaching delivery as instructors adopt fundamental ways in improving pedagogical practices and teaching (Baumann et al., 2015; Dallaire, 2011).

Many instructors adopted SRS for different reasons across different disciplines (Osterman, 2008) like economics (Bojinova & Oigara, 2013; Buil et al., 2016; Camacho-Miñano & Del Campo, 2016), engineering (Donahue, 2014), language (Garatti, 2013); legal studies (Park & Farag, 2015), medical and allied (Sebelego, 2019); neurosciences (Sarvary & Gifford, 2017);

nursing (Lin, 2015; Toothaker, 2018), philosophy (Yu & Yu, 2017), physical sciences (Balta & Tzafilkou, 2019; Hodges et al., 2017; Mazur, 1997), and psychology (Egelandsdal & Krumsvik, 2017; Landrum, 2013). They use SRS to administer quizzes, check students' comprehension of material, pose conceptual questions, and take attendance. The use of SRS in classrooms may give students who typically were reluctant to raise their hands an opportunity to participate (King & Joshi, 2008; Stowell et al., 2010; Ulbig & Noltman, 2012), increase participation from women (Niemeyer & Zewail-Foote, 2018) and reduce cultural barriers (Williamson Sprague & Dahl, 2010).

Problem Statement

Given the amount of research suggesting the beneficial use of SRS across levels of education (Mayer et al., 2009; Sevian & Robinson, 2011; Smith et al., 2011), instructors of large classes find ways to augment their lecture style format and devote time to engage their students in discussion, hands-on activities, and active learning activities (Cuseo, 2007, Dean, et al., 2016; Exeter et al., 2010; McDonald, 2013; Mulryan-Kyne, 2010). Large lecture courses present significant challenges related to issues of distraction and engagement. Students perceived lecture-style delivery to be didactic and impersonal as it involved one-way delivery of content from the instructor to the students (White, 2006). According to Trees and Jackson (2007), large lecture classes can pose challenges to student learning because they (1) limit opportunity to practice activities that promote higher-order learning, (2) limit instructors' opportunity to provide feedback, (3) limit opportunities for student engagement, (4) promote an expectation that students are passive learners, (5) reduce students' sense of responsibility for interacting in class, and finally (6) create a reluctance to participate and speak in class.

With the dramatic increase in available educational applications and technologies that has been documented since the year 2000 (Ng & Nicholas, 2013), students are the driving force in adopting technologies in higher education (Dahlstrom, 2012). The current generation of students, sometimes called the Net Gen (Tapscott, 2009) has grown up in an environment in which they are constantly exposed to digital technology. "Millenials assimilated technology because they grew up with it...[People today have an a]ttention span that is very short and generally broken in 10 to 15 minute content blocks and supported by multimedia audio and visual components" (McNeill, 2011, p. 3). According to Robinson (2007), "students who have grown up being entertained present particular challenges to teachers" (p. 12). Furthermore, Liu and Taylor (2013) argued "the problems associated with this misalignment of teacher and student expectations were further compounded by the prevalence of very large classes" (p. 154). Therefore, working in large classrooms can result in student disengagement (White, 2006; Walker et al., 2008; Liu & Taylor, 2013). To avoid these challenges of misalignments and reengaging students, Robinson (2007) suggested to create a more learner-focused classrooms for Millennials. Similarly, Carnaghan, et.al (2011) recommended for instructors to prepare early and be flexible while gaining familiarity with the SRS technology before implement grading policy.

Furthermore, little research is available about the relationships between SRS use, participation, attendance, and performance in UF classes in this Institution. The empirical studies are needed provide evidence on the effectiveness of SRS to promote classroom participation and attendance, and improve student learning as indicated by performance.

Purpose of the Study

The purpose of this study was to expand current research and perform quantitative analysis on SRS use considering relevant measures of the factors including participation and attendance whether they have significant impact on learner's performance based on final course grades, controlling for age, gender, state residency, and admission index.

Operational Definitions

Admissions index is a matrix that analyzes applicants admissibility based on a combination of high school GPA and SAT/ACT scores.

Age means the subject's age.

Attendance is a record of how often a student goes to classes.

Control group consists of students enrolled in UF courses where instructors used traditional lecture format and did not get the intervention.

Demographic variables relevant to this research are Age and Gender.

Dependent variable measured for this study is the UFs final course grades.

Experimental group consists of students enrolled in UF course where instructors used SRS.

Final grade is defined as earning a letter grade of A through F. For UF classes, students must earn at least a C- or better on an ABCDF grading scale and are required to pass the course.

Gender means the subject's gender.

Independent variables relevant to this research included Age, Gender, Admission Index, State Residency, Participation, and Attendance.

Intervention means applying specific treatment or SRS to the experimental group.

Participation was measured with points awarded to students who attended and polled during lecture. To earn the session participation points, students must respond to a certain percentage of questions in a session. Depending upon the total number of questions, iClicker Cloud automatically calculated the minimum number of responses needed. For the control group, participation was measured with points awarded in any discussion activities.

State Residency is based on information provided on the student's application for admission.

UF courses introduce students to college-level critical inquiry and focus on foundational historical and cultural context, transferable concepts, or big ideas that are of clear value to any educated person, regardless of major or future career.

Research Questions

The research questions for this study are:

1. To what extent there is a difference in student academic performance between experimental and control groups in UF 100 classes? (e.g., final course grades, attendance, and participation)?
2. To what extent there is a difference in SRS use by student demographics in UF 100 classes?

Theoretical Framework

The theoretical framework guiding this study is based on the generative theory of learning. Wittrock's (1974) learning theory suggested that learning involves actively organizing and integrating new ideas into the existing knowledge structures. The focus of learning was to generate association to newly acquired information to increase understanding of the instructional concept. According to Wittrock (1992), the generative theory of learning involved four concepts that can be applied in instructional methods in the classroom: attention, motivation, knowledge and preconceptions, and generation. It encourages full immersion in the learning experience, so learners may develop strategies to solve problems or scenarios. The use of SRS leads to more interaction between students and teachers, and among peers when instructors use polling and questioning methods that enhance engagement, which can lead to improved student performance. The use of SRS also promotes active learning that asks students to connect new information with their prior knowledge, foster higher-level thinking, and extend their understanding. Furthermore, to foster the generative learning process, instructors may engage students by asking relevant questions, asking students to teach other peers, and asking students to make self-explanations (Clark & Mayer, 2016). Similarly, the use of SRS serves as a tool for instructors in prompting students, encouraging them to describe their concepts, and challenging their opinions.

Assumptions

There were several basic assumptions in this study. All UF instructors had ample training and technical support in using SRS in the classroom as they had one-on-one consultations with the researcher. Both the experimental group and the control group had the equivalent average academic ability level. The students did not cheat during polling, in which it would skew the participation scores. Students learned equally regardless of their meeting times for three 50-minute sessions per week, 2 plenary/lecture sessions and 1 discussion group and two 75-minute sessions, with 1 plenary/lecture and 1 discussion group. There could be any difference in student performance depending on the subject/topic of the class as students were in the nearly the same size classes.

Significance of the Study

The UF classes each study different topics or themes and must be taken by every new first year student regardless of their area of discipline or major. The topics, themes, and learning outcomes are varied: writing; oral communication; critical inquiry; innovation and teamwork; ethics; diversity and internationalization; quantitative reasoning and mathematics; natural, physical, and applied sciences (University Foundations, 2020). The research sites librarians who developed an information literacy curriculum that was aligned with the UF's learning outcomes, incorporating a Project Oriented Guided Inquiry Method (POGIL) and active, team-based learning (Moore et al., 2015).

The study will provide information on what is and is not significant at both the micro and macro level. At the micro level, the results will assist the researcher to help instructors at the UF program to devise teaching and learning mechanisms in the classroom with a student-centered active learning technique like POGIL that is aligned with the UF's learning outcomes. Secondly, the study will add value to the literature published on this topic. Thirdly, the results will assist administration, Learning Technology Solutions (LTS) department, and UF program coordinators in determining if an enterprise license will benefit future student learning.

At the macro level, the study will contribute to the existing research on the effects of SRS in a large enrollment class across academic disciplines as this study includes students from a variety of disciplines. Secondly, the results may provide knowledge to instructors or practitioners in adopting SRS as an active learning tool, so that instructors or practitioners may be in a better position getting students involved in the classroom. Thirdly, this study will fill the gap by providing evidence on the impact of SRS used in UF classes.

Researcher Positionality

LTS is an organizational unit within the Office of Information Technology and provides coordination, management, advanced technical support, and faculty consultation. They support instructional technology environments like Blackboard Learning Management System, Course Evaluation System, iClicker Cloud, Panopto, Review+, Qualtrics, and Zoom. The researcher is a member of LTS, product owner of iClicker Cloud and Course Evaluation System, and has administrator’s access to the supported technology at the Institution. The researcher declared no potential conflicts of interest with respect to the research for this dissertation.

CHAPTER II: Literature Review

Introduction

Studies spanning many years have pointed to the effects of SRS on student engagement (Crossgrove & Curran, 2008; Dallaire, 2011; Frick et al., 2020; MacGeorge et al., 2008; Stevens et al., 2017), performance (Blasco-Arcas et al., 2013; Buil et al., 2016; Dallaire, 2011, Kaleta & Joosten, 2007; Morling et al., 2008; Poirier & Feldman, 2007; Powell et al., 2011; Preszler et al., 2006; Salmonson et al., 2009; Stines-Chaumeil et al., 2019; Ueltschy, 2001; Yoder & Hochevar, 2005), participation (Dallimore et al., 2010; Frick et al., 2020; Guthrie & Carlin, 2004; Oigara & Keengwe, 2013; Ueltschy, 2001; Young, 2010), and attendance (Kenwright, 2009; Nelson & Hauck, 2008; MacGeorge et al., 2008; Robinson, 2006) in both large (Cooper et al., 2018; Felce; 2007; Gauci et al., 2009; Guardia, et al., 2019; Trees & Jackson, 2007; Woelk, 2008) and small classes (Flosason et al., 2015; Khan et al. (2019); Lopez-Quintero et al., 2016; Oigara & Keengwe, 2013; Smith et al., 2011; Todd & Kristin, 2016**)** across higher education. This chapter also presents research on student participation, attendance, active learning, cognitive load theory, gender differences, and impediments to use of SRS in the classroom.

Research on SRS

Previous studies have been published on various aspects of SRS use. These included theory and general techniques of use (Buhay, 2010; Cain & Robinson, 2008; Draper & Brown, 2004; FitzPatrick et al., 2011; Mazur, 1997) and perceived benefits of SRS on student and teacher's perception (Bojinova & Oigara, 2013; Buil, et al., 2016; Keough; 2012; Mayer et al., 2009; Tlhoaele et al., 2014). Research indicates that learners benefited from the learning process when they are actively engaged (Bloom, 1984; Bojinova & Oigara, 2013).

Poirier and Feldman (2007) found using clickers revealed students performed significantly better than students in the traditional course. Stagg and Lane (2010) found that SRS increased in student engagement, satisfaction, feedback, and perception of use and reported use of clicker improved their final grade. Powell et al. (2011) found evidence suggested for increased academic achievement, measured by final grades when comparing clicker and non-clicker groups. Anthis (2011) found there was no significant difference in exams that used SRS. Elicker and McConnell (2011) indicated there was no differences in learning across groups and no significant relationships when using average performance as well as individual performance on exams. Fallon & Forrest (2011) found students using clickers did not generally enhance test performance or reduce anxiety. Keough (2012) found students exposed to clickers out-performed non-clicker students in academic performance before SRS was introduced. Fortner-Wood et al. (2013) found no significant effect on grades for students in developmental psychology class.

However, there was significant difference in student engagement with measure of engagement, ratings of experience, and attendance. Sutherlin et al. (2013) indicated that there was no significant increase in student appreciation of clicker use in classroom instruction for all four studies. The study also indicated that there was no evidence that clicker usage played a significant role in predicting student achievement in university science classes. Bojinova and Oigara (2013) found there was increased in student participation and engagement and reported better performance in clicker group. Blasco-Arcas et al. (2013) indicated that use of clickers led to more interactivity between students and teachers, which led to increased peer to peer engagement and improved student learning performance. Brady et al. (2013) indicated that there was statistically significant differences in metacognition and performance outcomes for summer cohorts. However, the results indicated that metacognitive processes for the fall experimental group was significant from the fall low-technology group, and the quantitative findings on metacognition seemed to be inconsistent. Furthermore, the overall study indicated the performance outcomes for both groups demonstrated that response systems may influence metacognition and a high degree of significance for performance outcomes when clickers are used. Heaslip et al. (2014) indicated the overall individual and overall participation showed that interactivity increased during mid-tests and post-tests. Tlhoaele et al. (2014) found clickers had a significant impact on students' performance as compared to more traditional lectures when interactive engagement activities are included. Baumann et al. (2015) indicated that students' attitudes toward clicker devices and their perception of their efficacy had a significant effect and found clickers had positive effects on grade outcomes. Fuad et al. (2018) indicated 97% of students were able to achieve a grade of B or higher using mobile-based visual and interactive problem-solving paired with SRS. Stines-Chaumeil et al. (2019) indicated that students' exam scores improved, and failure rates decreased with the use of clickers in the enzymology class.

Student Participation

Participation is defined as taking part in classroom activity, homework, discussion sessions, and active learning process (Reschly & Christenson, 2006; Unal et al., 2018). According to Young (2010), student engagement comprises of student's affective, behavioral, and cognitive involvement as faculty creates learning activities that impacts students' levels of engagement. "Participation could thus also be seen as one facet of student engagement" (Carnaghan et al., 2011, p. 272). Engaged students have a high level of involvement that leads them to prepare themselves better for the class, pay more attention, take good notes, think and be able to recall material from previous lectures (Caldwell, 2007).

Similarly, Astin (1999) defined that “student involvement refers to the amount of physical and psychological energy that the student devotes to the academic experience” (p. 518). Astin clearly emphasized that involvement implied a behavioral involvement; it was what the individual did, not so much about what the individual felt or thought.

Astin’s (1999) developmental theory of study involvement is rooted in a study theory of college persistence and concluded that the factors contributing to persistence are related to the degree of student’s direct involvement in their academic experience. Therefore, Astin argued that the theory of involvement emphasizes active participation of the student in the learning process.

According to Baumann et al. (2015), “the literature on clicker usage suggests that their incorporation into large-enrollment courses will have positive effects to students engagement and may increase performance in the class” (p. 251). Similarly, Bojinova and Oigara (2013) indicates that SRS has perceived benefits including “greater student engagement, increased student interest, and heightened discussion and interactivity” (p. 155); Landrum (2013) found evidence that students participate more often in a course. Furthermore, Stines-Chaumeil et al. (2019) reported that clicker use is an effective tool in a large group and it “increased student engagement, enhanced motivation and participation, and greater satisfaction with the course” (p. 568). However, Chaudhury (2011) believes that “questioning technique alone when integrated into lecture was not so effective” (p. 17) as the seamless integration of clicker questions. Park and Farag (2015) argue that getting students to raise their hands and ask questions can be problematic. The study found students were unlikely to want to verbally participate in answering questions, but the use of questioning in a lecture-style class can be very beneficial (Katz et al., 2017, p. 26), and it allowed student interaction with instructors and each other. Therefore, using SRS can offer an excellent opportunity for students who are shy and uncomfortable participating in class discussion. Moreover, it gave students the opportunity to pay attention and interact (Burnham et al., 2017; Macmillan, 2018; Masikunis et al., 2009) with peers to stimulate discussion and engage in the lesson (Dallaire, 2011; Hwang et al., 2015).

Attendance

Research on attendance has been widely cited and demonstrates a significant positive correlation between attendance and performance (Boscardin & Penuel, 2012; Burnham et al., 2017; Durden & Ellis, 1995; Evans, 2012; Lamdin 1996; Romer, 1993; Trees & Jackson, 2007). Stanca (2006) suggested that the effect of unobservable factors correlated to attendance should be accounted for, such as ability, motivation, and effort. However, research investigating the role of attendance as a distinct factor on academic performance identified that attendance had an independent effect on degree outcome (Burd & Hodgson, 2006; Colby, 2005; Marburger, 2001; Newman-Ford et al., 2008; Woodfield et al., 2006). Moreover, Crede et al.'s (2010) meta-analytic study primarily examined the relationship between class attendance in college and college grades. They suggest if class attendance exhibited a strong relationship with the grades attained in class and may result in policy changes, the use of clickers may "substantially ease the burden of collecting attendance data" (p. 273).

