MOBILE POLLING AND SELF-REGULATION:

HOW STUDENTS MAY BE TEMPTED WITH DISTRACTIONS

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Lee Hardin

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Examining Committee Members:
Dr. James Byrnes, Advisory Chair, Department of Psychological Studies in Education
Dr. Catherine Schifter, Department of Policy, Organizational, and Leadership Studies
Dr. Janice Laurence, Department of Psychological Studies in Education
Dr. Shanta Hattikudur, Department of Psychological Studies in Education

ABSTRACT

Mobile polling is a widely used classroom response system at the university level. The current study examines the predictors and outcomes of mobile polling including self-regulation and academic achievement. Furthermore, this study explores whether or not mobile polling benefits some students more than others, specifically those with higher levels of self-regulation. The data was collected from two separate University classrooms taught by the same teacher (n = 66). The first section of students were to use mobile polling software after taking their midterm exam and use the software for the remainder of the semester. The other section of students served as the control group and received the same instruction, Powerpoints, and assignments minus the usage of mobile polling. All students from both classes were given an 89 question survey known as the Barkley Deficits in Executive Function Scale (BDEFS) which measured their ability to self-regulate their behavior.

A hierarchical regression model was used to find that mobile polling had no statistical significance on academic achievement at the end of the semester. The only significant predictor throughout the entire study was the initial achievement variable, which was the scores from the midterm exam. Another hierarchical regression model found that self-regulation, measured with the use of the BDEFS system, was not a significant predictor of academic achievement. When initial achievement was controlled for, the Overall EF score from the BDEFS system revealed that self-regulation had zero effect on the variance as denoted by R Square and the R Square change in the regression model. Supplemental analysis revealed that Overall EF is a significant predictor of academic achievement when a Repeated Measures ANOVA was used, though the R Square change was still low. Factor analysis was used to find which questions loaded together under five subscales, truncating the BDEFS system and revealing that Self-Restraint/Inhibition

traits were a better predictor than the overall score from the BDEFS questionnaire yet was not a significant predictor of achievement. Finally, a 2 x 2 ANCOVA that investigated the interaction between high/low levels of Self-Regulation and usage of Mobile Polling and found that it did not significantly affect academic achievement. In fact, the highest mean came from the completely opposite group as expected, which was students in the control group with lower levels of self-regulation.

DEDICATION

This dissertation is dedicated to my sons Evan and Owen. Though you were too young to understand why your father was always busy or away for work, your enduring love and excitement to spend time with me was a driving force to finish this long journey and spend more time with you. I hope that you will live out your dreams, forever find happiness, and spread your joy and curiosity with the rest of the world. I love you.

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To my parents, whom were my first educators, I want to thank you for all that you have given to help me reach my fullest potential. I love you both so much.

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CHAPTER 1

INTRODUCTION

Problem

One of the most discussed issues regarding education in the United States is the poor results on international tests for academic achievement displayed by American students. The Programme for International Student Assessment (PISA) is an achievement test given in more than 70 countries, certain cities, and includes special administrative regions in China such as Hong Kong, Macau, and Shanghai. The assessment is given every three years to 15-year-old students, and the most recent results currently available have been published in 2015 (Marchant, 2018). The test does not reflect any specific school curriculum, and it goes beyond simple achievement to determine the students' ability to apply content to authentic situations. And on the most recent test results, the PISA has revealed that the United States are placed at an underwhelming rank of 38th out of 70 countries in math, 25th in science, and 24th in reading scores. Moreover, the U.S. ranked 30th in math, 19th in science, and 19th in reading scores amongst the 35 members of the Organization for Economic Cooperation and Development (2016).

Given these low statistical scores, educators look at different ways to interpret the results and explain why our students are doing poorly compared to other countries. Many cognitive psychologists argue that failures of metacognition lie at the root of learning problems (Brown, 1978; Flavel, 1979, Brown, Bransford, Ferrara, & Campione, 1983), and there is a vast amount of evidence to support that the use of metacognitive strategies improves academic achievement (Gorsuch & Taguchi, 2010; Peters & Kitsantas, 2010; Sperling, Richmond, Ramsay, & Klapp,

2012, Vula, Avdyli, Berisha, Saqipi, & Elezi, 2017). One way to improve a student's metacognition and overall performance is the use of corrective feedback after formative assessments (Potts, Shanks, & Gauthier, 2014). There is also evidence to suggest that generating answers to assessments can still be beneficial despite making many errors, if corrective feedback is then provided (Kornell, Hays, & Bjork, 2009; Metcalfe, 2017). With educators looking for ways to improve undergraduate instruction and Universities wishing to expand on classroom technology, the creation of electronic feedback systems and their app-driven successor, Mobile Polling, have forged a new business within the realm of classroom technology in regards to formative assessments and feedback.

Classroom Response Systems (CRS), also known as Audience Response Systems, or informally known as *clickers*, are now common in academic environments, most notably in higher education (Gilbert, 2005; Martyn, 2007). Research has found that use of clickers can increase student engagement, enhance active learning, and improve conceptual learning due to use of instructor-created formative assessments that can be built in and around their existing lectures (Cotner, Fall, Wick, Walker, & Baepler, 2008; Bode, Drane, Kolikant, Schuller, 2009; Cai et al., 2011; Voelkel & Bennett, 2014). More recently, several digital companies such as TopHat and Poll Everywhere have been promoting mobile apps to be superior to clickers for classroom polling purposes. These companies argue that the smart-phone and tablet apps are more convenient and include features that clickers lack, such as question feedback directly to their screen, wireless internet capabilities, system prompts confirming answer choices, and chat communication with instructors and classmates (Sun, 2014).

However, an increasing number of studies have been finding that the presence of cell phones in classrooms distract students from learning (Ali, Papakie, & McDevitt, 2012; Berry &

Westfall, 2015; Burns & Lohenry, 2010; Tindell & Bohlander, 2012). With this research in mind, teachers encouraging students to use their own mobile devices for class purposes could be welcoming additional distractions and hindering the benefits of formative assessments and feedback from mobile polling. One study that looked at both distractions and mobile polling found that almost 42% of students who were directed to use a mobile app for polling throughout a semester were "sometimes" distracted by other things running on their mobile device (Stowell, 2015). Yet, it is unclear from this previous study how self-regulated these students were when using mobile polling in class, the secondary effects on the students' final grades, or if mobile polling only produces beneficial results for individuals who are highly self-regulated and able to use their mobile devices for educational purposes as intended. Therefore, the current study below intends to investigate the differences in overall academic achievement and self-regulation between a class of students who use mobile polling apps and a class that does not, and if mobile polling is only beneficial to certain students based on their ability to self-regulate their classroom behavior.

Purpose

The current study has three goals. The first is to determine the effects of using mobile polling software in regard to overall academic achievement compared to a class that doesn't use mobile polling. The second is to determine if students who report higher levels of self-regulation shower higher academic achievement than students who report lower levels of self-regulation. The third is to determine if mobile polling helps all students learn more or only some based on their level of self-regulation.