Instructors who implemented clicker technology have reported a dramatic increase in attendance (Boscardin & Penuel, 2012; Burnham et al., 2017; Carnaghan et al., 2011; Dallaire, 2011; Landrum, 2013; Lincoln, 2009); they attribute these findings to increased student participation. Similarly, instructors who implemented interactive lectures with clicker technology have reported in increase in student participation and attendance, which led to an overall improvement in grades (Burnham et al. (2017); Evans (2012); and Khan et al. 2019; Trees and Jackson, 2007).

Active Learning

Active learning is defined as a "result of a deliberate and conscious attempt on the part of a teacher to cause students to participate overtly in a lesson" (Pratton & Hales, 1986, p. 211). This type of learning is based on Piaget's (1973) theory of cognitive constructivism, which posited that people learn by actively constructing new knowledge and from Vygotsky's (1978) theory of social constructivism, which posited that learners construct or interpret their own experiences through the help of the instructor or peers that can lead to learning.

Jonassen (1999) argued that "constructivist conceptions of learning, assumed that knowledge is individually constructed and socially co-constructed by learners based on their interpretation of experience in the world. Because knowledge cannot be transmitted, instructions should consist of experiences that facilitate knowledge construction" (p. 217). The constructivist view of learning presents a model for designing active learning that engages students in the classroom and breaks up tedium of lecture and passive venues (Mayer, 2004). Green and Repetti (2015) argue that "social constructivist learning theory has led to peer-to-peer and learner-centered learning. Interactivity was essential as part of the active learning class design" (p. 173). In the recent decade, college educators have increasingly begun to consider implementing classroom instructions that are more interactive (Lambert, 2012; Rimer, 2009; Shapiro, 2017). As more educators seek to integrate activities designed to involve active engagement of students,

With the use of SRS, Bojinova and Oigara (2013) suggested the use of SRS can offer educators a way to employ active learning in the classroom that "enabled the instructor to gauge students' understanding, and respond according to the class needs" (p. 154). Furthermore, the use of SRS can provide information for instructors before moving to a new topic (Stuart et al., 2004; Unal, 2018; Yourstone, 2008). Based on the clicker responses in class, students moved from passive participants to active learners and can “discuss their own experiences in the context of the class” (Stagg & Lane, 2010). Moreover, the use of clickers can be used as a method for conveying information and asking increasingly difficult questions that might offer an excellent opportunity for students to engage with their peers and further discuss questions or responses, which generally allow students to learn from other students or the instructor (Park and Farag, 2015).

Cognitive Load Theory

While prior studies provide evidence to support that clickers were easy to use (Lincoln, 2009; MacArthur & Jones, 2008; Stagg & Lane, 2010; Trees & Jackson, 2007), DeBourgh (2007) suggests both cognitive and application goals should be considered in each classroom clicker session by including learning goals. Van Merriënboer and Ayres (2005) stated that the “cognitive load theory (CLT) has become an established theory in the field of learning and instruction” (p. 5) where more applications of CLT have emerged to offer new insights to instructional practices and designs. According to Paas et al. (2010), “CLT was concerned with the learning of complex cognitive tasks, in which learners were often overwhelmed by the number of interactive information elements that need to be processed simultaneously before meaningful learning can commence” (p. 116). Furthermore, the impact of technology that hinders learning rather than promoting and improving it can “overload the mind’s capacity for processing information” (Sorden, 2005, p. 265). Therefore, improving students’ critical thinking requires significant understanding of human cognitive architecture and learning processes.

Schemas are significant to Cognitive Load Theory. Van Merriënboer and Ayres (2005) stated that “although cognitive schemas were stored, and long-term memory and novel information must be processed in working memory” (p. 6). Similarly, according to Wong et al.

(2012), “instructional designs that did not aim to alter long-term memory and which ignored working memory limitations when processing novel information were unlikely to be effective” (p. 450). One of the goals of CLT-based instruction is not to overload the learners’ working memory when materials are presented (Paas et al., 2010). The primary purpose of instruction is to construct schema in the long-term memory (Wong et al., 2012) that enhances learning objectives. Thus, creating unnecessary activities that hindered learning is an important rule to be avoided in any form of instruction (Sorden, 2005).

According to Sweller et al. (2019), CLT identified three broad categories of cognitive load:

> The first, intrinsic cognitive load, referred to the complexity of the information being processed and was related to the concept of element interactivity. The second type, extrinsic cognitive load, is (sic.) not determined by the intrinsic complexity of the information but rather, how the information is presented and what the learner is required to do by the instructional procedure. Unlike intrinsic cognitive load, it can be changed by changing instructional procedures. The third type of cognitive load, germane cognitive load, was defined as the cognitive load required to learn, which refers to the working memory resources that are devoted to dealing with intrinsic cognitive load rather than extrinsic cognitive load. (p. 264-265)

As an example, more experienced learners are able to interact between the nature of the materials being learned and process a higher level of expertise, and not be overloaded by their capacity when compared to novice learners. The more experienced learners are, the more they have developed their cognitive schema. By understanding intrinsic cognitive load, it may reduce extraneous cognitive load that may have negative effects on learning and can interfere with the forming or organizing of schemas. In turn, reduction in extraneous cognitive load increases germane load. Therefore, it might heighten learning efficiencies and optimize learning and teaching process (Yu et al., 2014). The implication for clicker adoption in lectures, therefore, was to provide students opportunity to identify parallels and draw differences when presenting clicker questions including better pacing of materials (Jensen et al., 2009). Furthermore, Yu et al., (2014) reported that participants using clickers revealed significantly lower cognitive loads when compared to multimedia participants.

Gender Differences

Numerous studies have investigated the role of gender in computer-related behavior, attitude, and use (AAUW, 2000; Hilao & Wichadee, 2017; Kang et al., 2012; Kay, 2008; King & Joshi, 2008; Muhanna & Abu-Al-Sha'r, 2009; Niemeyer & Zewail-Foote, 2018; Whitley, 1997). Some studies have indicated roughly 30 to 50% differences in computer attitude, ability, and use that favored males (AAUW, 2000; Kay, 2008; Whitley, 1997). Another study on the attitude of mobile learning indicated male students positively appreciated using cell phone in learning environment (Muhanna & Abu-Al-Sha'r, 2009). A recent study found there was no significant impact between men and women in their attitudes towards using mobile phones in the learning environment (Liu, 2020).

Previous studies about gender differences suggests that women have a lower comfort level with technology (Chen, 1986; King & Joshi, 2008; Popovich et al, 2008; Shashaani, 1994). According to King and Joshi (2008), these studies are generally attributed to the relative amount of time each gender spent with using computers. Popovich et al. (2008) examined the gender differences and compared attitudes of undergraduates toward the use of computer. Furthermore, they reported the overall attitude of students toward the use of computer was relative to the amount spent and the number of computer classes taken.

Some research investigated gender differences in attitude toward SRS (Kang et al., 2012; Kay, 2008; King & Joshi, 2008; Niemeyer & Zewail-Foote, 2018). Although SRS are widely adopted **(**Gibbons et al., 2017; MacGeorge et al., 2008; Niemeyer & Zewail-Foote, 2018**),** various studies indicate different findings on how gender plays a role in SRS use (Kay 2008; King & Joshi, 2008; Niemeyer & Zewail-Foote, 2018). Reay et al. (2008) reported the use of clickers reduces the gap between the performance of women and men on exams. However, in a study of three large university lecture courses, MacGeorge et al. (2008) reported the evaluation of SRS was not substantially impacted by gender. King and Joshi (2008) found both genders who actively participated during clicker questions were more likely to have higher final grades in the course. Kang et al. (2012) found women performed better with clickers while men performed markedly better with traditional teaching method. Niemeyer and Zewail-Foote (2018) found that women strongly perceived that SRS improved their classroom experience, encouraged them to be more engaged, and helped them to learn the course better.

Impediments to the Use of SRS in the Classroom

Teaching a large class can pose a number of challenges or impediments to a sound pedagogical use of SRS (Trees & Jackson, 2007; Stagg & Lane, 2010). Several studies have highlighted three broad categories of challenges to effective use of SRS; technology-based, instructor-based, and student-based (Gok, 2011; Kay & Lesage, 2009).

The most common reported impediment to effective use of SRS is the administrative burden with technology (Beatty, 2004; Bursntein & Lederman, 2003; Fies & Marshall, 2006; Harlow et al., 2009; Park & Farag, 2016). As with any technology, technical issues may arise and affect the adoption and use of SRS in the classroom. Some of the major frustrations with SRS include students' negative feedback in their response to lost or forgotten clickers, technical problems with software and hardware, instructor's lack of experience, consumption of class time (Caldwell, 2007; Hatch et al., 2005; Reay et al., 2005; Sharma et al., 2005; Siau, Sheng, & Nah, 2006; Sprague & Dahl, 2010), and problems with infrared clicker devices as they operate within the line of sight of the communication (Connor, 2009; El-Rady, 2006). With malfunctioning technology, this had an adverse effect on students particularly when they were being evaluated for grades (Gok, 2011). Furthermore, Hwang et al. (2015) reported that the use of web-based SRS poses some challenges for students as they were not able to connect to the Internet and tended to use up students' mobile devices' battery life. While Park and Farag (2015) did not have any difficulty using SRS in their classrooms and getting institutional support from their respective universities, they reported that at some universities support and training got lost in the cracks.

The second reported impediment to the use of SRS is instructor-based challenges. As instructors change their teaching approaches from passive, lecture-based instruction to a more interactive engagement, creating clicker questions can be time consuming and challenging (Beatty et al., 2006; Milner-Bolotin et al., 2010). Some of the negative feedbacks with SRS included financial and time implications for setup and delivery, and utilize effectively the SRS technology in the classroom (Walklet et al., 2016). Lincoln (2009) found that difficulty in learning how to operate the clicker technology as a barrier for future adoption. According to Rana et al. (2016) and Strasser (2010), clicker questions are not only difficult to compose but also need to be designed in a way that can really test students' understanding on the related subject matter. Carnaghan et al. (2011) described while there is a learning curve in using SRS in the classroom, an “instructor must learn to operate the hardware and software that comprised the SRS. Carnaghan et al. (2011) suggests that instructors should be familiar with the technology as students asked questions from how to turn on the clicker to how to change the batteries. Furthermore, like other technology, some of the instructor-based challenges take time to plan to use SRS in the classroom (Milner-Bolotin et al., 2010; Premkumar & Coupal, 2008; Sevian & Robinson, 2011; Sprague & Dahl, 2010) and to integrate new technology into their pedagogical practices and classroom instruction. Moreover, some concerns that faculty expressed were the potential of cheating exists and the idea of forcing students to pay attention (Caldwell, 2007; Park & Farag, 2015).

The third reported impediment to the use of SRS was student-based challenges. Previous studies have investigated that students have expressed dissatisfaction especially in instances where clickers are used mainly as attendance-polling devices (Katz et al., 2017; MacArthur & Jones, 2008; Stagg and Lane, 2010) and when students have to register and associate their name with their clicker (Abrahamson, 2006; Kolikant et al., 2010; Stowell et al., 2010). Furthermore, the idea of forcing students to pay attention and reduce downtime may reinforce conditioned responses that do not lead to higher order of thinking and deeper learning (Caldwell, 2007; Parslow, 2007; Robinson, 2007; Siau et al., 2006). Carnaghan et al. (2011) suggests that “care must be taken to ensure the questions achieve the level of difficulty and cognitive skill desired” (p. 280). Moreover, students have expressed negative feedback relating to financial value of clickers as it added additional cost to already overpriced books (Bujega, 2008; Carnaghan, 2011; Dallaire, 2011; Lincoln, 2009; Park & Farag, 2015; Powell et al., 2011; Sprague & Dahl, 2010). Students had to pay between $15 to $70 (Carnaghan et al., 2011; Dallaire, 2011; Steinberg, 2010) depending on the model or whether the device is new or used. As these impediments accumulated, “students may resent the use of clickers and this might interfere with learning and engagement with the course material” (Dallaire, 2011, p. 200).

Conclusion

The review of literature indicated that many instructors used SRS to track attendance, increase participation, facilitate discussions, and measure performance in a variety of disciplines, as well as positive findings exist from studies on SRS use that spanned two decades. The research also includes a compilation of instructional design theory, teaching strategy, learning theory, practices, and challenges of SRS use. Also, past research discussed preliminary evidence on the effects of SRS on student engagement, participation, attendance, and gender differences.

CHAPTER III: Methodology

Purpose of the Study

The purpose of this study was to expand current research and perform quantitative analysis on SRS use considering relevant measures of the factors including participation and attendance whether they have significant impact on learner's performance based on final course grades, controlling for age, gender, state residency, and admission index.

Research Questions

The research questions for this study were:

1. To what extent there is a difference in student academic performance between experimental and control groups in UF 100 classes? (e.g., final course grades, attendance, and participation)?
2. To what extent there is a difference in SRS use by student demographics in UF 100 classes?

Research Design

This quantitative research is a quasi-experimental design. According to Creswell (2009), quantitative research is a means for testing phenomena by attempting to understand the relationships among variables. The intent of this research was to correlate the relationships of the outcome variable, final course grade to the independent variables.

Participants

The population of this study consists of UF 100 students between spring 2017 to fall 2019 (n = 7,813). Comprehensive information on this population is available for this research. Records from Learning Technology Solutions (LTS) went back as far as 2016. Based on the available data since 2016, a total of 9,950 students registered their physical remotes or mobile devices that they used in their classes.

Students enrolled in foundations courses where instructors used SRS were part of the experimental group. Students enrolled in UF courses where instructors who did not use clickers and taught using traditional lecture format were part of the comparison group. Students who got Pass/Fail, incomplete, audit, unsatisfactory audit, and withdrew during the years of 2017-2019 were excluded from this study because students did not get a letter grade of A through F. The University uses a 4.0 grading scale and calculates grade-point average. Students who repeated were excluded as they could have advantage because of prior knowledge and understanding of the course material, teaching format, and/or methods over students who were taking the class for the first time. Students who were enrolled in online UF courses between spring 2017 and fall 2019 were excluded in this study because the SRS technology did not have the flexibility to create pathways for student engagement and active participation asynchronously.

Research Site

The mid-size four-year university in the Intermountain West is designated as a doctoral research institution by Carnegie Classification of Institutions of Higher Education with an enrollment of 25,540 students and 3,304 total employees. There are 1,508 faculty members and 769 of those are considered full-time. This university is a public institution with majority of undergraduate students and offers about 200 programs of study, including14 doctoral programs.

Data Collection

Institutional Review Board (IRB) approval was obtained for this research. The Protocol Number is 101-SB19-270. The Office of Institutional Research (IR) provided historical and current data on matriculated students. IR collected student data that included demographic variables, admission index, state residency status, and final course grades.

The researcher has administrator privileges for both iClicker Cloud and Blackboard Learning Management System and collected students' identification number assigned to each student that matched the participation and attendance data from iClicker Cloud and Blackboard Learning Management System. The data from IR and the researcher's data were combined. Once the data were combined, all identifying data were removed before analysis.

Demographic and academic information from matriculated students included age, gender, state residency, and admission index scores. These data were obtained during admission process that students submitted for application to the Institution.

Data for this research included participation points, attendance points, final course grades, age, gender, state residency, and admission index. Participation and attendance data were presented as part of student scores throughout the semester. Participation data were collected from the Gradebook module while attendance data were collected from the Attendance module of iClicker for the experimental group. Both participation and attendance data were collected from the Blackboard Learning Management System Gradebook for the comparison group. Some students did not receive an index score because of the following reasons: homeschool students, unaccredited high school students, non-degree, GED students, transfer students, returning institution students, new freshmen over the age of 21, and 2nd-degree students (S. Brueck, personal communication, April 24, 2020).

Treatment

iClicker Cloud from Macmillan Learning was the technology for this research. This system included students' mobile devices, tablets, laptops, clicker remotes, and iClicker bases or receivers that are plugged into the existing classroom computers. The iClicker Cloud software is downloaded from the iClicker website. iClicker bases or receivers and instructor remotes are available at no cost to the departments and colleges.

Variables

Age is used as a continuous variable. Gender is a categorical variable. Admission index is a scale variable between 0 - 100. Participation and attendance data is used as continuous variables. State residency is a categorical variable. The clicker variable is a categorical variable. Final course grade is an ordinal variable. It was converted into binary variable.

Field (2013) stated that “logistic regression is multiple regression but with an outcome variable that is categorical and predicator variables that are continuous and categorical” (p. 761). In this study, the dependent variable is dichotomous in nature and represented in binary form. Dummy coding allows to convert into categories and can be represented as 1 or 0 to a subject (Hair et al., 2010). Some independent variables are dichotomous and others are continuous.

Coding Variables

Age is a continuous variable from 13 to 69. Gender has two categories: male (0) and female (1). Therefore, gender variable is a dichotomous variable indicated by Male (0) or Female (1). Admission index is a score between 1 - 100 and represented with two categories: (0) < 36 and (1) > 36. Participation and attendance data are continuous variables and were normalized using Z-scores. The state residency has two categories: (0) Out-State High School and (1) In-State. The clicker variable is a categorical variable with two categories: No (0) and Yes (1). The value of 1 was assigned if students were in one of the classes taught using SRS or equal to 0 for students who were in non-SRS class. Final course grade is an ordinal variable represented by a letter grade from A+ to F. Final course grades were transformed and represented as dichotomous variables: NotHighPass(0) and HighPass (1). The value of 0 was a grade score between 1.7 to 2.7

and the value of 1 was a grade score between 3.0 to 4.0. Any missing variables were coded a value of -9999.

Data Cleaning

Checking data quality was important to resolve ambiguities and inconsistencies of the data. Microsoft Excel was used to manage data. A unique identification number was assigned to each record before the analyses. A Codebook was created and used to provide a guide for coding variables to match responses and record definitions of variables in the data file. Variable values that were missing were labeled correctly and unusable records were dropped.

Pre-Analysis

Siebert and Siebert (2017) explained the importance of coverage and understanding of the data before and during any statistical tests. They suggested that “one frequently used guideline dictates that a categorical variable should have a minimum of five respondents representing each category before using the variable in each category” (p. 29). Categorical coverage in this research was sufficient. There was enough coverage for the gender variable prior to analysis as the data set contained 7,812 samples. Due to the large sample, scale variables more closely represent the variability and distribution of the entire population of students. If the variability of the distribution was less than 1%, the variable was not included. Data not meeting the inclusion criteria for this study were removed before analysis.

Data Analysis

Data was imported into SPSS after they were cleaned and coded using Microsoft Excel. This study was designed to explore the relationships between SRS use and final grades, demographics, and high school academic performance. It was important to understand how these relationships affect each other to provide guidance for administrators or policy decisions at the

University. Different analyses were used to explore these relationships. Bivariate and multivariate analyses explored the relationships between gender, residency, admission index, participation, attendance, SRS, and final grades.

This research examined data using univariate analyses to describe and find patterns that exist within the data. It examined the data using bivariate analyses, reported cross tabulations and frequency distribution of the variable, listing the values acquired in the sample. It also examined multivariate analyses to determine which variables influence the outcome variable. A frequency distribution was depicted in a graphical or chart form. The three measures of central tendency were used to calculate the mean, median, and mode of specific variables. The measures of the center and spread were used for estimating and predicting when analyzing univariate data. Chi-square, correlation, independent t-test, and logistic regression were used as measurements or tests to explore these relationships.

Chi-Square Goodness of Fit was used to measure the observed cell frequencies compared to expected cell frequencies. Chi-Square Test for Independence was performed to determine whether there was an association between categorical variables. Similarly, Correlation Test for Independence was performed to determine whether there was an association between continuous variables. Homogeneity of Variance using Levene's test was performed to determine that comparison groups have the same variance.

Outliers were not be removed if they are natural part of the population being studied. However, if the outliers in question were data or measurement errors, they were corrected if possible, otherwise removed from the study. According to Dong and Peng (2013), "the impact of missing data on quantitative research can be serious, leading to biased estimates of parameters, loss of information, decreased statistical power, increased standard errors, and weakened generalizability of findings" (p. 1). The most common techniques to handle missing data are listwise and pairwise deletion (Peugh & Enders, 2004). According to Baraldi and Enders (2010), listwise deletion is a technique of discarding cases with missing values but cases that have complete data are analyzed. On the other hand, pairwise deletion includes all available data which "minimizes the number of cases discarded in any given analysis. Rubin (1976) and Little and Rubin (2002) classified the three missing data mechanisms: Missing Completely at Random (MCAR), Missing at Random (MAR), and Missing Not at Random (MNAR). These mechanisms according to Baraldi and Enders (2010) are "assumptions that dictate the performance of different missing data techniques" (p. 7). According to Meeyai (2016), "most techniques assume missing data are Missing Completely at Random, while some also assume Missing at Random" (p. 129-130). Little (1988) suggested missing data should be handled carefully by testing for MCAR missing data mechanism as the missing data appear to be unrelated to any study variable. In this study, there was no missing bias and missing variables were assumed missing at random. Chi-square tests were used to look for relationship between missingness variables and age, gender, residency, admission index, and SRS usage.

According to Allen (1997), "logistic regression analysis was developed precisely for the purpose of estimating the parameters of regression models with binary dependent variables" (p. 189). In this study, logistic regression was used to test if SRS use significantly affected the UF final course grade which is the dependent variable. It measured the relationship between a binary outcome variable and combination of predictor variables (demographics, class academic performance, and high school academic performance) by estimating probabilities using a Log (p/(1-p). According to Muijs (2010), "logistic regression also produces odd ratios associated with each predictor value" (p. 158). It predicts a probability value between 0 and 1. The odds variable produced odd ratios associated with each independent variable, defined as the amount by which the odds of the outcome increase (greater than 1.0) or decrease (less than 1.0) when the independent variable was increased by 1 unit.

Data Protection

A computing system was used for the data analyses. The University's network drive was utilized to store the initial data collection. After the data were stripped of student-identifier information, the dataset was saved and any original datasets containing student-identifier information was deleted to comply with IRB guidelines.

CHAPTER IV: Results

The purpose of this research was designed to explore the relationships between SRS use and final grades, demographics, and high school academic performance. It is important to understand how these relationships affect each other in an effort to provide guidance for administrators or policy decisions at the University. Different analyses were used to explore these relationships. Bivariate and multivariate analyses explored the relationships between gender, residency, admission index, participation, attendance, SRS, and final grades. Chi-square, correlation, independent t-test, Welch and Brown-Forsythe t-test, analysis of variance (ANOVA), and logistic regression were used to explore these relationships.

There were a total of 7,812 students enrolled in UF 100 classes between spring 2017 and fall 2019. The demographics characteristics of participants presented in Table 4.1 include 4,268 students who identified as female (54.6%), 3,543 students who identified as male (45.2%), and 1 student who did not report gender (.0%). The sample includes 3,597 non-residents (46%) and 4,215 residents (54%). Most students were 18 years old (n=4,965, 63.6%).

Table 4. 1

Demographics Characteristics of Participants

Characteristic	Frequency	Percent
	n	%
Gender		
Female	4268	54.6
Male	3543	45.2
Missing	1	.0
In-State Resident		
No	3597	46.0
Yes	4215	54.0
Student Age		
Age 13	1	.0
Age 15	1	.0
Age 16	8	.1
Age 17	326	4.2
Age 18	4965	63.6

Age 19	1511	19.3
Age 20	299	3.8
Age 21	151	1.9
Age 22	92	1.2
Age 23	67	.9
Age 24	79	1.0
Age 25	47	.6
Age 26	44	.6
Age 27	34	.4
Age 28	28	.4
Age 29	26	.3
Age 30	11	.1
Age 31	14	.2
Age 32	19	.2
Age 33	11	.1
Age 34	12	.2
Age 35	6	.1
Age 36	5	.1
Age 37	9	.1
Age 38	6	.1
Age 39	3	.0
Age 40	4	.1
Age 41	4	.1
Age 42	5	.1
Age 43	3	.0
Age 44	1	.0
Age 45	3	.0
Age 46	4	.1
Age 47	1	.0
Age 49	4	.1
Age 51	2	.0
Age 52	1	.0
Age 54	1	.0
Age 56	1	.0
Age 60	1	.0
Age 62	1	.0
Age 69	1	.0

Note: N=7,812 for each variable. Only one did not report gender.

Students' high school academic performance presented in Table 4.2 includes an academic index (i.e., Admission index) that is a matrix based on a combination of high school GPA and SAT/ACT scores.

Table 4. 2

Descriptive Statistics for High School Academic Performance

Variable	*n*	*M*	*SD*
Admission Index	7015	59.41	16.052

Note: N=7,812. Missing values were not included for analysis.

Participation scores and attendance scores were converted to z scores. According to Field (2013), z scores are a way of standardizing scores that were measured on different scales. Students' academic performance presented in Table 4.3 includes 1,160 students who had a final grade between 1.7 to 2.7 (15.7%), 6,233 students who has a final grade between 3.0 to 4.0 (84.3%), and 419 students did not pass (5.4%). Students who did not pass were not included in the analysis. Students' participation scores and attendance scores were converted to z scores. The mean of students' attendance score is -.02 for male and a mean of .02 for female among the 5,380 students. The mean of students' participation score is -.07 for male and .06 for female among 7,193 students.

Table 4. 3

Descriptive Statistics for UF 100 Academic Performance

Variable	Frequency	Percent
	n	%
Final Grade		
1.7 to 2.7	1160	15.7
3.0 to 4.0	6233	84.3
Z Score Attendance		
Male	2495	46.4
Female	2885	53.6
Z Score Participation		
Male	3246	45.1
Female	3947	54.9

Note: N=7,812. Missing values were not included for analysis.

Chi-Square Test of Independence Analysis

Chi-square test determines to test relationships between categorical variables and measures of observed frequencies compared to expected frequencies (Hair et al., 2010). Students' group assignment presented in Table 4.4 included 4,674 (59.8%) students who belonged to the Non-SRS group and 3,188 (40.2%) students who belonged to the SRS group. The Chi-Square analysis between gender and SRS use suggested there was significant association, $x^2(1, N = 7{,}812) = 4.466$, $p = .035$. There was no significant association between residency status and SRS use $x^2(1, N = 7{,}812) = 1.41$, $p = .707$.

Table 4. 4

Crosstabulation of Entering Characteristics and SRS Use

Variable	Non-SRS Use		SRS Use		
	n	%	n	%	$x^2(2)$
Gender					.024
Male	2166	61.1	1378	38.9	
Female	2508	58.8	1760	41.2	
Residency					-.004
No	2144	59.6	1453	40.4	
Yes	2530	60.0	16.85	40.0	

Note: N=7,812. Missing values were not included for analysis.

Assumption of Normality

Testing the Assumption of Normality was conducted to test the shape of the data. There were at least two approaches used to conduct a statistical test of the Assumption of Normality. The Kolmogorov-Smirnov and the Shapiro-Wilk Tests are nonparametric tests and were conducted to check the shape of the sample against a variety of skewness and kurtosis, including the normal or bell-curve distribution. If the resulting *p*-value is .05 or less, there is a significant evidence that the sample is not normal.

In this research, assumption of normality has been violated because the shape of the data is not normally distributed. According to Hair et al. (2010), “larger sample sizes reduce the detrimental effect of nonnormality” (p. 72). While the sample size is sufficiently large (N=7812) and does not meet the assumption of normal distribution, Gall et al. (2010) suggested to use nonparametric tests; Furthermore, with larger samples, they can yield with the same level of statistical significance.

Siebert and Siebert (2017) suggested two primary options when variable fails the assumption of normality. The first option is to transform the data using log or square transformation. The second option is to use nonparametric tests or bootstrapping. The data are still skewed and kurtotic after using data transformation strategies: square root, log10, and bootstrapping functions. Therefore, using nonparametric tests as suggested by Siebert and Siebert (2017) and Gall et. al (2010) were conducted to test statistical significance.

Because the assumption of normality has been violated, a simple ANOVA procedure was conducted to compare the between-groups variance in scores with amount of within-groups variance (Gall et al., 2010). Welch’s t-test is robust against normality even if the distribution of data deviates from normality. It is more rigorous test when variances are not equal. Therefore, a nonparametric test using Welch’s t-test was conducted to test the difference between two group means when the group variances and samples sizes are unequal.

Independent Sample T-test Analysis

Independent Samples t-test compares the means of two independent groups (Muijs, 2011) and represented in Table 4.5. An independent samples t-test was conducted and indicated that scores were significantly higher for the SRS group (M = -.0659, SD = 1.01) than for non-SRS (M = .04431, SD = .9885), $t(7810)$ = 4.786, p <.0001. These results suggested that SRS use does have an effect on student academic performance measured by final grades. Cohen's *d* was estimated at .11, which is a small effect based on Cohen's (1988) guidelines. The Levene's test indicated equal variance *F*(1,7810) = .024, *p* = .877. Therefore, the assumption of homogeneity has not been violated.

An independent samples t-test was conducted and indicated that admission index scores were significantly higher for the SRS group (*M* = 60.50, *SD* = 16.22) than for non-SRS (*M* = 58.67, *SD = 15.894*), *t*(7013) = -4.676, *p* <.0001. The SRS group has statistically significantly higher mean score on admission index than non-SRS group. Cohen's *d* was estimated at .-11, which is a small effect based on Cohen's (1988) guidelines. The Levene's test indicated equal variance *F*(1,7013) = 2.732, *p* = .098. Therefore, the assumption of homogeneity has not been violated.

An independent samples t-test was conducted and indicated that there was not statistically significant different between the clicker use for non-resident (*M* = .54, *SD* = .498) and for resident (*M* = .54, *SD = .499*) groups, *t*(.376) = .552, *p* =.707. Cohen's *d* was estimated at .009, which is a small effect based on Cohen's (1988) guidelines. The Levene's test indicated equal variance *F*(1,7810) = .552, *p* = .458. Therefore, the assumption of homogeneity has not been violated.

An independent samples t-test was performed to compare SRS and non-SRS with participation scores. Participation scores were higher for non-SRS (*M* = .25888, *SD* = .9870) than for SRS (*M* = -.3674, *SD =.8981*), *t*(6742) = 27.950, *p* <.0001. Cohen's *d* was estimated at .658, which is a medium effect based on Cohen's (1988) guidelines. The Levene's test indicated unequal variance. Therefore, the degrees of freedom were adjusted from 7191 to 6742. In this case, the assumption of homogeneity has been violated.

Because the assumption of homogeneity has been violated, a Welch's ANOVA t-test was conducted to test the difference between two group means when the group variances and samples sizes are unequal. Welch test is more rigorous tests when variances are not equal. Participations scores differed significantly among groups, $F(1,7191) = 756.10$, = $p < .0001$. The results from the Welch's test indicated a significant difference among groups, $F_W(1,7191) = 781.20$, = $p < .0001$. There was a significant difference in mean between the male (M = .26, SD = .99) and female (M = -.37, SD = .90) groups. The results are represented in Table 4.6.

Table 4. 5

Results of Independent Samples t-tests for SRS and Non-SRS

Variable	SRS		Non-SRS		*t*	*p*	*Cohen's d*
	M	*SD*	*M*	*SD*			
Final Grade	-.0659	1.01	.04431	*.9885*	4.786	.001	.11
Admission Index	60.50	16.22	58.67	*15.894*	-4.676	.001	-.11
Residency	.54	*.498*	.54	*.499*	.376	.707	.009
Participation	-.3674	*.8981*	.25888	.9870	27.950	.001	.658

Note: N=7,812. Missing values were not included for analysis.

Table 4. 6

Results of Welch's t-tests for SRS and Non-SRS Groups

Variable	SRS		Non-SRS		*F ratio*	*df*	η^2
	M	*SD*	*M*	*SD*			
Participation Score	-.37	.90	.26	.99	756.10	1	.095

Note: N=7,812. Missing values were not included for analysis.

An independent samples t-test was conducted to compare age with male and female groups and represented in Table 4.7. There was not a significant difference in mean between the male (M = 18.95, SD = 2.984) and female (M = 18.97, SD = 3.099) groups. The results of an independent t test showed that this difference was not statistically significant, $t(7810) = -.319$, $p = .750$. Cohen's *d* was estimated at -.007, which is a small effect based on Cohen's (1988) guidelines. The Levene's test indicated equal variance $F(1,7810) = 2.089$, $p = .148$. Therefore, the assumption of homogeneity has not been violated.