Clickers, the predecessor of mobile polling, had many positive findings with its usage but did not have to deal with the convenience of Wi-Fi and 4G. Mobile polling technology does not

prevent students from browsing other apps in class or during polling, and teachers are unable to tell what students are doing on their phones from the prompts they receive on their screen or from Excel spreadsheet reports. Students can answer a poll and easily disengage from the class once their answer is submitted by checking text messages, email, notifications from social media, fantasy sports, and so on. Moreover, students could cheat on polling questions and text a classmate the answer with a simple swipe and click, which wasn't as easy to do with a clicker (Ali, Papakie, & McDevitt, 2012). Despite mobile polling being an activity which does require the student to participate in order to receive credit for their answer, is it possible that self-regulated students will get more out of using the technology than students who allow themselves to be distracted?

The current study is an examination of opportunity (e.g., mobile polling, formative assessments) and propensity (e.g., self-regulation) factors that may contribute to student success in overall academic achievement. The Byrnes' (2003, 2007, 2009, 2016) Opportunity-Propensity Model is used as a way to analyze each factor's relationship to overall academic achievement as well as the factors' relations to one another. Antecedent factors, a third type of factor within Byrnes' Opportunity-Propensity Model that includes variables such as race/ethnicity, gender, and socioeconomic status, are not considered in this study.

Research Questions

As a prelude to a discussion on the current research study and its methods, it is necessary to review the research questions here:

1. Do students enrolled in courses that utilize the mobile polling technique show higher achievement at the end of the semester than students enrolled in business-as-usual classrooms, controlling for initial achievement?

2. Do students who report higher levels of self-regulation show higher achievement at the end of the semester than students who report lower levels of achievement, controlling for initial achievement?
3. Do students only benefit from mobile polling depending on their level of self-regulation?

Significance to Study

The current study aims to make several contributions within the realms of formative assessments, corrective feedback, self-regulation, and classroom technology. Formative assessments are a common instructional method that can be used by educators within any subject and class size. As an effective tool that improves student learning, formative assessments provide actionable evidence of student performance that allows teachers the ability to guide or alter instruction (Christ & Kiss, 2018). When used as an instrument, formative assessments are well-established tools for data collection that can document reliability and validity evidence to screen, diagnose, develop instructional plans, and monitor performance. Mobile polling contains features that meet the criteria for all components listed above which teachers can use to improve their course based on the information they receive. However, mobile polling is now operating in a realm of powerful, privately owned devices that cannot be controlled or monitored by educators or Universities implementing the use of this software. Unlike clicker studies from the mid-2000's, the current state of culture and technology on college campuses grant Wi-Fi and 4G coverage virtually everywhere in the United States. While Mobile Polling may still be an effective formative assessment tool by design, the current study seeks to discover how beneficial the tool is amongst different groups of students while also comparing to the results of a traditional classroom not using mobile polling technology.

Additionally, mobile polling is commonly used a few times during a class to assess student's knowledge on recently covered material and gauge how well the class understands the content of the course. Students can still become distracted in between polling sessions, leading to the possibility of getting a polling question incorrect because they were not paying attention. Therefore, it's important to identify the levels of self-regulation within the students in the class to understand the impact it has when using mobile polling.

Lastly, Universities spend an incredible amount of money to integrate, train, and support educational technology at their campuses for numerous reasons. These reasons include but are not limited to attracting future students, establishing a reputation as a technology leading institution, remaining competitive amongst other schools who adopt similar technologies, providing faculty different instructional methods for teaching courses, and so on. With the plethora of research discussing the benefits of classroom polling systems, it is important for institutions to understand the possible limitations on educational technology before making a substantial investment to incorporate it within their infrastructures or curriculums. The mound of research on distractions from mobile devices should not be ignored as smartphones in US culture are just as common and important as having your keys or wallet on you when leaving your home. Moreover, identifying limitations on technology and making them public is ultimately how software and hardware companies improve their products, leading to new or enhanced features that could benefit the user compared to previous models.

Definition of Terms

With an overview of the current study above, this chapter concludes with a list of key theoretical and common technology terms that will appear in the following chapters:

- *Active Learning:* A learning style where students are required to do something instead of simply listening to a lecture and absorbing written text (Goldstein, Wallis, & Rhem, J. 2015). These activities can vary from group problem-solving, completing worksheets in class, or using classroom response systems (Freeman et al., 2014).
- *Antecedent factors:* refers to the factors that "enable or explain the emergence of opportunities to learn or propensities" (e.g., socioeconomic status; Byrnes & Miller, 2007, p. 601).
- *Classroom Response Systems:* informally known as "clickers", these handheld devices look and work like remote controls. Students use the devices to respond to classroom polls or quizzes without having to raise a hand or their voice (Gilbert, 2005).
- *Executive Functioning:* Partially independent, top-down cognitive functions involved in top-down control of behavior, emotion, and cognition; support goal-directed behavior and cognition; and can be employed for top-down Self-Regulation (Barkley, 2012). Regarding ADHD, Executive Functioning has also been described as, "self-regulation across time for the attainment of one's goals (self-interests), often in the context of others" (Barkley, 2011a).
- *Metacognition:* refers to "'a set of superordinate functions that encode and maintain representation of the current task…[and engage] working memory…attention…action selection and inhibition' (Botvinick & Braver, 2015) and "active maintenance of goals and means to achieve them" (Miller & Cohen, 2001)
- *Mobile Polling:* a method or system that allows mobile devices to participate in an online survey community by entering opinions (Shao & McGee, 2000).

- *Opportunities:* in reference to the Opportunity-Propensity Model - the aspects of learning contexts that promote learning such as content exposure and instructional approach (Byrnes & Miller, 2007).
- *Propensity:* in reference to the Opportunity-Propensity Model - a student's ability and willingness to take advantage of opportunities presented (e.g., value, computational skills, etc.; Byrnes & Miller, 2007).
- *Receivers:* small devices the size of a flash drive that receive responses from classroom clickers via radio frequencies. These devices plug directly into the USB port of a laptop or desktop computer and sometimes work in conjunction with an installed polling software (Gilbert, 2005).
- *Self-Regulation:* The *intrinsic* processes aimed at adjusting mental and physiological state adaptively to context (Nigg, 2017).
- *Social Media:* any form of computer-mediated communication where individuals can generate and present content and/or view and interact with content of their friends or other users online (Carr & Hayes, 2015).

Dissertation Organization

The first chapter expands upon the purpose of the current study, the research questions, the significance of the study, and the definitions of terms to be used. Chapter 2 examines the Opportunity-Propensity Model as the theoretical framework for this current study, a comprehensive review of the current literature on metacognition and mobile polling, a hefty analysis of the gaps in the literature regarding mobile polling, and ends with the research questions. Chapter 3 provides a detailed explanation of the methodology and statistical analysis

prepared for the current study. The appendices following the references display the measures mentioned in Chapter 3.

CHAPTER 2

LITERATURE REVIEW

Classroom clickers have been around since the early 2000's yet they hit their stride in education around 2004 with companies like eInstruction and Turning Technologies leading the charge (Gilbert, 2005). The technology originally used infrared signals to transmit student responses like a remote control for your television. Manufacturers began replacing the infrared clickers with radio frequency clickers due to reliability and lower cost. Clicker usage started to increase as polling companies began integrating their devices with Microsoft PowerPoint, different operating systems, and websites. Such product enhancements coupled with the surge of students owning smart devices gave birth to clicker companies expanding their markets to mobile phones. Now, mobile polling services allow students to submit answers via text (Talbott, 2011), mobile applications (Stowell, 2015), and social media such as Twitter (Hoppenfeld, 2012).

Despite the increased use of mobile device polling, radio frequency clickers are still used today due to several reasons. First, Wi-Fi access throughout campuses can pose an issue, especially to smaller schools that do not have the budget or the staff to support their own network. Students could use 4G data services to participate in polling. However, this could be unreliable based on signal strength (Stowell, 2015). In addition to this, some buildings have classrooms located on basement floors and both Wi-Fi and 4G signals can be hindered due to building structure. Moreover, some companies offer accessible clickers for students with motor disabilities or visual impairments since touch screen phones could be hard to use (Elliot, 2011). Therefore, recent and future studies may see a mix of clickers and mobile devices together pending which polling service is used or if the institution is currently transitioning from one

product to another. For example, Poll Everywhere is a flagship mobile polling company that only supports texting and Twitter messages while Turning Technologies supports both clickers and their own polling app known as ResponseWare.

The Benefits of Mobile Polling

Mobile Polling has carried over many of the positive benefits from its clicker-type predecessor while incorporating new features over time due to consumer requests and hardware upgrades. Arguably one of biggest improvements concerning mobile polling is the fact that it is cost-effective for students, faculty, and institutions as students no longer need to pay for and carry around an expensive piece of clicker hardware which can be lost or forgotten at home (Richards, 2009; Lee et al., 2013). Students have paid various costs hovering around $40 USD for an individual clicker (Wuttiprom, Toeddhanya, Buachoom, & Wuttisela, 2017) and up to $60 USD for some of the advanced clickers with additional features (Barber & Njus, 2007). While some may view these prices rather cheap, the cost of these devices may not be worth the purchase if they are hardly used or bought by a student who is about to graduate.

Meanwhile, some faculty and universities have paid thousands of dollars to supply their students with these devices, often resulting in the clickers used a few times or never leaving their cases (Moss & Crowley, 2011). One study performed by a U.K. market firm tracked global market purchases regarding educational technology purchases and produced data that nearly one million clickers were purchased by schools and Universities, mostly in the United States (Gilbert, 2005). Even when these devices are bundled together for a discounted price, Universities and Institutions are paying a good chunk of money for devices that may become lost, damaged, or rarely utilized. Furthermore, using Mobile Polling would be cost-effective for both students and institutions pending on the software, such as using Poll Everywhere or Kahoot

when the class size is less than forty students (Shon & Smith, 2011). If this is the case, faculty members can use either software for free and students have the choice of downloading the Poll Everywhere app, texting their answers to a specific "class code" that the instructor creates, or logging into a unique Kahoot URL through any mobile browser they wish to use (Poll Everywhere, 2018; Kahoot, 2018). If the class size is larger, there are subscription plans available for almost every vendor that can charge the student as low as $9 USD per semester or charge the institution anywhere from $150 to $350 USD pending on the number of users, types of activities, and desired methods of reporting or storing results.

A secondary benefit for institutions is that mobile polling can be conducted without the use of additional hardware (clicker receivers) that take time to download software and use up computer memory space to maintain its functionality (Shon & Smith, 2011). Clicker receivers are small devices that look like thumb-drives and are used to capture student responses from their clickers. The receiver uploads the data to the classroom podium software and registers the participant's response for recording purposes. These receivers usually plug into a USB slot on podium machines, which could either be inaccessible to a faculty member or accidently damaged by another person using or maintaining the classroom hardware. Despite having all the students bring their own clickers to class, a faulty receiver may not allow any student responses to register. This can be a problem if the faculty member was administering a quiz or taking attendance, and there may not be anything the faculty member could do to fix the receiver on the spot. Furthermore, receivers have their own cost and can be up to $100 USD per receiver, per classroom (Koenig, 2010).

Another benefit that mobile polling brings to the table is the ability answer in free text (Cliffe, Davenport, De Vos, Parmar, & Hayes (2010). Early models of classroom clickers were

programmed to answer multiple choice questions with as few as four answer buttons to choose from. Later, clickers were produced with their own display screen and additional answer buttons, allowing students to respond to larger multiple choice and matching questions (Turning Technologies, 2018a). Though some of the newer and more expensive clickers can type in free text (Turning Technologies, 2018b), a personal mobile device cuts out the middleman and utilizes a keypad that students are familiar with using. This ability to use free texts allows instructors to include short answer and short essay questions for both polling and formative assessments in class.

To further relate to this current study, researchers recently explored mobile phone usage among students and discovered that 95% of students own a smartphone and 57% own a tablet (Chen, Seilhamer, Bennett, & Bauer, 2015). Though they are mainly used for social purposes, the study indicated that 73% of the smartphone owners and 45% of the tablet owners used the devices for learning purposes, whether it was on their own accord or required by the instructors. On top of that, the study concluded that fewer than 20% of instructors require the usage of mobile devices for coursework, suggesting that instructors may be missing out on a key opportunity to leverage an existing, free technology resources that students are already comfortable with.

Polling systems have been heavily studied within the last decade from multiple perspectives. Students have had positive perceptions on the feedback they receive from answering polling questions in their classes while finding clickers easy to use (Cotner, Fall, Wick, Walker, & Baepler, 2008; Shon & Smith, 2011; Keough, 2012; Chen, Seilhamer, Bennett, & Bauer, 2015). Studies where teachers providing motivational incentives for using clicker technology also show positive perceptions from students (Oswald & Rhoten, 2014). Other studies have shown

increased student engagement within large lecture hall classes while providing the teacher the ability to take attendance and quiz their students on lecture material (Bode, Drane, Kolikant, Schuller, 2009; Cai et al., 2011; Voelkel & Bennett, 2014). Furthermore, electronic feedback devices have been found to lower anxiety in students during classes (Sun, 2014) and help students with lower intrinsic motivation to perform better in class (Kim, 2020).

Current research is now undergoing a transition to look at mobile device polling, which has been compared directly to classroom clickers (Sun, 2014; Stowell, 2015). And with the numerous benefits from Mobile Polling and other classroom technology being researched, Universities are trying to find ways to improve student performance and increase their retention rates while navigating through increasingly tech-dependent learning environments. There are some abysmal data sets that outline the poor performance of American students on standardized tests, putting a strain on how institutions should improve K-12 education. Below, we will explore recent standardized test data that can highlight why educators are seeking ways to enhance learning via technology.

Standardized Test Performance

Standardized test scores are one of the driving forces that push for changes in academic curriculums around the world. The results from published test scores have the potential to bring along change, further increasing the likelihood of authoritative powers influencing educational policies for numerous reasons. The Programme for International Student Assessment (PISA), which is a well-known battery of tests that measure academic achievement, is a perfect example. PISA is a system of international assessments that allow countries to compare the learning outcomes of students near the end of compulsory schooling, and currently more than 70 countries use it as a global measuring stick. The primary assessments of PISA focus on the

performance of 15-year-old students in the areas of mathematics, science, and reading literacy (National Center for Educational Statistics, 2016).