Table 4. 7

Results of Independent Samples t-tests for Gender and Age

Gender	Female		Male		*t*	*p*	*Cohen's d*
	M	*SD*	*M*	*SD*			
Age	18.97	3.099	18.95	2.984	-.319	.750	-.007

Note: N=7,812. Missing values were not included for analysis.
¶

An independent samples t-test was conducted to compare admission index scores with male and female groups. There was a significant difference in mean between the male ($M = 57.79$, $SD = 16.52$) and female ($M = 60.69$, $SD = 15.55$) groups. The results of an independent t test showed that this difference was statistically significant, $t(7013) = -7.512$, $p < .0001$, $d = -.18$. The Levene's test indicated equal variance $F(1,7013) = 10.205$, $p < .0001$. Therefore, the degrees of freedom were adjusted from 7013 to 6442. The assumption of homogeneity has been violated.

Because the assumption of homogeneity has been violated, a Welch's ANOVA t-test was conducted to test the difference between two group means when the group variances and samples sizes are unequal represented in Table 4.8. Welch test is more rigorous tests when variances are not equal. Admission index differed significantly among groups, $F(1,7810) = 78.35$, $= p < .0001$. The results from the Welch's test indicated a significant difference among groups, $F_W(1,7810) = 75.91$, $= p < .0001$. There was a significant difference in mean between the male ($M = .79$, $SD = .410$) and female ($M = .86$, $SD = .345$) groups. The results are represented in Table 4.9.

Table 4. 8

Results of Independent Samples t-tests for Gender and Admission Index

Gender	Female		Male		*t*	*p*	*Cohen's d*
	M	*SD*	*M*	*SD*			
Admission Index	60.69	15.55	57.79	16.52	-7.512	.001	-*.18*

Note: N=7,812. Missing values were not included for analysis.

Table 4. 9

Results of Welch's t-tests for Gender

Gender	Female		Male		*F ratio*	*df*	*η2*
	M	*SD*	*M*	*SD*			
Admission Index	.86	.345	.79	.410	75.91	1	.010

Note: N=7,812. Missing values were not included for analysis.

An independent samples t-test was conducted to compare age with resident and non-resident groups and represented in Table 4.10. There was not a significant difference in mean between the non-resident (*M* = 18.94, *SD* = 2.877) and resident (*M* = 18.97, *SD* = 3.185) groups. The results of an independent t test showed that this difference was not statistically significant, $t(7810) = -.421$, $p = .508$. Cohen's *d* was estimated at -.010, which is a small effect based on Cohen's (1988) guidelines. The Levene's test indicated equal variance $F(1,7810) = .439$, $p = .674$. Therefore, the assumption of homogeneity has not been violated.

Table 4. 10

Results of Independent Samples t-tests for Age and Residency

Residency	Resident		Non-Resident		*t*	*p*	*Cohen's d*
	M	*SD*	*M*	*SD*			
Age	18.97	3.185	18.94	2.877	-.421	.674	-.010

Note: N=7,812. Missing values were not included for analysis.

An independent samples t-test was conducted to compare admission index scores with resident and non-resident groups and represented in Table 4.11. There was a significant difference in mean between the non-resident (*M* = 60.07, *SD* = 14.96) and resident (*M* = 58.81, *SD* = 16.98) groups. The results of an independent t test showed that this difference was statistically significant, $t(7013) = 3.297$, $p < .0001$, $d = -.18$. The Levene's test indicated equal variance $F(1,7013) = 76.23$, $p < .0001$. Therefore, the degrees of freedom were adjusted from 7013 to 6996.

Because the assumption of normality has been violated, a nonparametric test using Welch was conducted to test the difference between two group means when the group variances and samples sizes are unequal. Admission index differed significantly among groups, $F(1,7810) = 142.39$, $= p < .0001$. The results from the Welch's test indicated a significant difference among groups, $F_W (1,7810) = 148 = p < .0001$. There was a significant difference in mean between the non-resident (*M* = .88, *SD* = .322) and resident (*M* = .78, *SD* = .414) groups. The results are represented in Table 4.12.

Table 4. 11

Results of Independent Samples t-tests for Admission Index and Residency

Residency	Resident		Non-Resident		*t*	*p*	*Cohen's d*
	M	*SD*	*M*	*SD*			
Admission Index	60.69	15.55	57.79	16.52	3.297	.001	.078

Note: N=7,812. Missing values were not included for analysis.

Table 4. 12

Results of Welch's t-tests for Residency

Residency	Resident		Non-Resident		*F ratio*	*df*	η^2
	M	*SD*	*M*	*SD*			

Admission Index	.78	.414	.88	.322	148	1	.002

Note: N=7,812. Missing values were not included in the analysis.

Correlation Analysis

Correlation measures the relationship between two continuous variables. Correlations were calculated to determine if there were significant relationships between participation scores, attendance points, and admission index and represented in Table 4.13. The results of the Pearson's Correlation Coefficient test showed that there was a significant positive linear relationship between participation scores and attendance points ($r(4869) = .232$, $p < .001$. The results of the Pearson's Correlation Coefficient test showed that there was a significant positive linear relationship between participation scores and admission index ($r(6459) = .118$, $p < .001$. The results of the Pearson's Correlation Coefficient test showed that there was a significant positive linear relationship between admission index and attendance points ($r(4836) = .048$, $p < .001$. There is enough evidence to suggest that the correlation we observed does exist in the population for Attendance and Participation.

Table 4. 13

Correlations for Study Variables

Variable	Attendance	Participation
1. Attendance	-	.232**
2. Participation	.232**	-

Note: N=7,193. Missing values were not included in the analysis. ** Correlation is significant at the 0.01 level (2-tailed).

Regression Analyses: Multivariate Tests of Relationships Predicting UF 100 Final Grades

Logistic regression was used to investigate what factors impact the outcome. The Enter method model was used to predict UF final grades. Final course grades were transformed and represented as dichotomous variables: NotHighPass(0) and HighPass (1). The independent variable included a vector of student characteristics that could potentially influenced academic performance measured by final grades. The six predictors considered are included: 1) Participation Score, 2) Admission Index, 3) Gender, 4) Residency, 5) SRS, and 6) Student Age.

A series of binary logistic analyses was conducted to test for multiple variables to investigate if one or more of the independent variables were predictive of a certain outcome. The first step was to test one variable with the dependent variable. The next iteration was to add one more independent variable and repeated the process until all predictors were tested. The last series of binary logistic analysis included testing multiple variables simultaneously. In this research, it was important to find and control all relevant variables that could affect the outcome.

The Omnibus Tests of Model Coefficients was conducted to determine whether or not the new model indicates a good fit or an improvement over the base line model (Muijs, 2011). If the significant value is under .05, the model indicates a good model fit.

The first series of logistic regression analysis model included SRS as the only independent variable. Students in the SRS group were more likely to get a high pass in final grades. The Omnibus Tests of Model Coefficients is significant ($p < .001$). Additionally, the [-*2log Likelihood* = 6419.067] and [*Nagelkerke R squared* = .001]. The results are presented in Table 4.14.

Table 4. 14

Results of Logistic Regression Between UF Final Grade and SRS

Predictor	*B*	*SE*	*df*	*p*	e^B	95% CI
Clicker (0 = Non-SRS, 1 = SRS)	.152	.065	1	.019	1.164	[1.025, 1.322]

Constant	1.592	.049	1	.000	4.914	

Note. *p < .05. **p < .01. ***p < .001. N = 7393. R^2 = .001 (Cox & Snell), .001 (Nagelkerke). N= 419 were not included in the analysis.

The second series of logistic regression analysis model included SRS and admission index variables. In this model, students in the SRS group were more likely to get a high pass in final grades. Similarly, students who had higher admission index were more likely to get a high pass in final grades. The Omnibus Tests of Model Coefficients is significant ($p < .001$). Additionally, the [*-2log Likelihood* = 5282.373] and [*Nagelkerke R squared* = .125]. The results are presented in Table 4.15.

Table 4. 15

Results of Logistic Regression Between UF Final Grade and SRS and Admission Index

Predictor	*B*	*SE*	*df*	*p*	e^B	95% CI
Clicker (0 = Non-SRS, 1 = SRS)	.251	.071	1	.000	1.285	[1.118, 1.478]
Admission Index (0 = 0 – 35, 1 = 36-100)	.050	.002	1	.000	1.051	[1.046, 1.056]
Constant	-1.232	.138	1	.000	.292	

Note. *p < .05. **p < .01. ***p < .001. N = 6659. R^2 = .073 (Cox & Snell), .125 (Nagelkerke). N=1153 were not included in the analysis.
.

The third series of logistic regression analysis model included SRS, admission index, and gender. In this model, students in the SRS group were more likely to get a high pass in final grades. Similarly, students who had higher admission index and are female were more likely to get a high pass in final grades. The Omnibus Tests of Model Coefficients is significant ($p <$ .001). Additionally, the [*-2log Likelihood* = 5209.19] and [*Nagelkerke R squared* = .142]. The results are presented in Table 4.16.

Table 4. 16

Results of Logistic Regression Between UF Final Grade and SRS, Admission Index, and Gender

Predictor	*B*	*SE*	*df*	*p*	e^B	95% CI
Clicker (0 = Non-SRS, 1 = SRS)	.262	.072	1	.000	1.299	[1.129, 1.496]
Admission Index (0 = 0 – 35, 1 = 36-100)	.048	.002	1	.000	1.049	[1.044, 1.054]
Gender (0 = Male, 1 = Female)	.606	.071	1	.000	1.883	[1.594, 2.107]
Constant	-1.460	.141	1	.000	2.32	

Note. *p < .05. **p < .01. ***p < .001. N = 6659. R^2 = .083 (Cox & Snell), .142 (Nagelkerke). N=1153 were not included in the analysis.

The fourth series of logistic regression analysis model included SRS, admission index, gender, and residency. In this model, students in the SRS group were more likely to get a high pass in final grades than students in the non SRS group. Similarly, students who had higher admission index and are female were more likely to get a high pass in final grades. Meanwhile, resident students were less likely to get High Pass on their final grades than non-residents. The Omnibus Tests of Model Coefficients is significant ($p < .001$). Additionally, the [*-2log Likelihood* = 5192.31] and [*Nagelkerke R squared* = .146]. The results are presented in Table 4.17.

Table 4. 17

Results of Logistic Regression Between UF Final Grade and SRS, Admission Index, Gender, and Residency

Predictor	*B*	*SE*	*df*	*p*	e^B	95% CI

Clicker (0 = Non-SRS, 1 = SRS)	.262	.072	1	.000	1.300	[1.129, 1.497]
Admission Index (0 = 0 – 35, 1 = 36-100)	.047	.002	1	.000	1.049	[1.044, 1.053]
Gender (0 = Male, 1 = Female)	.610	.071	1	.000	1.840	[1.600, 2.116]
Residency (0 = Non-Resident, 1 = Resident)	-.293	.072	1	.001	.746	[.649, .858]
Constant	-1.274	.148	1	.000	.280	

Note. *p < .05. **p < .01. ***p < .001. N = 6659. R^2 = .085 (Cox & Snell), .146 (Nagelkerke). N=1153 were not included in the analysis.

The fifth series of logistic regression analysis model included SRS, admission index, gender, residency, and student age. In this model, students in the SRS group were more likely to get a high pass in final grades. Similarly, students who had higher admission index and are female were more likely to get a high pass in final grades. Meanwhile, resident students were less likely to get High Pass on their final grades than non-residents. Student age was not a significant predictor in this model. The Omnibus Tests of Model Coefficients is significant ($p <$ .001). Additionally, the [*-2log Likelihood* = 5192.31] and [*Nagelkerke R squared* = .146]. The results are presented in Table 4.18.

Table 4. 18

Results of Logistic Regression Between UF Final Grade and SRS, Admission Index, Gender, Residency, and Age

Predictor	*B*	*SE*	*df*	*p*	e^B	95% CI

Clicker (0 = Non-SRS, 1 = SRS)	.261	.075	1	.000	1.299	[1.121, 1.504]
Admission Index (0 = 0 – 35, 1 = 36-100)	.047	.002	1	.000	1.049	[1.044, 1.053]
Gender (0 = Male, 1 = Female)	.610	.071	1	.000	1.840	[1.600, 2.116]
Residency (0 = Non-Resident, 1 = Resident)	-.293	.072	1	.001	.746	[.649, .858]
StudentAge	.001	.013	1	.961	1.001	[.976, 1.026]
Constant	-1.285	.269	1	.000	.277	

Note. *p < .05. **p < .01. ***p < .001. N = 6659. R^2 = .085 (Cox & Snell), .146 (Nagelkerke). N = 1153 were not included in the analysis.

The last series of logistic regression analysis model included all predictor variables: SRS, admission index, gender, residency, student age, and Z-participation scores. In this model, SRS and student age were not significant predictors in this model. However, students who had higher admission index and are female were more likely to get a high pass in final grades. Meanwhile, resident students were less likely to get High Pass on their final grades than non-residents. Student age was not a significant predictor in this model. Students who had higher participation scores from the SRS group were likely to get High Pass in final grades. The Omnibus Tests of Model Coefficients is significant (p < .001). Additionally, the [*-2log Likelihood* = 5192.31] and [*Nagelkerke R squared* = .146]. The results are presented in Table 4.19.

Table 4. 19

Results of Logistic Regression Between UF Final Grade and SRS, Admission Index, Gender, Residency, Participation, and Age

Predictor	*B*	*SE*	*df*	*p*	e^B	95% CI
Clicker (0 = Non-SRS, 1 = SRS)	.121	.086	1	.160	1.129	[.953, 1.336]
Admission Index (0 = 0 – 35, 1 = 36-100)	.048	.003	1	.000	1.049	[1.044, 1.053]
Gender (0 = Male, 1 = Female)	.578	.075	1	.000	1.783	[1.539, 2.066]
Residency (0 = Non-Resident, 1 = Resident)	-.268	.075	1	.000	.765	[.660, .886]
StudentAge	.016	.014	1	.247	1.016	[.989, 1.044]
Zscore(Part)	.250	.048	1	.000	1.284	[1.170, 1.410]
Constant	-1.477	.286	1	.000	.228	

Note. *p < .05. **p < .01. ***p < .001. N = 6659. R^2 = .085 (Cox & Snell), .146 (Nagelkerke). N=1153 were not included in the analysis.

Assumption of Multicollinearity

The assumption of collinearity indicated that multicollinearity was not a concern (*Gender, Tolerance = .986, VIF = 1.015, Participation, Tolerance = .990, VIF = 1.011, Residency, Tolerance = .981, VIF = 1.019, Admission Index, Tolerance = .971, VIF = 1.030, Student Age, Tolerance = .993, VIF = 1.007).* According to Hair et al. (2010), a tolerance value should be high and a variance inflation factor (VIF) of 1.00 indicates lack of multicollinearity. Menard (1995) suggested “a tolerance of less than .20 is a cause for concern; a tolerance of less than .10 almost certainly indicates a serious collinearity problem” (p. 66). All results were above the collinearity tolerance between .10 and .20.

CHAPTER V: Conclusions

The purpose of this study was to expand current research and perform quantitative analysis on SRS use considering relevant measures of the factors including participation and attendance whether they have significant impact on learner's performance based on final course grades, controlling for age, gender, state residency, and admission index. This chapter includes a discussion on research findings as related to the literature on SRS and what implications may be valuable for use by higher education administrators, faculty, instructional technologists. This chapter concludes with a discussion of the limitations of the study, areas for future research, and implications for higher education administrators and faculty.

Discussion of Research Findings

This chapter contains discussion of research findings and future research opportunities to help answer the research questions:

(R1): To what extent there is a difference in student academic performance between experimental and control groups in UF 100 classes? (e.g., final course grades, attendance, and participation)?

This study began by exploring how vector of student characteristics may affect students' academic performance. Correlations indicated students who had higher participation scores also had higher attendance scores and a positive relationship indicated between attendance and admission index.

The slope for the z-scored participation is .250 and is significant at $p < .001$. Since participation scores were standardized, this suggests the slope can be interpreted as the predicted changed in logits for one standard deviation unit increase on the predictor by a factor of 1.284. According to the regression results, students who were in the experimental group with 1 z- score unit increase in student's participation score would boost their final course grades by 1.29 % on average, controlling for the influence of other variables constant.

(R2): To what extent there is a difference in SRS use by student demographics in UF 100 classes?