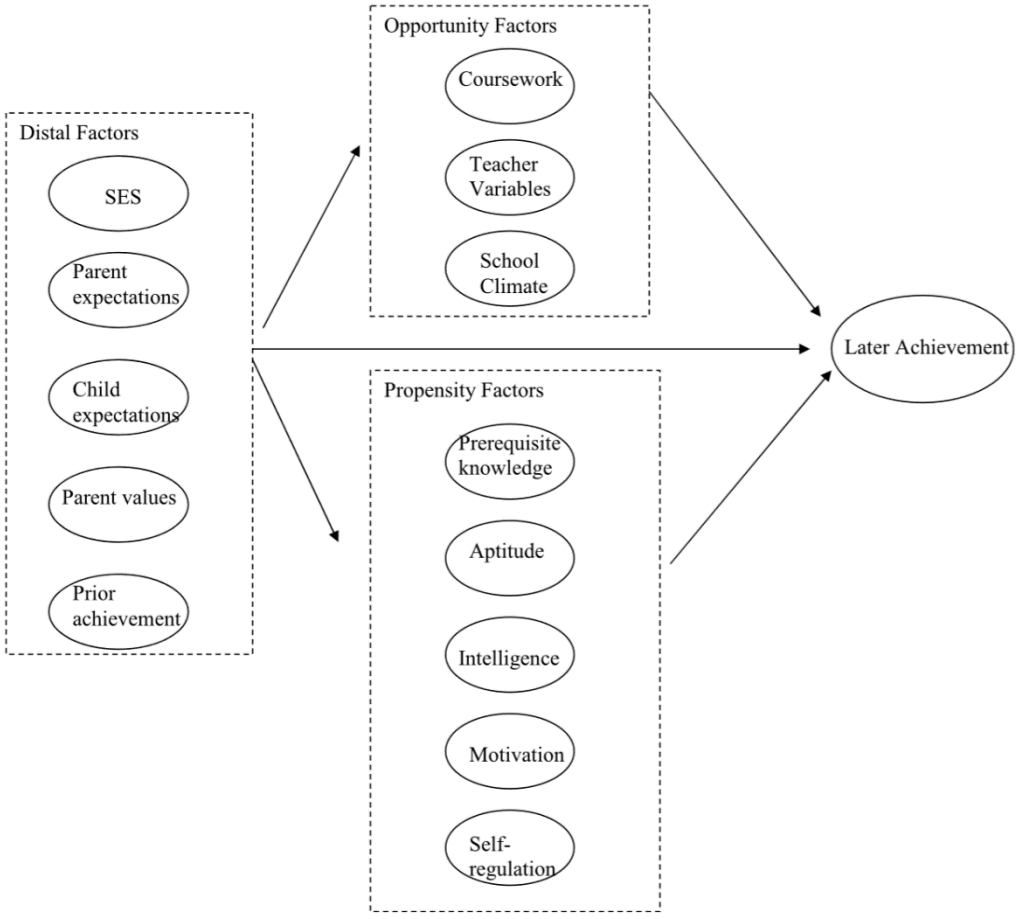
Given every three years to 15-year-old students around the world, a sample of over 500,000 is randomly selected and then weighted to be comparable to 28 million students that are representative of both the student's school and their country (Marchant, 2008). With the most recent results published from 2015, the PISA has revealed that the United States are placed at an underwhelming rank of 38th out of 70 countries in math, 25th in science, and 24th in reading scores. Moreover, the U.S. ranked 30th in math, 19th in science, and 19th in reading scores amongst the 35 members of the Organization for Economic Cooperation and Development (2016). The test does not reflect any specific school curriculum, and it goes beyond simple achievement to determine the students' ability to apply content to authentic situations.

Despite the assessment's low-stakes consequences for students, teachers, and schools, the resulting rankings of countries impact national educational policies. The negative consequences of concern include an increase in other standardized testing, a narrowing of curriculum to focus on PISA-based content, differential student familiarity with test format and technology, and a lack of cultural sensitivity. This concern over results also pressures institutions to implement new educational technology, curriculum designs, and instructional methods that may be financially draining or time-consuming. Thus, researchers and educators from numerous domains and fields look at different ways to interpret data, attempting to explain why U.S. students under-perform on both national and international comparisons. With many scholars pointing towards metacognition as the root of learning problems, the next section below will expand on the Byrnes Opportunity-Propensity Model as a theoretical framework for this study and how it ties into metacognition.

Byrnes' Opportunity-Propensity Model of Achievement (OPMA)

Educational research is a large umbrella that covers over countless domains and fields of learning. Holistically, there are countless variables across these fields that impact a student's ability to learn, and researchers will often target specific variables within their domain to isolate learning experiences. This is where the Byrnes Opportunity-Propensity Model of Achievement helps examine numerous factors at once which contribute to learning, placing them into three categories, and then describes their interactions and overall progression as shown in Figure 1.

Figure 1. The Opportunity-Propensity Model of Achievement (OPMA). From Byrnes and Miller, 2007).



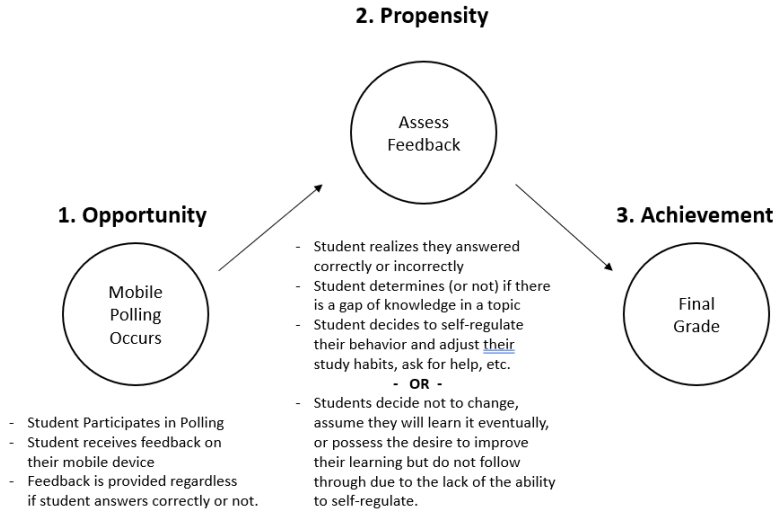
Byrnes and Miller (2007) took predictive factors and broke them down into three specific categories: opportunity, propensity, and antecedent factors (formerly known as distal factors). Opportunity refers to aspects of learning contexts at home and school that promote learning such as content exposure (what content is taught) and instructional approach (how this content is taught). It's important to note the wide variety of learning environments students are exposed to, such as classrooms, parents reading books to their children, trips to museums, online videos, and so on. Meanwhile, Propensity refers to the characteristics that make students prone to acquire skills in these learning contexts such as existing knowledge, motivation, self-regulation, and others (Byrnes, Wang, Miller-Cotto, 2019).