The first series of logistic analysis had a single predictor and the regression slope is positive. This indicated that students from the SRS group were more likely to get a High Pass between 3.0 to 4. 0 in final grades than students who were in the non-SRS group. The odds of students in the SRS group having a final grade between 3.0 to 4.0 was predicted to be more than one times greater than the odds of non-SRS students getting between 3.0 to 4.0 final grades in UF 100. The odds ratio indicates that every one unit increased in the predictor, the odds of students from the SRS group getting a final grade between 3.0 to 4.0 increased by a factor of 1.164.

Based on the Likelihood Ratio (LR) Chi-square test, the full model represents a significant improvement in fit relative to the null model, LR $\chi^2(1) = 5.482$, $p = .012$. In this case, Model 1 is statistically significant because the p-value is less .005.

Next, the study looked at the second series of logistic regression model and how SRS affected admission index. The regression slope for SRS is positive and statistically significant (b

= .251, $p < .001$), indicating the probability of students getting a final grade between 3.0 to 4.0 was higher for those in the SRS group controlling for admission index. The odds ratio for this predictor indicates that the odds of students getting a final grade between 3.0 to 4.0 changed by a factor of 1.285.

The regression slope for admission index is also positive and statistically significant (b = .050, $p < .001$), indicating the probability of students who had higher admission index were more likely to get a final grade between 3.0 to 4.0. The odds ratio indicates that every one unit increased in the predictor, the odds of student who had higher admission index were more likely to get a final grade between 3.0 to 4.0 changed by a factor of 1.051.

Based on the Likelihood Ratio (LR) Chi-square test, the full model represents a significant improvement in fit relative to the null model, LR $\chi^2(1) = 501.530$, $p < .001$. In this case, Model 2 is statistically significant because the p-value is less .005.

The study looked at the third series of logistic regression model where three predictors were added: SRS, admission index, and gender. The regression slope for SRS is positive and statistically significant (b = .262, $p < .001$), indicating the probability of students getting a final grade between 3.0 to 4.0 was higher for those in the SRS group controlling for admission index and gender. The odds ratio for this predictor indicates that the odds of students getting a final grade between 3.0 to 4.0 changed by a factor of 1.299.

The regression slope for admission index is also positive and statistically significant (b = .048, $p < .001$), indicating the probability of students who had higher admission index were more likely to get a final grade between 3.0 to 4.0 and controlling for SRS and gender. The odds ratio indicates that every one unit increased in the predictor, the odds of student who had higher admission index were more likely to get a final grade between 3.0 to 4.0 changed by a factor of 1.049.

The regression slope for gender is positive and statistically significant (b = .606, $p < .001$), indicating the probability of female getting a final grade between 3.0 to 4.0 was higher than male, controlling for SRS and admission index . The odds ratio for this predictor indicates that the odds of female students getting a final grade between 3.0 to 4.0 changed by a factor of 1.833. Gender is the highest predictor in this model.

Based on the Likelihood Ratio (LR) Chi-square test, the full model represents a significant improvement in fit relative to the null model, LR $\chi^2(1) = 574.712$, $p < .001$. In this case, Model 3 is statistically significant because the p-value is less .005.

The study looked at the fourth series of logistic regression model where four predictors were added: SRS, admission index, gender, and residency. The regression slope for SRS is positive and statistically significant (b = .262, $p < .001$), indicating the probability of students getting a final grade between 3.0 to 4.0 was higher for those in the SRS group controlling for admission index, gender, and residency. The odds ratio for this predictor indicates that the odds of students getting a final grade between 3.0 to 4.0 changed by a factor of 1.300.

The regression slope for admission index is also positive and statistically significant (b = .047, $p < .001$), indicating the probability of students who had higher admission index were more likely to get a final grade between 3.0 to 4.0 and controlling for SRS, gender, and residency. The odds ratio indicates that every one unit increased in the predictor, the odds of student who had higher admission index were more likely to get a final grade between 3.0 to 4.0 changed by a factor of 1.049.

The regression slope for gender is positive and statistically significant (b = .610, $p < .001$), indicating the probability of female getting a final grade between 3.0 to 4.0 was higher than male, controlling for SRS, admission index, and residency. The odds ratio for this predictor indicates that the odds of female students getting a final grade between 3.0 to 4.0 changed by a factor of 1.840. Gender is the highest predictor in this model.

The regression slope for residency is negative and statistically significant (b = -.293, $p < .001$), indicating the probability of resident students were less likely to get a final grade between

3.0 to 4.0 in UF 100 than non-residents controlling for SRS, admission index, and gender. The odds ratio is .746, which means that the odds of getting high pass grade is .746 times for non-residents.

Based on the Likelihood Ratio (LR) Chi-square test, the full model represents a significant improvement in fit relative to the null model, LR $\chi^2(1) = 591.590$, $p < .001$. In this case, Model 4 is statistically significant because the p-value is less .005.

The study looked at the fifth series of logistic regression model where all predictors were included: SRS, admission index, gender, residency, age, and participation score. The regression slope for SRS is negative and is not statistically significant (b = .121, $p = .160$), controlling for admission index, gender, residency, age, and participation scores.

The regression slope for admission index is also positive and statistically significant (b = .048, $p < .001$), indicating the probability of students who had higher admission index were more likely to get a final grade between 3.0 to 4.0 and controlling for SRS, gender, residency, age, and participation score. The odds ratio indicates that every one unit increased in the predictor, the odds of student who had higher admission index were more likely to get a final grade between 3.0 to 4.0 changed by a factor of 1.049.

The regression slope for gender is positive and statistically significant (b = .578, $p < .001$), indicating the probability of female getting a final grade between 3.0 to 4.0 was higher than male, controlling for SRS, admission index, residency, age, and participation score. The odds ratio for this predictor indicates that the odds of female students getting a final grade between 3.0 to 4.0 changed by a factor of 1.783. Gender is the highest predictor in this model.

The regression slope for residency is negative and statistically significant (b = -.268, $p <$ .001), indicating the probability of resident students were less likely to get a final grade between 3.0 to 4.0 in UF 100 than non-residents controlling for SRS, admission index, gender, age, and participation score. The odds ratio is .765, which means that the odds of getting high pass grade is .756 times for non-residents.

The regression slope for age is positive but it is not statistically significant (b = .001; $p <$ .961) controlling for SRS, admission index, gender, residency, and participation score.

Based on the Likelihood Ratio (LR) Chi-square test, the full model represents a significant improvement in fit relative to the null model, LR $\chi^2(1) = 591.592$, $p < .001$. In this case, Model 5 is statistically significant because the p-value is less .005.

The study looked at the sixth series of logistic regression model where all predictors were included: SRS, admission index, gender, residency, age, and participation score. The regression slope for SRS is negative and is not statistically significant (b = .121, $p = .160$), controlling for admission index, gender, residency, age, and participation scores.

The regression slope for admission index is also positive and statistically significant (b = .048, $p < .001$), indicating the probability of students who had higher admission index were more likely to get a final grade between 3.0 to 4.0 and controlling for SRS, gender, residency, age, and participation score. The odds ratio indicates that every one unit increased in the predictor, the odds of student who had higher admission index were more likely to get a final grade between 3.0 to 4.0 changed by a factor of 1.049.

The regression slope for gender is positive and statistically significant (b = .578, $p <$ .001), indicating the probability of female getting a final grade between 3.0 to 4.0 was higher than male, controlling for SRS, admission index, residency, age, and participation score. The odds ratio for this predictor indicates that the odds of female students getting a final grade between 3.0 to 4.0 changed by a factor of 1.783. Gender is the highest predictor in this model.

The regression slope for residency is negative and statistically significant (b = -.268, $p <$ .001), indicating the probability of resident students were less likely to get a final grade between 3.0 to 4.0 in UF 100 than non-residents controlling for SRS, admission index, gender, age, and participation score. The odds ratio is .765, which means that the odds of getting high pass grade is .756 times for non-residents.

The regression slope for age is positive but it is not statistically significant (b = .001; $p <$ .961) controlling for SRS, admission index, gender, residency, and participation score.

The slope for the z-scored participation is .250 and is significant at $p < .001$. Since participation scores were standardized, this suggests the slope can be interpreted as the predicted changed in logits for one standard deviation unit increase on the predictor by a factor of 1.284. According to the regression results, students who were in the experimental group with 1 z- score unit increase in student's participation score would boost their final course grades by 1.3 % on average, controlling for the influence of other variables constant.

The results revealed a mix of vector of student characteristics and final grades were significant. The model resulted in independent variables (SRS and age) not significant (p > 0.05). The estimated odds ratio favored an increase by 1.3 times greater for those students who were in the experimental group than their peers in the control group.

Based on the Likelihood Ratio (LR) Chi-square test, the full model represents a significant improvement in fit relative to the null model, LR $\chi^2(1) = 591.711$, $p < .001$. In this case, Model 6 is statistically significant because the p-value is less .005.

Limitations

This section discusses the limitations and possible bias for this research. The researcher chose to conduct this study where she is employed, for it is practical, convenient, and accessible. Due to the nature of the study, the design did not use random-assignment of students in constructing experimental and control groups. The entire classes of students were assigned to groups when they enrolled in their respective courses. However, the design is subject to selection bias because of the lack of randomization of group assignments (Flannelly et al., 2018). As a result, the experimental and control groups may be different prior to the study. Any prior differences of the nonequivalent groups may affect the outcome and could jeopardize internal validity (Campbell & Stanley, 1966).

The lack of randomization is a major limitation and possible factor affecting internal validity of this study. There will be uncertainty when controlling for relevant differences between the experimental and the control groups and an inability to control for confounding variables. According to Campbell and Stanley (1966), it should be recognized that nonequivalent control group reduces greatly the equivocality of interpretation in one-group design. They suggested the more this similarity is confirmed by the scores on the pretest, the more effective this control becomes. This will increase the internal validity of the study because it will eliminate some of the most important confounding variables. However, in this research, pretests were not administered as the researcher collected primary data and gathered minimal materials from the students and faculty.

With a large sample size of 7,812 for this study, the population is broadly defined as students who were enrolled in UF classes between spring 2017 to fall 2019. Furthermore, the results might be generalizable only to this Institution; Because according to Watson and Stock

(2018), “even the if the population being studied and the population of interest are identical, it might not be possible to generalize the study results if the setting differs” (p. 363). Moreover, instructor quality can be a major factor affecting students’ achievements and performance in the classroom. While the homogeneity of a sample is useful for assessing the experimental effects of independent variables on a dependent variable, it reduces the external validity of the study (Campbell, 1957; Flannelly, et al., 2018).

The shortcoming of this research is a failure to capture the contextual experiences of instructors and students. The researcher did not send out survey instrumentation. Because the researcher has access to the primary data, the researcher gathered minimum materials from the students and instructors, focusing more on attendance, performance, and participation scores that are available from the iClicker Cloud and Blackboard Learning Management System gradebooks.

Conclusion

As more higher education institutions integrate SRS into their learning systems and teaching practices to improve student learning process, it is very important to put an in-depth understanding of the techniques behind the effects of student response system on learning performance. While there is a plethora of literature about the student response system, several gaps still exist in fully understanding the effects of student response system.

In this study, the primary objective was to expand research and perform quantitative analysis on SRS use considering relevant measures of the factors including participation and attendance whether they have significant impact on learning performance based on final course grades controlling for other factors such as age, gender, state residency, admission index, and participation.

An in-depth analysis of the data using statistical techniques for data analysis was employed to better understand the effects of student response system and its association with learning performance. Model 1 found a positive association between SRS use and final grades. Model 2 also found a positive association between SRS, admission index, and final grades. Model 3 found a positive association between SRS, admission index, gender, and final grades. Model 4 found a positive association between SRS, admission index, gender, and final grades; a negative association but statistically significant between residency and final grades, favoring non-residents. Model 5 found a positive association similar to Model 4 except student age was not significant. Model 6 found no association with SRS and age, a negative association with residency but positive association with admission index, gender, and participation.

The results from the regression analyses indicate this study found some evidence to suggest the use of SRS in a large, college level UF class contributed to student academic performance measured by final grades. It appears that SRS use supports generative learning because when students answer questions, they are encouraged to select relevant information, mentally organizing the material, and integrate it with their prior knowledge (Mayer, et al., 2009), thereby, improving academic performance measured by final grades. The findings of this study are consistent with the previous research about gender differences using SRS where women performed better (Kang et al., 2012; Niemeyer and Zewail-Foote, 2018). Furthermore, the study findings are consistent with previous research (Blasco-Arcas et al., 2013; Bojinova & Oigara, 2013; Powell, et al., 2011) in terms of class participation and student academic learning. It is important to highlight that SRS itself may not exclusively be the reason why student academic performance was improved. SRS is just one of the many instructional tools that can be used in the classrooms that can enhance and improve teaching practices and student learning.

Future research should examine the effects of student response system on student learning by including other student characteristics like UF course themes or topics, study major, midterm exam, final exam, freshman, sophomore, junior, and senior, and capture the live experiences of faculty members. This would increase the ability to generalize the model at this university and other universities.

Future research should consider student participation with student response system asynchronously. This would allow students to measure their understanding of the homework and collectively work on the same questions while receiving immediate feedback and evaluate team members, by employing team-based learning. This will also allow students to work through at their own pace and provide lightweight student assessment.

Implications for Higher Education Administrators and Faculty

In this university, student response system is often used in large enrollment classes to engage students, allowing faculty to gage students' knowledge and providing opportunity to give immediate feedback to students in real time. The researcher aimed to improve instructional strategy and practice in the university while making decisions on how the student response system is implemented, used, and deployed successfully and informing purchasing decisions.

Implications for higher education administrators and faculty include (1) making pedagogical decisions on SRS use [Note: while SRS was shown to be a significant predictor of the UF final grades in some of the simpler models, this relationship did not hold when other factors were included]; (2) facilitating student interaction and engagement in large enrollment classes using different instructional strategies and tools; (3) encouraging active learning and participation among students; and (4) promoting formative assessment versus summative and group participation versus individual participation.

As learners become diverse, administrators and faculty must adapt to different types of learning needs. Similarly, as technology evolves, administrators and faculty need to continue to find ways to be innovative in their teaching and learning strategies. This research has contributed to the body of SRS literature on evidence-based teaching and the incorporation of SRS in large enrollment classrooms.

References

Addison, S., Wright, A., & Milner, R. (2009). Using clickers to improve student engagement and performance in an introductory biochemistry class. *Biochemistry and Molecular Biology Education*,*37*(2), 84–91. https://doi.org/10.1002/bmb.

Ah Yun, K., & Lojo, M. (2010). The effect of clickers on student learning. *Academic Exchange Quarterly*, 7-12.

Allen, M. (1997). *Understanding regression analysis*. Plenum Press.

American Association of University Women [AAUW]. (2000). Educational Foundation. Commission on Technology, Gender, and Teacher Education. *Tech-savvy: Educating girls in the new computer age*. American Association of University Women Educational Foundation.

Anthis, K. (2011). Is it the clicker, or is it the question? Untangling the effects of student response system use. *Teaching of Psychology, 38*(3), 189-193. https://doi.org/10.1177/0098628311411895

Armbruster, P., Patel, M., Johnson, E., & Weiss, M. (2009). Active learning and student-centered pedagogy improve student attitudes and performance in introductory biology. *Cell Biology Education Life Sciences Education*, *8*(3), 203–213. https://doi.org/10.1187/cbe.09-03-0025

Astin, A. W. (1999). Student involvement: A developmental theory for higher education. *Journal of College Student Personnel*, *25*(3), 297-308.

Baraldi, A. N., & Enders, C. K. (2010). An introduction to modern missing data analyses. *Journal of School of Psychology, 48*(1), 5-37. https://doi.org/10.1016/j.jsp.2009.10.001

Baumann, Z. D., Marchetti, K., & Soltoff, B. (2015). What's the payoff?: Assessing the efficacy of student response systems. *Journal of Political Science Education, 11*(3), 249-263. https://doi.org/10.1080/15512169.2015.1047104

Beatty, I. (2004). Transforming student learning with classroom communication systems. *Educause Center for Applied Research Bulletin, ERB0403*(3).