The Opportunity-Propensity Model states that it is necessary for two conditions to be met for high achievement to occur in a specific domain,: (1) students must be exposed to *opportunities* that would inevitably allow them to acquire knowledge in a particular domain and (2) students must have the *propensity* or the ability and willingness to take advantage of these opportunities (Byrnes & Miller, 2007; Byrnes & Miller-Cotto, 2016; Byrnes et al., 2019). To give an example of these two steps, a teacher could provide office hours to students or create supplemental instructional material for free online. The opportunity to use these resources is now present to the students. However, the students must have the ability and willingness to make the necessary steps forward to utilize this opportunity effectively. In the same line of reasoning, it is also important to ask why some students are exposed to more learning opportunities and why they are more willing and able to benefit from these opportunities when they are presented. Antecedent factors are variables that provide answers to these questions and include things like socio-economic status, gender, race/ethnicity, and parental expectations for their children's education. Thus, the theory is constructed by considering a variety of possible variables in

empirical, multi-variate studies (Byrnes et al., 2019). In the case of this study, teachers would have to understand the value of polling, possess a certain level of tech-savvy to learn how to use it, and utilize mobile polling effectively with their content. These characteristics of teachers could technically be antecedent variables that explain why students are exposed to polls in class. Another antecedent factor could be anything explaining why a student chooses a specific class with a specific professor.

Relating the model to the current study, an opportunity for high achievement can also come in the form of receiving feedback on formative assessments. Students can engage in a low-stakes classroom activity designed by their teacher and answer questions using their mobile devices during class. Their answers are private, taking away social awkwardness or fear of being wrong in front of their peers, and students can use mobile polling as a self-assessment tool to check if they understand the class material or topic. Below, Figure 2 shows how the Opportunity Propensity Model implicates a mediation analysis of the ability to self-regulate: a key propensity factor.

Figure 2. OPMA applied to the usage of Mobile Polling and Self-Regulation



To summarize, teachers who use mobile polling in their classes are giving an opportunity to all students to see what they know and what they don't know, regardless of the antecedent factors present that would typically limit the types or chances of learning opportunities to occur. However, factors that influence the perception of an opportunity, the willingness to participate in mobile polling, or the desire to do well on the polling assessments tie into the concept of metacognition. With the O-P Framework in mind, we will explore the construct of metacognition in the next section to further analyze the mediating role of self-regulating behavior.

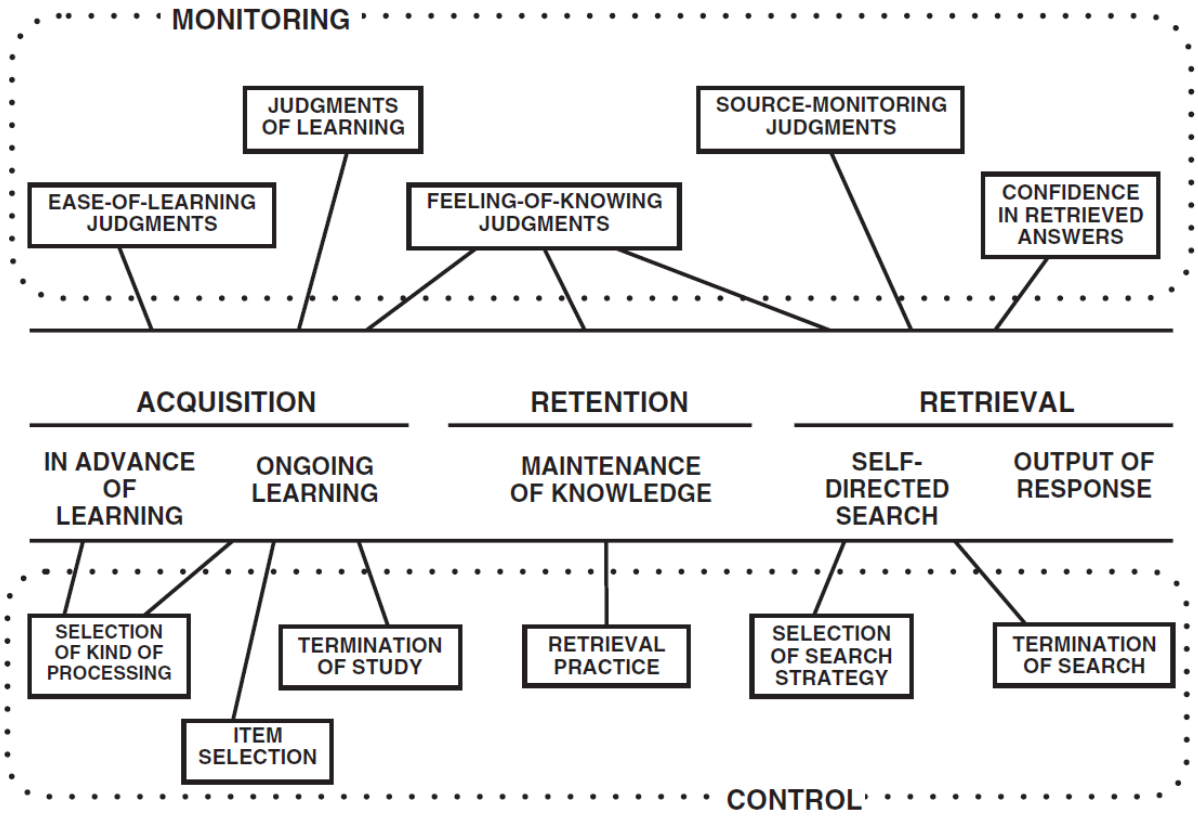
Metacognition

The concept of metacognition was derived from cognitive information processing theory to include traces back to Jean Piaget (Robson, 2016) and was conceived in the early 1970's from the studies by Ann Brown and John Flavell analyzing metamemory. Specifically, these studies refer to exploring children's ability to store and retrieve information (Brown et al., 1983; Flavell, 1976; Flavell, Miller, & Miller, 2002; Schneider and Artelt, 2010). There are numerous definitions and conceptualizations of the term "metacognition" within literature on cognitive development. In simpler terms, Brown (1987) stated that metacognition is "one's knowledge and control of their cognitive system" while Nelson & Narens (1994) refer metacognition as the monitoring and control of one's thought processes. However, a recent article by Nigg (2017) highlights how several constructs have been blurred across the field of psychology as such simplistic definitions has caused some conceptual confusion. Nigg points out that specific lower-level functions are called upon in response to conflict, whether it may be a response to a problem or interference from task-irrelevant thoughts. These functions are often highlighted in research as working memory, attention, action selection, and inhibition (Botvinick & Braver,

2015), and Nigg stresses that these functions and their continual maintenance is what separates metacognition from other constructs such as Self-Regulation (which are *intrinsic* processes, that are both higher and lower, aimed at adjusting mental and physiological state adaptively to context) and Executive Function (which are top-down cognitive functions involved in top-down control of behavior, emotion, and cognition; support goal-directed behavior and cognition; and can be employed for top-down Self-Regulation). Therefore, Nigg concludes that while the lower level functions of metacognition are important, it's important to acknowledge the continual upkeep necessary to dynamically shift between tasks. He found this was best defined by Miller & Cohen (2001) as "the active maintenance of goals and means to achieve them."

With this idea of active maintenance in mind, Nelson & Narens (1990) wrote an influential paper that argued metacognitive monitoring and metacognitive control play primary roles and interact in important ways when it comes to the acquisition, retention, and retrieval of to-be-learned information. The framework they developed, displayed with two additions below in Figure 3, became an early guide for metacognition research and was further adapted to highlight some of the lower functions and continual maintenance required to exercise cognitive control.