Beatty, I. D., Gerace, W. J., Leonard, W. J., & Dufresne, R. J. (2006). Designing effective questions for classroom response system teaching. *American Journal of Physics, 74*(1). https://doi.org/10.1119/1.2121753

Bellur, S., Nowak, K. L., & Hull, K. S. (2015). Make it our time: In class multitaskers have lower academic performance. *Computers in Human Behavior, 53,* 63-70. https://doi.org/10.1016/j.chb.2015.06.027

Bidin, S., & Ziden, A. A. (2013). Adoption and application of mobile learning in the education industry. *Procedia - Social and Behavioral Sciences, 90,* 720-729. https://doi.org/10.1016/j.sbspro.2013.07.145

Blasco-Arcas, L., Buil, I., Hernández-Ortega, B., & Sese, F. J. (2013). Using clickers in class. The role of interactivity, active collaborative learning and engagement in learning performance. *Computers & Education, 62,* 102-110. https://doi.org/10.1016/j.compedu.2012.10.019

Biesta, G. (2007). Why "what works" won't work: Evidence-based practice and the democratic deficit in educational research. *Educational Theory, 57,* 1–22. https://doi.org/10.1111/j.1741-5446.2006.00241.x

Bojinova, E., & Oigara, J. (2013). Teaching and learning with clickers in higher education. *International Journal of Teaching and Learning in Higher Education, 25*(2), 154-165.

Bonwell, C. C., & Eison, J. A. (1991).*Active learning: Creating excitement in the classroom*(Ser. Ashe-eric higher education report, 1, 1991). School of Education and Human Development, George Washington University.

Boscardin, C., & Penuel, W. (2012). Exploring benefits of audience-response systems on learning: A review of the literature. *Academic Psychiatry: The Journal of the American Association of Directors of Psychiatric Residency Training and the Association for Academic Psychiatry, 36*(5), 401-407. http://doi.org/10.1176/appi.ap.10080110

Brady, M., Seli, H., & Rosenthal, J. (2013). “Clickers” and metacognition: A quasi-experimental comparative study about metacognitive self-regulation and use of electronic feedback devices. *Computers & Education, 65*, 56-63. https://doi.org/10.1016/j.compedu.2013.02.001

Bruff, D. (2009). *Teaching with classroom response systems: Creating active learning environments*. Jossey-Bass.

Burd, E., & Hodgson, B. (2006). Attendance and attainment: A five year study. *Innovation in Teaching and Learning in Information and Computer Sciences, 5*(2). https://doi.org/10.11120/ital.2006.05020004

Burnham, N., Kadam, S., & DeSilva, E. (2017). In-class use of clickers and clicker tests improve learning and enable instant feedback and retests via automated grading. *Physics Education*, *52*(6). https//doi.org/10.1088/1361-6552/aa8833

Bumstein, R. A., & Lederman, L. M. (2001). Using wireless keypads in lecture classes. *The Physics Teacher, 39*(1), 8-11. https://doi.org/10.1119/1.1343420

Caldwell, J. E. (2007). Clickers in the large classroom: current research and best-practice tips. *Cell Biology Education Life Sciences Education*, *6*(1), 9-20. http://doi.org/10.1187/cbe.06-12-0205

Camacho-Miñano, M., & Del Campo, C. (2016). Useful interactive teaching tool for learning: Clickers in higher education. *Interactive Learning Environments, 24*(4), 706-723. https://doi.org/10.1080/10494820.2014.917108

Campbell, D. T. (1957). Factors relevant to the validity of experiments in social settings. *Psychological Bulletin, 54*(4), 297–312. https://doi.org/10.1037/h0040950

Campbell, J., & Mayer, R. (2009). Questioning as an instructional method: Does it affect learning from lectures? *Applied Cognitive Psychology, 23*(6), 747-759. http://doi.org/10.1002/acp.1513

Campbell, D. T., & Stanley, J. C. (1966). *Experimental and quasi-experimental designs for research.* Rand McNally & Company.

Carnaghan, C., & Webb, A. (2007). Investigating the effects of group response systems on student satisfaction, learning, and engagement in accounting education. *Issues in Accounting Education, 22*(3), 391-409. https://doi.org/10.2308/iace.2007.22.3.391

Carnaghan, C., Edmonds, T., Lechner, T., & Olds, P. (2011). Using student response systems in the accounting classroom: Strengths, strategies and limitations. *Journal of Accounting Education, 29*(4), 265-283. http://doi.org/10.1016/j.jaccedu.2012.05.002

Carnegie Classification of Institutions of Higher Education. (2019). http://carnegieclassifications.iu.edu/

Chaudhury, R. (2011). The lecture. *New Directions for Teaching and Learning*, *2011*(128), 13-20. https://doi.org/10.1002/tl.464

Cheng, P.-H., Yang, Y.-T. C., Chang, S.-H. G., & Kuo, F.-R. R. (2016). 5E Mobile inquiry learning approach for enhancing learning motivation and scientific inquiry ability of university students. *Institute of Electrical and Electronics Engineers Transactions on Education*, *59*(2), 147-153. http://doi.or/10.1109/TE.2015.2467352.

Cheon, J., Lee, S., Crooks, S. M., & Song, J. (2012). An investigation of mobile learning readiness in higher education based on the theory of planned behavior. *Computers & Education, 59*(3), 1054-1064. https://psycnet.apa.org/doi/10.1016/j.compedu.2012.04.015

Chien, Y.-T., Chang, Y.-H., & Chang, C.-Y. (2016). Do we click in the right way? A meta-analytic review of clicker-integrated instruction. *Educational Research Review, 17,* 1-18. https://doi.org/10.1016/j.edurev.2015.10.003

Christopherson, K. M. (2011). Hardware or wetware: What are the possible interactions of pedagogy and technology in the classroom?. *Teaching of Psychology, 38*(4), 288-292. https:/doi.org/10.1177/0098628311421332

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates, Publishers.

Colby, J. (2005). Attendance and attainment - a comparative study. *Innovation in Teaching and Learning in Information and Computer Sciences, 4*(2). 1-13. https://doi.org/10.11120/ital.2005.04020002

Connor, E. (2009). Perceptions and uses of clicker technology. *Journal of Electronic Resources in Medical Libraries*, *6*(1), 19-32. https://doi.org/10.1080/15424060802705145

Cooper, K. M., Downing, V. R., & Brownell, S. E. (2018). The influence of active learning practices on student anxiety in large-enrollment college science classrooms. *International Journal of Stem Education*, *5*(1), 1–18. https://doi.org/10.1186/s40594-018-0123-6

Crede, M., Roch, S. G., & Kieszczynka, U. M. (2010). Class attendance in college: A meta-analytic review of the relationship of class attendance with grades and student characteristics. *Review of Educational Research, 80*(2), 272-295. http://doi.org/10.3102/0034654310362998

Crossgrove, K., & Curran, K. L. (2008). Using clickers in nonmajors- and majors-level biology courses: Student opinion, learning, and long-term retention of course material. *Cell Biology Education Life Sciences Education, 7*(1), 146–154. https://doi.org/10.1187/cbe.07-08-0060

Crowson, H. M. (2020). Binary logistic regression: A much ‘deeper dive’ into understanding and interpreting your SPSS results [Powerpoint slides] https://drive.google.com/open?id=1JP4oSflFxf0ZhIWC6Brthv_V5HMOQhE1]

Cuseo, J. (2007).The empirical case against large class size: Adverse effects on the teaching, learning, and retention of first-year students. *Journal of Faculty Development, 21*(1),5-21.

Dahlstrom, E., Dziuban, C., & Walker, J. D. (2012). *Educause Center for Applied Research Study of Undergraduate Students and Information Technology, 2012* (Research Report). Educause Center for Applied Research, September 2012, available from http://www.educause.edu/ecar

Dallaire, D. (2011). Effective use of personal response "clicker" systems in psychology courses. *Teaching of Psychology*, *38*(3), 199-204. https://psycnet.apa.org/doi/10.1177/0098628311411898

Dallimore, E. J., Hertenstein, J. H., & Platt, M. B. (2010). Class participation in accounting courses: Factors that affect comfort and learning. *Issues in Accounting Education, 25*, 613-629. https://doi.org/10.2308/iace.2010.25.4.613

Dean, T., Lee-Post, A., & Hapke, H. (2017). Universal design for learning in teaching large lecture classes. *Journal of Marketing Education*, *39*(1), 5–16 https://doi.org/10.1177%2F0273475316662104

DeBourgh, G. A. (2008). Use of classroom "clickers" to promote acquisition of advanced reasoning skills. *Nurse Education in Practice*, *8*(2), 76–87. https://doi.org/10.1016/j.nepr.2007.02.002

Dietz, S., & Henrich, C. (2014). Texting as a distraction to learning in college students. *Computers in Human Behavior*, *36,* 163-167. https://psycnet.apa.org/doi/10.1016/j.chb.2014.03.045

Domingo, M. G., & Garganté, A. B. (2016). Exploring the use of educational technology in primary education: Teachers' perception of mobile technology learning impacts and applications' use in the classroom. *Computers in Human Behavior, 56,* 21-28. https://doi.org/10.1016/j.chb.2015.11.023

Dong, Y., & Peng, C. J. (2013). Principled missing data methods for researchers. *SpringerPlus (2)*222, 1-17. https://doi.org/10.1186/2193-1801-2-222

Durden, G., & Ellis, L. (1995). The effects of attendance on student learning in principles of economics. *The American Economic Review, 85*(2), 343-346.

Elicker, J., & McConnell, N. (2011). Interactive learning in the classroom: Is student response method related to performance? *Teaching of Psychology, 38*(3), 147-150. https://doi.org/10.1177%2F0098628311411789

El-Rady, J. (2006). To click or not to click: That's the question. *Innovate: Journal of Online Education*, *2*(4). https://www.learntechlib.org/p/104268/.

Evans, H. (2012). Making politics "click": The costs and benefits of using clickers in an introductory political science course. *Journal of Political Science Education, 8*(1), 85-93. http://doi.org/10.1080/15512169.2012.641427

Exeter, D. J., Ameratunga, S., Ratima, M., Morton, S., Dickson, M., Hsu, D., & Jackson, R. (2010). Student engagement in very large classes: The teachers' perspective. *Studies in Higher Education, 35*, 761-775. https://doi.org/10.1080/03075070903545058

Fallon, M., & Forrest, S. L. (2011). High-tech versus low-tech instructional strategies: A comparison of clickers and handheld response cards. *Teaching of Psychology,38*(3), 194–198. https://doi.org/10.1177/0098628311411896

Falloon, G. (2015). What's the difference? Learning collaboratively using iPads in conventional classrooms. *Computers & Education, 84,* 62-77. https://doi.org/10.1016/j.compedu.2015.01.010

Fan, H., & Song, X. (2020). The advantages of combining mobile technology and audience response systems. *Journal of Accounting Education, 50*. https://doi.org/10.1016/j.jaccedu.2020.100657

Felce, A. (2007). A critical analysis of the use of electronic voting systems: Ask the audience. *Emirates Journal for Engineering Research, 12*, 11–26.

Fies, C., & Marshall, J. (2006). Classroom response systems: A review of the literature. *Journal of Science Education and Technology*, *15*(1), 101–109. https://doi.org/10.1007/s10956-006-0360-1

FitzPatrick, K. A., Finn, K. E., & Campisi, J. (2011). Effect of personal response systems on student perception and academic performance in courses in a health sciences curriculum. *American Journal of Physiology - Advances in Physiology Education*, *35*(3), 280–289. https://doi.org/10.1152/advan.00036.2011

Flannelly, K. J., Flannelly, L. T., & Jankowski, K. R. B. (2018). Threats to the internal validity of experimental and quasi-experimental research in healthcare, *Journal of Health Care Chaplaincy*, *24*(3), 107-130. http://doi.org/10.1080/08854726.2017.1421019

Flosason, T. O., McGee, H. M., & Diener-Ludwig, L. (2015). Evaluating impact of small-group discussion on learning utilizing a classroom response system. *Journal of Behavioral Education*,*24*(3), 317–337. https://doi.org/10.1007/s10864-015-9225-0

Frick, H., Birt, J., & Waters, J. (2020). Enhancing student engagement in large management accounting lectures. *Accounting & Finance*,*60*(1), 271–298. https://doi.org/10.1111/acfi.12318

Fortner-Wood, C., Armistead, L., Marchand, A., & Morris, F. (2013). The effects of student response systems on student learning and attitudes in undergraduate psychology courses. *Teaching of Psychology*, *40*(1), 26-30. https://doi.org/10.1177/0098628312465860

Gall, M., Gall, J., & Borg, W. (2007).*Educational research: An introduction* (8th ed.). Pearson/Allyn & Bacon.

Gallini, S. M., & Moely, B. E. (2003). *Service-Learning and Engagement, Academic Challenge, and Retention*. Ann Arbor, MI: Michigan Publishing, University of Michigan Library. http://hdl.handle.net/2027/spo.3239521.0010.101

Garatti, M. (2013). Clickers and the teaching-assessment of culture in the beginning-level Italian classroom. *Italica*,*90*(1), 72–94.

Gauci, S. A., Dantas, A. M., Williams, D. A., & Kemm, R. E. (2009). Promoting student-centered active learning in lectures with a personal response system. *Advances in Physiology Education*,*33*(1), 60–71. https://doi.org/10.1152/advan.00109.2007

Gibbons, R. E., Laga, E. E., Leon, J., Villafañe, S. M., Stains, M.; Murphy, K., & Raker, J. R. (2017). Chasm crossed? Clicker use in postsecondary chemistry education. *Journal of Chemical Education, 94*, 549−557. https://doi.org/10.1021/acs.jchemed.6b00799

Gok, T. (2011). An evaluation of student response systems from the viewpoint of instructors and students. *Turkish Online Journal of Educational Technology - Tojet*, *10*(4), 67–83.

Green, A., & Repetti, T. (2015). Clickers: A strategy for active learning in a hospitality classroom. *Journal of Hospitality and Tourism Education*, *27*(4), 171-179. http://doi.org/10.1080/10963758.2015.1089513

Greenspan, V. C. (2010). Idaho Nurses Association (INA) Delegates serving at the American Nurses Association House of Delegates. *Registered Nurses Idaho, 33*(2), 5-6.

Guardia, J. J., Del, O. J. L., Roa, I., & Berlanga, V. (2019). Innovation in the teaching-learning process: The case of Kahoot! *On the Horizon, 27*(1), 35–45. https://doi.org/10.1108/OTH-11-2018-0035

Guarino, J., Chyung, S-Y., Adams, C., DeLeon, R., Scheepers, M., Castellon, F., Wiedenfeld, M.G., & Williams, P. (2011). Creating and implementing cloud-based simulations to enhance a multivariable calculus course. *118th ASEE Annual Conference and Exposition, June 26-29, 2011, Vancouver, BC, Canada*.

Guthrie, R. W. & Carlin, A. (2004). Waking the dead: Using interactive technology to engage passive listeners in the classroom. *Proceedings of the Tenth Americas Conference on Information Systems, Association for Information Systems,* 1-8.

Hair, J. F. Jr., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate data analysis* (7th ed.). Prentice Hall.

Hake, R. R. (1998). Interactive engagement versus traditional methods: A six-thousand student survey of mechanics test data for introductory physics courses. *American Journal of Physics, 66*(1), 64-74. http://dx.doi.org/10.1119/1.18809

Han, J., & Finkelstein, A. (2013). Understanding the effects of professors' pedagogical development with clicker assessment and feedback technologies and the impact on students' engagement and learning in higher education. *Computers & Education*, *65*, 64-76. http://doi.org/10.1016/j.compedu.2013.02.002

Harlow, J., Kushnir, L. P., Bank, C., Browning, S., Clarke, J., Cordon, A., & Serbanescu, R. (2009). What's all the clicking about? A study of classroom response system use at the University of Toronto. *Collected Essays on Learning and Teaching*, *2*, 114–121.

Hatch, J., Jensen, M., & Moore, R. (2005). Manna from heaven or "clickers" from hell: Experiences with an electronic response system. *Journal of College Science Teaching, 34*(7), 36-39.

Heaslip, G., Donovan, P., & Cullen, J. (2014). Student response systems and learner engagement in large classes. *Active Learning in Higher Education*, *15*(1), 11-24. https://doi.org/10.1177%2F1469787413514648

Heflin, H., Shewmaker, J., & Nguyen, J. (2017). Impact of mobile technology on student attitudes, engagement, and learning. *Computers & Education*, *107*, 91-99. https://doi.org/10.1016/j.compedu.2017.01.006

Hilao, M. P., & Wichadee, S. (2017). Gender differences in mobile phone usage for language learning, attitude, and performance. *The Turkish Online Journal of Distance Education, 18*(2), 68–79. https://doi.org/10.17718/tojde.306558

Hoaglin, D., Iglewicz, B., & Tukey, J. (1986). Performance of some resistant rules for outlier labeling. *Journal of the American Statistical Association*, *81*(396), 991-999. https://doi:10.2307/2289073

Hodges, L., Anderson, E., Carpenter, T., Cui, L., Feeser, E., & Gierasch, T. (2017). Using clickers for deliberate practice in five large science courses. *Journal of College Science Teaching, 47*(2), 22-28.

Hoekstra, A., & Mollborn, S. (2012). How clicker use facilitates existing pedagogical practices in higher education: Data from interdisciplinary research on student response systems. *Learning, Media and Technology, 37*(3), 303-320. https://doi.org/10.1080/17439884.2011.568493

Hsu, Y.-C., & Ching, Y.-H. (2013). Mobile computer-supported collaborative learning: A review of experimental research. *British Journal of Educational Technology, 44*(5), E111-E114. https://doi.org/10.1111/bjet.12002

Hsu, Y.-C., Ching, Y.-H., & Snelson, C. (2014). Research priorities in mobile learning: An international Delphi study. *Canadian Journal of Learning and Technology*, *40*(2), 1-22.

Jandu, N. (2018). Clicker student response systems: Dedicated physical devices or web-enabled systems that allow student to bring their own device (BYOD).*Journal of Microbiology & Biology Education*, *19*(1), 62. https://doi.org/10.1128/jmbe.v19i1.1467

Jeng, Y.-L., Wu, T.-T., Huang, Y.-M., Tan, Q., & Yang, S. J. H. (2010). The add-on impact of mobile applications in learning strategies: A review study. *Educational Technology & Society*, *13*(3), 3-11.

Jonassen, D. (1991). Objectivism versus constructivism: Do we need a new philosophical paradigm? *Educational Technology Research and Development*, *39*(3), 5-14. https://doi.org/10.1007/BF02296434

Jonassen, D. (1999). Designing constructivist learning environments. In C. M. Reigeluth (Ed.), *Instructional-design theories and models*, (2nd ed., pp. 215-219). Lawrence Erlbaum Associates.

Johnson, E. S., & Smith, L. A. (2011). Response to intervention in middle school: A case story. *Middle School Journal*, *42*(3), 24-32.

Junco, R. (2012). In-class multitasking and academic performance. *Computers in Human Behavior*, *28*(6), 2236-2243. https://doi.org/10.1016/j.chb.2012.06.031

Kaleta, R., & Joosten, T. (2007). Student response systems: A University of Wisconsin System study of clickers. *Educause Center for Applied Research: Research Bulletin,* 10, 1-12.

Kay, R. (2008). Exploring Gender Differences in Computer-Related Behaviour: Past, Present, and Future. In Kidd, T. T., & Chen, I. (Eds.), *Social Information Technology: Connecting Society and Cultural Issues* (pp. 12-30). IGI Global. http://doi:10.4018/978-1-59904-774-4.ch002

Kay, R. H., & Knaack, L. (2009). Exploring individual differences in attitudes toward audience response systems. *Canadian Journal of Learning and Technology,35*. https://doi.org/10.21432/T2830H

Kay, R. H., Lesage, A., & Knaack, L. (2010). Examining the use of audience response systems in secondary school classrooms: A formative analysis. *Journal of Interactive Learning Research. 21,* 343-365. https://www.learntechlib.org/primary/p/29551/

Katz, L., Hallam, M., Duvall, M., & Polsky, Z. (2017). Considerations for using personal wi-fi enabled devices as "clickers" in a large university class. *Active Learning in Higher Education, (201702)*. http://doi.org/10.1177/1469787417693495

Kenwright, K. (2009). Clickers in the classroom. *Techtrends: Linking Research and Practice to Improve Learning, 53*(1), 74-77.

Keough, S. M. (2012). Clickers in the classroom: A review and a replication. *Journal of Management Education, 36*(6), 822-847. https://doi.org/10.1177/1052562912454808

Kerlinger, F. N., & Pedhazur, E. J. (1973). *Multiple regression in behavioral research*. Holt, Rinehart & Winston.

Khan, A., Schoenborn, P., & Sharma, S. (2019). The use of clickers in instrumentation and control engineering education: A case study. *European Journal of Engineering Education, 44*(1-2), 271-282. http://doi.org/10.1080/03043797.2017.1405240

Kline, R.B. (2005). *Principles and practice of structural equation modeling.* Guilford Press.

Kolikant, Y., Drane, D., & Calkins, S. (2010). "Clickers" as catalysts for transformation of teachers. *College Teaching, 58*(4), 127-135. http://www.jstor.org/stable/25763428

Kortemeyer, G. (2016). The psychometric properties of classroom response system data: a case study. *Journal of Science Education and Technology,25*(4), 561–574. https://doi.org/10.1007/s10956-016-9613-9

Kozel-Gains, M. A., & Stoddart, R. A. (2011). Supplementing a librarian's information literacy toolkit with textbooks: A scan of basic communication course texts. *Communications in Information Literacy, 5*(1), 55-67. https://doi.org/10.15760/comminfolit.2011.5.1.102

Kukulska-Hulme, A. (2012). How should the higher education workforce adapt to advancements in technology for teaching and learning?. *The Internet and Higher Education, 15*(4), 247-254. https://doi.org/10.1016/j.iheduc.2011.12.002

Kulatunga, U., & Rameezdeen, R. (2014). Use of clickers to improve student engagement in learning: Observations from the built environment discipline. *International Journal of Construction Education and Research, 10*(1), 3-18. https://doi.org/10.1080/15578771.2013.826754

Kulesza, A. E., Clawson, M. E., & Ridgway, J. S. (2014). Student success indicators associated with clicker-administered quizzes in an honors introductory biology course. *Journal of College Science Teaching, 43*(4), 73-79.

Lambert, C. (2012). Twilight of the lecture. *Harvard Magazine*, *114*(4), 23–27.

Lamdin, D. (1996). Evidence of student attendance as an independent variable in education production functions. *The Journal of Educational Research, 89*(3), 155-162. https://doi.org/10.1080/00220671.1996.9941321

Landrum, R. E. (2013). The ubiquitous clicker SoTL applications for scientist–educators. *Teaching of Psychology*, *40*(2), 98-103. http://dx.doi.org/10.1177/0098628312475028

Landrum, R. (2015). Teacher-ready research review: Clickers. *Scholarship of Teaching and Learning in Psychology*, *1*(3), 250-254. https://psycnet.apa.org/doi/10.1037/stl0000031

Lee, U. J., Sbeglia, G. C., Ha, M., Finch, S. J., & Nehm, R. H. (2015). Clicker score trajectories and concept inventory scores as predictors for early warning systems for large stem classes. *Journal of Science Education and Technology*, *24*(6), 848–860. https://doi.org/10.1007/s10956-015-9568-2

Lincoln, D. J. (2009). Student response systems adoption and use in marketing education: A status report. *Marketing Education Review, 19*(3), 25-40, https://doi.org/10.1080/10528008.2009.11489085

Little, R. J. A. (1988). A Test of Missing Completely at Random for Multivariate Data with Missing Values. *Journal of the American Statistical Association, 83*(404), 1198. https://doi.org/10.2307/2290157

Little, R. J. A., & Rubin, D. B. (2002). *Statistical analysis with missing data* (Second, Ser. Wiley series in probability and statistics). Wiley. https://doi.org/10.1002/9781119013563

Liu, Y. (2020). Use of mobile phones in the classroom by college students and their perceptions in relation to gender: a case study in China. *International Journal of Information and Education Technology, 10*(4), 320–326. https://doi.org/10.18178/ijiet.2020.10.4.1383

Liu, C., Chen, S., Chi, C., Liu, Y., Chou, T.-L., & Chien, K.-P. (2017). The effects of clickers with different teaching strategies. *Journal of Educational Computing Research*, *55*(5), 603–628. https://doi.org/10.1177/0735633116674213

Liu, D. Y. T., & Taylor, C. E. (2013). Engaging students in large lectures of introductory biology and molecular biology service courses using student response systems. In *Engaging students in large lectures of introductory biology and molecular biology service courses using student response systems* (pp. 154–162). essay. https://openjournals.library.sydney.edu.au/index.php/IISME/article/view/7074/7585#

López-Quintero, J. L., Varo-Martínez, M., Ana, M., Laguna-Luna, A. M., & Pontes-Pedrajas, A. (2016). Opinions on “classroom response system” by first-year engineering students.

Procedia - Social and Behavioral Sciences, 228, 183–189. https://doi.org/10.1016/j.sbspro.2016.07.027

Ma, S., Steger, D., Doolittle, P., & Stewart, A. (2018). Improved academic performance and student perceptions of learning through use of a cell phone-based personal response system. *Journal of Food Science Education, 17*(1), 27-32. http://doi.org/10.1111/1541-4329.12131

Macmillan Learning. (2018). Educator Studies. 2018 Boise State Physics I and II. https://www.macmillanlearning.com/catalog/page/learningscience/educational-results

Macmillan Learning. (2019). iClicker instructor remotes. https://www.iclicker.com/instructors/

Marburger, D. (2001). Absenteeism and undergraduate exam performance. *The Journal of Economic Education*, *32*(2), 99-109.

Masikunis, G., Panayiotidis, A., & Burke, L. (2009). Changing the nature of lectures using a personal response system. *Innovations in Education and Teaching International*, *46*(2), 199-212. https://doi.org/10.1080/14703290902843935

Mayer, R. (2004). Should there be a three-strikes rule against pure discovery learning? *American Psychologist*, *59*(1), 14-19. http://doi.org/10.1037/0003-066X.59.1.14

Mayer, R. E., Stull, A., DeLeeuw, K., Almeroth, K., Bimber, B., Chun, D., Bulger, M., Campbell, J., Knight, A., & Zhang, H. (2009). Clickers in college classrooms: Fostering learning with questioning methods in large lecture classes. *Contemporary Educational Psychology*, *34*(1), 51–57. https://doi-org.libproxy.boisestate.edu/10.1016/j.cedpsych.2008.04.002

Mazur, E. (1997). *Peer instruction: A user's manual* (Prentice hall series in educational innovation). Prentice Hall.

McDonald, G. (2013).Does size matter? The impact of student-staff ratios. *Journal of Higher Education Policy and Management, 35*, 652-667. https://doi.org/10.1080/1360080X.2013.844668

McGraw Hill. (2021). Inclusive access and Connect reduce financial burden for students while improving course grades. https://s3.amazonaws.com/ecommerce-prod.mheducation.com/unitas/highered/inclusive-access/case-study-somerset-cc-biology.pdf

McNeill, R. G. (2011). Adapting teaching to the millennial generation: A case study of a blended/hybrid course. Paper presented at the International Council on Hotel, Restaurant and Institutional Education Conference, University of Massachusetts, Amherst

Meeyai, S. (2016). Logistic regression with missing data: A comparison of handling methods, and effects of percent missing values. *Journal of Traffic and Logistics Engineering (4)*2, 128-132. https://doi.org/10.18178/jtle.4.2.128-134

Menard, S. W. (1995). *Applied logistic regression analysis* (Series Sage university papers series. quantitative applications in the social sciences, no. 07-106). Sage Publications.

Meyers, L. S., Gamst, G., & Guarino, A. J. (2017). *Applied multivariate research: design and interpretation*. Sage Publications.

Miller, M., & Hartung, S. Q. (2012). Evidence-based clicker use: Audience response systems for rehabilitation nurses. *Rehabilitation Nursing, 37*(3), 151-159. https://doi.org/10.1002/rnj.00041

Milner-Bolotin, M., Antimirova, T., & Petrov, A. (2010). Clickers beyond the first-year science classroom. *Journal of College Science Teaching, 40*(2), 14-18. https://www.learntechlib.org/p/54004/

Moore, C., Black, J., Glackin, B., Ruppel, M., & Watson, E. (2015). Integrating information literacy, the POGIL method, and iPads into a foundational studies program. *The Journal of Academic Librarianship*,*41*(2), 155–169. https://doi.org/10.1016/j.acalib.2014.12.006

Morling, B., McAuliffe, M., Cohen, L., & DiLorenzo, T. M. (2008). Efficacy of personal response systems ("clickers") in large, introductory psychology classes. *Teaching of Psychology*,*35*(1), 45–50. https://doi.org/10.1080/00986280701818516

Morrell, L. J., & Joyce, D. A. (2015). Interactive lectures: Clickers or personal devices?.*F1000Research*,*4*, 64. https://doi.org/10.12688/f1000research.6207.1

Muhanna, W. N., & Abu-Al-Sha'r, A. M. (2009). University students' attitudes towards cell phone learning environment. *International Journal of Interactive Mobile Technologies 3*(4). https://doi.org/10.3991/ijim.v3i4.1068

Muijs, D. (2011). *Doing quantitative research in education with SPSS* (2nd ed.). SAGE Publications Ltd. https://www.doi.org/10.4135/9781849203241

Mula, J. M., & Kavanagh, M. (2009). Click go the students, click-click-click: The efficacy of a student response system for engaging students to improve feedback and performance. *E-journal of Business Education and Scholarship of Teaching*, *3*(1), 1-17.

Mulryan-Kyne, C. (2010).Teaching large classes at college and university level: Challenges and opportunities. *Teaching in Higher Education*, *15*,175-185. https://doi.org/10.1080/13562511003620001

Nadelson, L., Bennett, D., Gwilliam, E., Howlett, C., Oswalt, S., & Sand, J. (2013). The intersection of preservice teachers' confidence, perceptions, and ideas for using instructional technology for teaching and learning. *International Journal of Higher Education, 2*(4), 77-90. http://dx.doi.org/10.5430/ijhe.v2n4p77

Nelson, M. L., & Hauck, R. V. (2008). Clicking to learn: A case study of embedding radio-frequency based clickers in an introductory management information systems course. *Journal of Information Systems Education, 19*, 55-64. https://aisel.aisnet.org/jise/vol19/iss1/6

Newman-Ford, L., Fitzgibbon, K., Lloyd, S., & Thomas, S. (2008). A large-scale investigation into the relationship between attendance and attainment: A study using an innovative, electronic attendance monitoring system. *Studies in Higher Education, 33*(6), 699-717. https://doi.org/10.1080/03075070802457066

Ng, W., & Nicholas, H. (2013). A framework for sustainable mobile learning in schools. *British Journal of Educational Technology, 44*(5), 695-715. https://doi.org/10.1111/j.1467-8535.2012.01359.x

Niemeyer, E. D., & Zewail-Foote, M. (2018). Investigating the influence of gender on student perceptions of the clicker in a small undergraduate general chemistry course. *Journal of Chemical Education, 95*(2), 218-223. https://doi.org/10.1021/acs.jchemed.7b00389

Oigara, J., & Keengwe, J. (2013). Students' perceptions of clickers as an instructional tool to promote active learning. Education and Information Technologies: *The Official Journal of the International Federation Information for Processing Technical Committee on Education, 18*(1), 15-28. http://doi.org/10.1007/s10639-011-9173-9

Osterman, A. (2008). Student response systems: Keeping the students engaged. *College & Undergraduate Libraries, 14*(4), 49-57. https://doi.org/10.1080/10691310802046801

Paas, F., Van Gog, T., & Sweller, J. (2010). Cognitive load theory: New conceptualizations, specifications, and integrated research perspectives. *Educational Psychology Review, 22*(2), 115-121. http://doi.org/10.1007/s10648-010-9133-8

Parette, H. P., Hourcade, J., Dinelli, J., & Boeckmann, N. M. (2009). Using Clicker 5 to enhance emergent literacy in young learners. *Early Childhood Education Journal, 36*(4), 355-363. https://doi.org/10.1007/s10643-008-0288-6

Parette, H. P., Hourcade, J., Dinelli, J., Boeckmann, N. M., & Blum, C. (2010). Handy manny and the emergent literacy technology toolkit. *Early Childhood Education Journal,37*(6), 483-491. http://dx.doi.org/10.1007/s10643-010-0377-1

Parette, H. P., Hourcade, J., Blum, C., Watts, E. H., Stoner, J. B., Wojcik, B. W., & Chrismore, S. B. (2013). Assistive technology user groups and early childhood educators. *Early Childhood Education Journal, 41*(3), 171-179. http://dx.doi.org/10.1007/s10643-012-0548-3

Park, S., & Farag, D. (2015). Transforming the legal studies classroom: Clickers and engagement. *Journal of Legal Studies Education, 32*(1), 47-90. http://dx.doi.org/10.1111/jlse.12022

Peugh, J. L., & Enders, C. K. (2004). Missing data in educational research: A review of reporting practices and suggestions for improvement. *Review of Educational Research, 74*(4), 525–556. https://doi.org/10.3102/00346543074004525

Physics Education Research. (2019). i>clicker. https://per.physics.illinois.edu/research/projects/project-details.asp?key=8694&title=i%3Eclicker

Poirier, C. R., & Feldman, R. S. (2007). Technology and teaching: Promoting active learning using individual response technology in large introductory psychology classes. *Teaching of Psychology, 34*(3), 194–196. https://doi.org/10.1080/00986280701498665

Powell, S., Straub, C., Rodriguez, J., & VanHorn, B. (2011). Using clickers in large college psychology classes: Academic achievement and perceptions. *Journal of the Scholarship of Teaching and Learning, 11*(4), 1-11.