Figure 3. Adapted from Nelson & Narens' (1990) framework of Metamemory. From Bjork, Dunlosky, and Kornell (2013).



To further expand on the additions to the framework, Dunlosky, Serra, & Baker (2008) added "Source-Monitoring Judgments" to the retrieval section while Bjork, Dunlosky, & Kornell (2013) later made a further addition with "Retrieval Practice" in the Retention section. The main purpose for these additions stated that a sophisticated learner will make a judgment during a criterion test pertaining to the source of a particular memory. However, in order to keep that information and procedures accessible until some criterion test, that learner knows to reinstate/retrieve that information and procedures prior to that test for better retention purposes. In summary, making continual assessments and decisions is the core of the learning process. Some examples of this could be considering what to study next, how to study it, determining

whether the learning will be successful when trying to recall the information later, analyzing what one has recalled is correct, and so forth (Bjork et al., 2013).

Moreover, this crucial back-and-forth process is also explained in Figure 3 between the overarching processes of monitoring and control. An effective learner is able to make judgments that assess the current state of one's learning (illustrated at the top of the figure as types of monitoring judgments) while also controlling their own learning processes and activities in response to their judgments (illustrated by the bottom of the figure as the decisions made to exercise control). Successfully handling these two processes can be a challenge since learners believe learning may have been achieved, usually resulting in overconfidence, or the tendency to believe certain learning activities may be effective when, in reality, they may not. Understanding the state of one's learning may also be challenging because of how that person bases their self-assessment, which may be a misleading subjective interpretation. Retrieval fluency, which is how accessible information and procedures come to mind when needed, could be affected by factors such as predictability, recency, and cues which are available during the learning process but not available later on (Dunlosky et al., 2008; Bjork et al., 2013).

Lastly, being aware of the biased judgments we make regarding hindsight and foresight is an important part of assessing one's own learning state. Fischoff (1975) referred to the concept of hindsight bias, which is the tendency learners have to think they knew the information all along once the information is presented to them. An example of this would be a student preparing for an upcoming exam and attempting to decide what to study beforehand, which may result in skimming through sections of a textbook and feeling like they know the topic. However, once the information is no longer in front of them, the learner is unable to retrieve the information and comes to the realization that they may not know it as well as they thought. As for foresight bias,

a learner may have the tendency to know-it-in-the-future when it comes to testing. This happens when a learner does not truly understand some type of information when studying but believes that the answer will "pop out" as somewhat natural or obvious when placed in context of a question. They believe the question itself will elicit a correct response. And like hindsight, the learner may be presented with a question during a test and find themselves unable to retrieve the correct answer (Koriat & Bjork, 2005).

Metacognition is both an interesting domain of study and serves as a connector between other domains, such as learning and motivation, memory and decision making, and how learning ties into cognitive development. Many cognitive psychologists argue that failures of metacognition lie at the root of learning problems (Brown, 1978; Flavel, 1979), and there is a vast amount of evidence to support that the use of metacognitive strategies improves academic achievement (Gorsuch & Taguchi, 2010; Peters & Kitsantas, 2010; Sperling, Richmond, Ramsay, & Klapp, 2012, Vula, Avdyli, Berisha, Saqipi, & Elezi, 2017). In the simplest of terms, students who are able to self-assess what they know, what they don't know, establish a goal for themselves to learn new material, identify what steps they need to take to learn the material, and put it into practice is crucial for their own development and academic achievement. And since there are many variables that can interfere or hinder this learning process, teachers and instructors do their best to present material in small, progressive chunks, often asking students to demonstrate their mastery of the subject matter over time through various types of assignments, presentations, or group work.

Linking Metacognition to Formative Assessments

One way to improve a student's metacognition and overall performance is the use of corrective feedback after formative assessments (Potts, Shanks, & Gauthier, 2014). Formative

assessments can come in the form of quizzes, graded assignments, or simple classroom facilitation of questions and answers. Instructors can provide feedback to the students in real-time in the classroom during a discussion or add comments when grading a paper. There is also evidence to suggest that generating answers to assessments can still be beneficial despite making many errors, if corrective feedback is then provided (Kornell, Hays, & Bjork, 2009; Metcalfe, 2017). The assessment and feedback are both tied together as an "opportunity" for the student, as long as they view the assessment and feedback as an opportunity and possess the propensity to apply the feedback moving forward. For example, a student with high levels of metacognition who did not perform well on a formative assessment could view the experience as an opportunity to focus on their specific weakness, set goals to improve those weaknesses, identify what steps they need to take, and regulate their behavior to ensure they take the necessary actions to meet their goals. When an instructor stops to assess student understanding of lecture material, formative assessments help students see that they really did not understand the material.

Moreover, feedback received in a classroom during exercises and formative assessments is an instructional method known as "active learning", which has been defined as "a learning style where students are required to do something instead of simply listening to a lecture and absorbing written text" (Goldstein, Wallis, & Rhem, J. 2015). These activities can vary from group problem-solving, completing worksheets in class, or using classroom response systems (Freeman et al., 2014). Newly taught information can be re-emphasized through active learning exercises, making students analyze and apply problems in an environment where they can receive help and feedback if they need it. Freeman and colleagues (2014) conducted a meta-analysis of 225 peer-reviewed, empirical studies that involved an intervention group that applied active learning compared to control groups of students that were given the passive, lecture style

methods in math and science courses. The findings revealed that courses who applied active learning methods had an increased average of 6% on examination scores. In addition, students in classes that were primarily utilizing traditional lecturing approaches were 1.5 times more likely to fail in comparison to students in active learning style classes. Though several types of active learning were included in the meta-analysis, classroom response systems were one of the primary methods of instruction.

Essentially, formative assessments and quality feedback provide new "opportunities" of knowledge for students to take in during a course and improve their metacognition. However, the way students perceive these opportunities and the actions they take after being exposed to such information can be entirely different based on the individual's antecedent and propensity factors. Even if a student has a goal of improving their grade in a class and establishes necessary steps they need take in order to reach that goal, the ability to self-regulate their own behavior and put those thoughts into action may be a crucial hindrance. Tying into a student's Propensity, the following section will expand on self-regulation and its impact on learning.

Self-Regulation and the use of Mobile Polling Systems

Self-regulated learning has been a popular topic in Educational Psychology for the past several decades, leading to such sub-domains as self-monitoring and self-assessment. Like Metacognition, various definitions have emerged to describe what Self-Regulation (SR) is, however, the differing terms across fields and domains has hindered progress on its role. Nigg (2017) argues this point heavily when comparing it to Executive Function and Metacognition, defining it as "The intrinsic processes aimed at adjusting mental and physiological state adaptively to context." As part of the "maintenance" function of Metacognition, SR contains top-down and bottom-up processes that alter emotion and behavior to achieve a goal. Such

processes are guided heavily by motivation, meaning that a person who can self-regulate their own behavior can engage in behaviors and implement cognitive processes that lead to achieving an established goals (Edens, 2008). This also refers to the awareness of their own behaviors and how they are adopted and practiced by the learner (Schunk, Meece, & Pintrich, 2013).