Premkumar, K., & Coupal, C. (2008). Rules of engagement-12 tips for successful use of "clickers" in the classroom. *Medical Teacher, 30*(2), 146-9. http://doi.org/10.1080/01421590801965111

Preszler, R. W., Dawe, A., Shuster, C. B., & Shuster, M. (2007). Assessment of the effects of student response systems on student learning and attitudes over a broad range of biology courses. *Cell Biology Education Life Sciences Education,6*(1), 29–41. https://doi.org/10.1187/cbe.06-09-0190

Rana, N. P., & Dwivedi, Y. K. (2017). Can clicking promote learning? *Journal of International Education in Business*, *10*(2), 201–215. https://doi.org/10.1108/JIEB-06-2016-0010

Rana, N. P., Dwivedi, Y. K., & Al-Khowaiter, W. A. A. (2016). A review of literature on the use of clickers in the business and management discipline. *International Journal of Management Education, 14*(2), 74-91. https://doi.org/10.1016/j.ijme.2016.02.002

Ravizza, S. M., Hambrick, D. Z., & Fenn, K. M. (2014). Non-academic internet use in the classroom is negatively related to classroom learning regardless of intellectual ability. *Computers & Education, 78,* 109-114. https://psycnet.apa.org/doi/10.1016/j.compedu.2014.05.007

Reay, N., Li, P., & Bao, L. (2008). Testing a new voting machine question methodology. *American Journal of Physics,* 76, 171−178. https://doi.org/10.1119/1.2820392

Reay, N. W., Bao, L., Li, P., Warnakulasooriya, R., & Baugh, G. (2005). Toward the effective use of voting machines in physics lectures. *American Journal of Physics*, *73*(6), 554-558. https:// doi.org/10.1119/1.1862638

Remon, J., Sebastian, V., Romero, E., & Arauzo, J. (2017). Effect of using smartphones as clickers and tablets as digital whiteboards on students' engagement and learning. *Active Learning in Higher Education, 18*(2), 173-187. https://doi.org/10.11772/1469787417707618

Reschly, A. L., & Christenson, S. L. (2006). Research leading to a predictive model of dropout and completion among students with mild disabilities and the role of student engagement. *Remedial and Special Education, 27*(5), 276-292. https://doi.org/10.11772/07419325060270050301

Rimer, S. (2009). At MIT, large lectures are going the way of the blackboard. (2009).*Physics Today,(2009)*. https://doi.org/10.1063/PT.5.022981

Robinson, S. (2006). Using games and clickers to encourage students to study and participate. *Proceedings of the Academy of Educational Leadership,11*, 25-29. https://doi.org/10.30935/cet.414820

Robinson, S. (2007). Engaging students through electronic response devices (clickers). *Management Review: An International Journal (2)*1, 4-16. https://www.researchgate.net/publication/254201918_Engaging_Students_Through_Electronic_Response_Devices_Clickers

Romer, D. (1993). Do students go to class? Should they? *The Journal of Economic Perspectives, 7*(3), 167-174. https://10.1257/jep.7.3.167

Rubin, D. B. (1976). Inference and missing data. *Biometrika*, (*63)*3, 581-592. https://doi.org/10.1093/biomet/63.3.581

Salmonson, Y., Andrew, S., & Everett, B. (2009). Academic engagement and disengagement as predictors of performance in pathophysiology among nursing students. *Contemporary Nurse, 32*(1-2), 123-132. https://doi.org/10.5172/conu.32.1-2.123

Sana, F., Weston, T., & Cepeda, N. J. (2013). Laptop multitasking hinders classroom learning for both users and nearby peers. *Computers & Education, 62,* 24-31. https://doi.org/10.1016/j.compedu.2012.10.003

Sarvary, M. A., & Gifford, K. M. (2017). The benefits of a real-time web-based response system for enhancing engaged learning in classrooms and public science events. *Journal of Undergraduate Neuroscience Education: June: A Publication of Fun, Faculty for Undergraduate Neuroscience*, *15*(2), 16.

Sebelego, I. K. (2019). The use of clickers to evaluate radiographer's knowledge of shoulder images. *Health SA Gesondheid*, *24,* 1053. https://doi.org/10.4102/hsag.v24i0.1053

Sevian, H., & Robinson, W. (2011). Clickers promote learning in all kinds of classes—small and large, graduate and undergraduate, lecture and lab. *Journal of College Science Teaching, 40*(3), 14-18. https://www.learntechlib.org/p/54008/

Shapiro, A. M., Sims-Knight, J., O'Rielly, G. V., Capaldo, P., Pedlow, T., Gordon, L., & Monteiro, K. (2017). Clickers can promote fact retention but impede conceptual understanding: the effect of the interaction between clicker use and pedagogy on learning. *Computers & Education, 111*, 44–59. https://doi.org/10.1016/j.compedu.2017.03.017

Sharma, M., Khachan, J., Chan, B., & O'Bryne, J. (2005). An investigation of the effectiveness of electronic classroom communication systems in large lecture classes. *Australalasian Journal of Educational Technology*, *21*(2), 137-154. https:// doi.org/10.14742/ajet.1330

Shih, W., & Allen, M. (2007). Working with Generation-D: Adopting and adapting to cultural learning and change. *Library Management, 28,* 89-100. https://.doi.org/10.11082/01435120710723572

Siau, K., Sheng, H., & Nah, F. (2006). Use of a classroom response system to enhance classroom interactivity. *Institute of Electrical and Electronics Engineers Transactions on Education, 49*(3). http://doi.org/10.1109/TE.2006.879802

Siebert, C., & Siebert, D. (2017). *Data analysis with small samples and non-normal data: Nonparametrics and other strategies* (Pocket guides to social work research methods). Oxford: Oxford University Press.

Simonson, S. R. (Ed.). (2019). *POGIL: An introduction to process oriented guided inquiry learning for those who wish to empower learners*. Stylus Publishing LLC.

Slavin, R. E. (2002). Evidence-based education policies: Transforming educational practice and research. *Educational Researcher, 31*, 15–21. https://doi.org/10.3102%2F0013189X031007015

Slavin, R. E. (2004). Education research can and must address “what works” questions. *Educational Researcher*, *33,* 27-28. https://doi.org/10.3102%2F0013189X033001027

Smith, M. K., Trujillo, C., & Su, T. T. (2011). The benefits of using clickers in small-enrollment seminar-style biology courses. *Cell Biology Education Life Science Education*; *10*(1):14-17. http://doi.org/10.1187/cbe.10-09-0114

Sorden, S. (2005). A cognitive approach to instructional design for multimedia learning. *Informing Science, 8*, 263-279. https://doi.org/10.28945/498

Sprague, E. W., & Dahl, D. W. (2010). Learning to click: An evaluation of the personal response system clicker technology in introductory marketing courses. *Journal of Marketing Education, 32*(1), 93-103. https://doi.org/10.1177/0273475309344806

Stanca, L. (2006). The effects of attendance on academic performance: Panel data evidence for introductory microeconomics. *The Journal of Economic Education, 37*(3), 251-266. https://doi.org/10.3200/JECE.37.3.251-266

Steinberg, J. (2010). The choice; more professors give out hand-held devices to monitor students and engage them. *New York Times, 160*(55226).

Stevens, N. T., McDermott, H., Boland, F., Pawlikowska, T., & Humphreys, H. (2017). A comparative study: Do "clickers" increase student engagement in multidisciplinary clinical microbiology teaching?. *BMC Medical Education 17***,** 70. https://doi.org/10.1186/s12909-017-0906-3

Stines-Chaumeil, C., Paumard, P., & Hooks, M. (2019). Incorporating clickers into an enzymology course improves student performance. *FEBS Open Bio, 9*(4), 562-570. http://doi.org/10.1002/2211-5463.12599

Stock, J. H., & Watson, M. W. (2015). *Introduction to econometrics* (3rd ed). Pearson Education, Limited

Stowell, J., Oldham, T., & Bennett, D. (2010). Using student response systems ("clickers") to combat conformity and shyness. *Teaching of Psychology 37*(2), 135–140. http://doi.org/10.1080/00986281003626631

Strasser, N. (2010). Who wants to pass math? Using clickers in calculus. *Journal of College Teaching & Learning, 7*(3), 49-52. https://www.learntechlib.org/p/108223/

Stuart, S. A. J., Brown, M. I., & Draper, S. W. (2004). Using an electronic voting system in logic lectures: One practitioner's application. *Journal of Computer Assisted Learning, 20*(2), 95–102.

Sutherlin, A., Sutherlin, G., & Akpanudo, U. (2013). The effect of clickers in university science courses. *Journal of Science Education and Technology, 22*(5), 651-666. https://doi.org/10.1007/s10956-012-9420-x

Sung, Y.-T., Chang, K.-E., & Liu, T.-C. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. *Computers & Education, 94*, 252-275. https://doi.org/10.1016/j.compedu.2015.11.008

Sun, J. C.-Y., Martinez, B., & Seli, H. (2014). Just-in-time or plenty-of-time teaching? Different electronic feedback devices and their effect on student engagement. *Educational Technology & Society, 17*(2), 234-244.

Sweller, J., Van Merriënboer, J., & Paas, F. (2019). Cognitive architecture and instructional design: 20 years later. *Educational Psychology Review, 31*(2).

Tanner, K. D. (2013). Structure matters: Twenty-one teaching strategies to promote student engagement and cultivate classroom equity. *Cell Biology Education Life Sciences Education*, *12*(3), 322–331.

Tapscott. D. (2009). *Grown up digital: How the net generation is changing your world*. McGraw- Hill.

Tlhoaele, M., Hofman, A., Naidoo, A., & Winnips, K. (2014). Using clickers to facilitate interactive engagement activities in a lecture room for improved performance by students. *Innovations in Education and Teaching International, 51*(5), 497-509. https://doi.org/10.1080/14703297.2013.796725

Todd, D., & Kristin, T. (2016). Effects of sharing clickers in an active learning environment. *Journal of Educational Technology & Society*, *19*(3), 260–268.

Toothaker, R. (2018). Millennial's perspective of clicker technology in a nursing classroom: A mixed methods research study. *Nurse Education Today, 62*, 80-84. http://doi.org/10.1016/j.nedt.2017.12.027

Trees, A. R., & Jackson, M. H. (2007). The learning environment in clicker classrooms: Student processes of learning and involvement in large university-level courses using student response systems. *Learning, Media and Technology*, *32*(1), 21–40. https://doi.org/10.1080/17439880601141179

Ueltschy, L. C. (2001). An exploratory study of integrating interactive technology into the marketing curriculum. *Journal of Marketing Education, 23*(1), 63-72. https://doi.org/10.1177%2F0273475301231008

Ulbig, S. G., & Notman, F. (2012). Is class appreciation just a click away?: Using student response system technology to enhance shy students' introductory American government experience. *Journal of Political Science Education, 8*(4), 352-371. https://doi.org/10.1080/15512169.2012.729450

Unal, C., Fathi, E., & Seyfullah, G. (2018). Clickers in EFL classrooms: Evidence from two different uses. *Contemporary Educational Technology*, *2*(9), 171–185. https://doi.org/10.30935/cet.414820

University Foundations. (2020, March 13). University Learning Outcomes. https://www.boisestate.edu/academics-uf/university-learning-outcomes/

Van Merriënboer, J., & Ayres, P. (2005). Research on cognitive load theory and its design implications for e-learning. *Educational Technology Research and Development, 53*(3), 5-13.

Walker, C., Fleischer, S., & Winn, S. (2008). A path analysis of first-year social science students' engagement with their degree and Level 1 academic outcome. *Enhancing Learning in the Social Sciences, 1(*2), 1-19. https://doi.org/10.11120/elss.2008.01020003

Walker, J. D., Cotner, S. H., Baepler, P. M., & Decker, M. D. (2008). A delicate balance: Integrating active learning into a large lecture course. *Cell Biology Education Life Sciences Education*, *7*(4), 361–367. https://doi.org/10.1187/cbe.08-02-0004

Walklet, E., Davis, S., Farrelly, D., & Muse, K. (2016). The impact of student response systems on the learning experience of undergraduate psychology students. *Psychology Teaching Review, 22*(1), 35–48.

Warden, C. A., Stanworth, J. O., & Chang, C.-C. (2016). Leveling up: Are non-gamers and women disadvantaged in a virtual world classroom? *Computers in Human Behavior*, *65*, 210–219. https://doi.org/10.1016/j.chb.2016.07.033

White, N. R. (2006). Tertiary education in the noughties: The student perspective. *Higher Education Research & Development*, *25*(3), 231-246. https://psycnet.apa.org/doi/10.1080/07294360600792947

Whitley, B. E. J. (1997). Gender differences in computer-related attitudes and behavior: A meta-analysis. *Computers in Human Behavior, 13*(1), 1–22. https://doi.org/10.1016/S0747-5632(96)00026-X

Williamson Sprague, E., & Dahl, D. W. (2010). Learning to click: An evaluation of the personal response system clicker technology in introductory marketing courses. *Journal of Marketing Education*, *32*(1), 93-103. https://doi.org/10.1177/0273475309344806

Wittrock, M. (2010). Learning as a generative process. *Educational Psychologist*, *45*(1), 40-45. http://doi.org/10.1080/00461520903433554

Woelk, K. (2008). Optimizing the use of personal response devices (clickers) in large-enrollment introductory courses. *Journal of Chemical Education*, *85*(10), 1400–1405. https://doi.org/10.1021/ed085p1400

Wong, A. (2016). Classroom response systems and student performance improvement: Local versus international students. *Journal of Teaching in International Business, 27*(4), 197-208. https://doi.org/10.1080/08975930.2017.1302393

Wong, A., Leahy, W., Marcus, N., & Sweller, J. (2012). Cognitive load theory, the transient information effect and e-learning. *Learning and Instruction, 22*(6), 449-457. http://doi.org/10.1016/j.learninstruc.2012.05.004

Woodfield, R., Jessop, D., & McMillan, L. (2006). Gender differences in undergraduate attendance rates. *Studies in Higher Education*, *31*(1), 1-22. https://doi.org/10.1080/03075070500340127

Young, M. (2010). The art and science of fostering engaged learning. *Academy of Educational Leadership Journal*, *14* (Suppl. special issue), 1-18

Yoder, J. D., & Hochevar, C. M. (2005). Encouraging active learning can improve students' performance on examinations. *Teaching of Psychology, 32*,91–95. https://doi.org/ 10.1207/s15328023top3202_2

Yourstone, S. A., Kraye, H. S., & Albaum, G. (2008). Classroom questioning with immediate electronic response: Do clickers improve learning? *Decision Sciences Journal of Innovative Education*, *6*(1), 75-88. https://doi.org/10.1111/j.1540-4609.2007.00166.x

Yu, Z., Chen, W., & Zheng, J. (2017). Advantages and disadvantages of clicker use in education. *International Journal of Information and Communication Technology Education*, *13*(1), 61-71. https://doi.org/10.4018/IJICTE.2017010106

Yu, Z., Chen, W., Kong, Y., Sun, X., & Zheng, J. (2014). The impact of clickers instruction on cognitive loads and listening and speaking skills in college English class. *Plos One*, *9*(9), 106626. http://doi.org/10.1371/journal.pone.0106626