Self-regulation is positively associated with achievement and contains several processes such as planning, attentional control, and self-evaluation (Dillen & Papies, 2015; Winne, 1995; Zimmerman, 1998; Zimmerman & Risemberg, 1997). Research has also found that the learning achievement for students significantly improved when self-regulation strategies were introduced and routinely utilized (Montague, 2007; Porath & Bateman, 2006). And with a suitable design in place, studies have shown that a learner's ability to self-regulate can be improved with the proper usage of classroom technology such as clickers and mobile devices (El-Bishouty, Ogata, Ayala, & Yano, 2010; Sha, Looi, Chen, Seow, & Wong, 2012). As an example related to the current study, Edens (2008) found highly self-regulated students significantly out-performed others with lower self-regulatory skills using classroom polling devices known as *clickers,* the predecessor to mobile polling. Moreover, Edens advocated for instructors to pursue the development of self-monitoring and self-assessing processes in their classrooms, with or without the use of clicker technology. However, it is important to note that Edens measured self-regulation differently than this current study, using the Motivated Strategies for Learning Questionnaire that includes a whole section on motivation on top of a learning strategies section (Pintrick, Smith, Garcia, & McKeachie, 1991).

As with the measurement example from Edens above, Self-regulation can be analyzed from the viewpoints of numerous domains. Scholars from varying theoretical backgrounds highlight different aspects of self-regulated learning. If we were to apply Bandura's social cognitive

theory (Bandura, 1986) to a modern-day classroom with mobile devices, environmental factors (e.g. how interactive the teacher is with their students) and behavioral factors (e.g. a student opening a mobile app in class) would reciprocally determine personal cognition (e.g. a learner's level of affect and motivation to learn). Traits such as being pro-active and having the ability to self-regulate are what best describe humans as compared to reactive beings that are exclusively molded by external environmental influences or genetic impulses that trigger certain reflexive responses (Bandura, 2001; Martin, 2004). Social Cognitive Theory describes how people become a product of their environment while also shaping it as their behavioral and cognitive functioning is determined. This theory suggests that the success of any learning environment to influence the behavioral engagement of a learner is conciliated by characteristics of the learner themselves, specifically the student's prior knowledge, their particular goals, and their self-perception of the task. Thus, a mobile learning environment is not only concerned with technological issues that could occur, but also with learners' personal factors and behavioral patterns (Sha et al., 2012).

Besides Social Cognitive Theory, there are other influential models of self-regulation learning (SRL) that span across different perspectives. Boekaert (1992, 1995, 1996) developed a model of adaptable learning which declared appraisals are at the center of the SRL process. The perception of the learning situation, domain-specific metacognitive knowledge, and motivational factors influence appraisals, which were assumed to the learner's classroom behavior. Positive appraisals assume to extend subject knowledge and increase skills while negative appraisals may move toward protecting self-ego to prevent a loss of resources. Under this theory of SRL, Mobile Polling would provide students quality feedback via the formative assessments they provide. A student who participates in a mobile polling question and gets the question wrong

would not have to worry about protecting their ego in front of their classmates. The student will see the correct answer if the teacher chooses to show it to the class and will not reveal which individuals were incorrect. The negative appraisal will still occur; however, it is up to the student to then decide what to do next. If a student got one or two polling questions wrong and are aware that their responses are being recorded, the mobile polling experience may push the student to believe the class material is more important, improve their study habits, or pay better attention in class.

Boekaerts and Niemivirta (2000) later refined this model by assuming SRL interacts with metacognitive, motivational, and emotional control systems. They stressed the contrast between optimal and non-optimal conditions for SRL to occur, describing optimal conditions to be situations where an opportunity for leaning is combined with the feeling of learning being necessary. While every teacher would love to think that all students find their classroom lectures interesting and important, emotional factors outside of class and the motivation level of a student could affect their perception on the learning opportunity or the perception of how important the content may be. While mobile polling may not provide a solution to emotional issues outside of class, the sheer action of engaging in a classroom activity could help students break away from a nagging personal issue.

However, there are other mounds of research that target the negative aspects of classroom technology, especially those involving programs where instructors are unable to completely monitor the activity of students. Researchers from various domains and backgrounds have different perspectives that counter some of the positive points mentioned earlier regarding mobile polling. In the next section, we will explore the findings of other studies that focus on

distractions and disengagement specifically from mobile devices in a classroom while linking it to the crucial cognitive process of Executive Function.

Distractions through Mobile Devices

A common perception within education is that distracted students will equate lack of attention to the lecture or classroom activities. There have been numerous studies indicating the negative impact that distractions have on students and the classroom environment. Previous studies show that professors who allow cell phones within a classroom can experience detrimental effects to students' overall academic performance (Bugeja, 2007; Froese et al, 2012). Other studies have examined the distracting effects of a ringing cell phone and texting sounds during assessments, which reduced overall grades regardless of who owned the noisy cell phone (Shelton et al., 2009; Froese et al. 2012). Such examples highlight the fact that even focused, well-behaved students can be affected by a neighboring student who uses their phone in class.

Mobile phones are no longer considered novelty items and leaving home without it could be considered inconceivable. Tindell and Bohlander (2012) completed a study where 95% of the participating students brought their phone to class and 97% of those students admitted to sending or receiving text messages prior to class beginning. About 92% of the phone owners admitted to sending or receiving a text during class at least once and nearly 30% admitted they do this every class. Another overwhelming finding was that 97% of the students reported that they witnessed a fellow classmate texting at least once. These types of distractions pull students from class lectures, even if they are not using their phone.

Another notable study reported more than 80% of students across multiple universities use their phone at least once per class and that students generally believe this to be an acceptable practice (Berry & Westfall, 2015). To go along with this, one of the oldest concerns with phones

in classrooms is “noise pollution” where beeping, buzzing, vibrating, or other types of noises would interfere with class. Yet oddly enough, none of the teachers reported any type of audible disturbance. This demonstrates that students were courteous enough to place their phones on silent during class. However, 50% of students reported audible interruptions at least once or twice a class. The researchers of this study believe that this perception is possibly attributed to greater student sensitivity on localized disruptions which may go unnoticed by the instructor.

An older pilot study conducted by Burns and Lohenry (2010) noted only 45% of 197 students admitted using cell phones in their classrooms. However, 85% admitted they were distracted by people using cell phones. Though this study was primarily focused on how teachers can combat cell phone use in class, their research went into a larger case study which noted that texting is the most common cell phone misuse in class. However, many other activities were observed and reported, which included cheating, sexting, playing games, emailing, and using social media (Ali, Papakie, & McDevitt, 2012).

Moreover, there are several other cognitive processes at play when a student decides to shift their attention to their phone. The common daily use of mobile devices has many of us drifting in between levels of consciousness, checking our phones without knowing it all the way up to deliberate use of our devices. These tendencies to drift between such levels of consciousness are related to individual self-control and mindfulness (Bayer, Dal, Campbell, & Panek, 2016). There is a chance that students reach for their phones out of pure habit while listening to another person talking or watching tv, believing that they are still engaged. Texting and driving would be another example of this denial of distraction.

Social Media and Mobile Phones

While texting is still a common activity today as it was during these older studies, the widespread usage and accessibility to social media has become one of the main distractions and sources of time consumption for students both inside and outside of class. The amount of literature on social media is vast. However, there are numerous definitions that attempt to describe what social media is since there is not a mutually agreed definition across disciplines (Effing, van Hillegersberg, & Huibers, 2011; Kaplan & Haenlein, 2010; Xiang & Gretzel, 2010). In the broadest of terms, social media can be defined as any form of computer-mediated communication where individuals can generate and present content and/or view and interact with content of their friends or other users online (Carr & Hayes, 2015). The creation, viewing, and interaction of so-called "content" can include but is not limited to private messages, images, videos, profile pages, hashtags, "snaps", "likes", comments on profile pages, and comments under images and videos (Bruns & Burgess, 2012; Gonidis & Sharma, 2017; Hanusch and Bruns, 2016; Highfield, Harrington, & Bruns, 2013; Larsson and Moe, 2012; Russo, Watkins, Kelly, & Chan, 2008).

The access to social media platforms rapidly increased over the last fifteen years as the hardware for mobile devices improved. Social media companies began making their websites mobile friendly, allowing content to be resized and fit within tiny display parameters specifically for the web browsers on smaller devices. Eventually, social media companies created their own apps which bypassed mobile browsers and allowed users to view content faster due to customized interfaces and enhanced security features. Improvements to wireless networks by telecommunication companies and internet service providers further allowed social media users to have instantaneous access to real-time feeds, providing on-demand entertainment within

seconds. And now, students are experiencing numerous social media platforms rise and fall with social trends and the changing landscape of what social media has become. Many social networking sites and services are created and never establish a firm foothold, often bought out by other companies and either dismantled or integrated into other products (Lomborg, 2017).

The reason social media is so different compared to previous mobile device activities is that students receive notifications on their phones that usually do not make a sound compared to texting. Most current smart phones will have a lock screen for security purposes. However, the screen itself will light up with a notification from a social media app to alert the user that there is something of interest for them to see. Unless the user disables such alerts, these notifications could range from friends liking or commenting on one of the user's posts to receiving a private message. Moreover, Social Media users can quietly scroll through numerous posts and comments without typing anything, distracting them momentarily while they do so. Students can access these apps without making a sound or distracting their neighboring classmates, so the only true ways to restrict such access is by students turning off their phones, putting their devices on airplane mode, or putting their phones completely out of sight.

But Social Media is more than just apps and notifications. Social Networking sites are now a digital space that allows a free way to market products, services, and personal brands of young entrepreneurs like twitch streamers (Sjöblom & Hamari, 2017), YouTube creators (Hoiles, Aprem, & Krishnamurthy, 2017), meme generators (Zittrain, Nooney, & Portwood-Stacer, 2014), fitness enthusiasts (Stragier, Vanden Abeele, & De Marez, 2018), and aspiring entertainers in all realms of art. To go even further, many young adults use social networking sites as a catalyst for dating, finding job opportunities, or catching up on everything from local to national news with a tap or a swipe of their finger. One could argue that research on mobile

devices within the classroom from the mid-2000's is obsolete in certain respects due to the technology advancements on hardware, software, utilization, and cultural acceptance of mobile phones being something as necessary as your keys and wallet.

With many domains focusing on social media and its usage, cognitive and behavioral studies have found interesting results that could affect a student's study habits and classroom actions. Some studies analyzed chronic usage of social media in the terms of addiction and dependence on various characteristics that these platforms provide, such as entertainment, business facilitation, social capital, and social interaction (Andreassen, 2015; Hanusch and Bruns, 2016; Kuss et al., 2014). Some scholars go as far to say that social networking sites may be addictive since some users display symptoms that are associated with people who suffer from other forms of addiction (Kuss & Griffiths, 2017). Individuals who excessively use social networking sites have appeared to have withdrawal symptoms, mood modification, salience, conflict, tolerance, and relapse (Muller et al., 2016; Turel, Serenko, & Giles, 2011). While other authors argue on the classification of problematic social networking use as a disorder, there are a subset of social networking users that display a preference for computer mediated interactions in addition to a few negative consequences because of their overwhelming use (Caplan, 2005).

In regard to self-regulation and attention control, distractions may appear intentionally or unintentionally, yet both can have uncontrollable effects on a person's desires or behavior at that specific point in time. This can be considered especially true for stimuli that provide some type of motivational relevance for the individual, like a delicious piece of cake, the urge of smoking a cigarette, or the consoling of an angry spouse (Dillen & Papies, 2015). An urge to check a text message or a social media notification you just received could be stronger based on your emotional state and your personal priorities at that moment. In short, one could argue phones

and mobile devices serve as appealing stimuli to some students more than others based on the individual, especially if the student lacks the propensity to take advantage of the educational opportunity mobile polling provides. This notion of reacting to stimuli, or perceiving what is and what is not stimulating, brings us to a domain of cognitive and neuropsychological importance: Executive Functioning. The next section below will explore why it is an important part of self-regulating classroom behavior and explain the background of the measurement for the current study.

Executive Functioning and the Barkley Deficits in Executive Functioning Scale

Like the previously mentioned constructs, Executive Functioning (EF) has well over 50 definitions and up to 33 constructs associated with it (Eslinger, 1996). For example, several studies have focused on a hierarchical concept that describe EF as "A set of at least partially independent top-down functions that support goal-directed action" (Banich, 2009; Blair, Raver, & Finegood, 2016; Friedman & Miyake, 2016; Miyake et al., 2000). Meanwhile, there have been other studies that target a synchronous approach that can be defined as "complex cognition including manipulating two things in mind at once, reasoning, temporal projection, and complex mental and action sequences" (Barkley, 1997; Diamond, 2013). And to make matters worse, domain-specific studies often drill down into singular processes that could be argued as functions that belong to other constructs in one way or another.

On a neuropsychological level, EF includes various functions, abilities, and processes such as cognitions, emotions and motor/verbal behaviors (Barkley, 2012). The list of EF functions and processes is long, though researchers have tied many of these functions to both metacognition and self-regulation. These processes include set maintenance, set-shifting, response inhibition, use of feedback, use of goal-directed behaviors, filtering interference, and

the ability to anticipate the consequences of one's actions (Anderson, Anderson, Northam, & Mikiewicz, 2002; Ardila & Surloff, 2007; Barkley, 1997; Denckla, 1996; Fisk & Sharp, 2004; Goldberg, 2001; Jurado & Rosselli, 2007; Lezak, 1983; Luria, 1980; Mason, Humphreys, & Kent, 2005; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000; Pennington & Ozonoff, 1996; Quay, 1997; Stuss & Knight, 2002; Tannock, 1998; Welsh & Pennington, 1988). When these processes are integrated, EF can be considered the "make or break" point of a student completing their goals or deciding to change their behaviors to reach those goals in terms of their metacognition. The same could be said for a student who experiences a distraction and has their ability to self-regulate challenged, forcing them to make a choice, adapting to a situation, and inhibiting inappropriate behavior to stay on track.

However, the lack of a clear definition has made it difficult to evaluate EF, especially with researchers focusing on specific processes within EF. Working memory is arguably one of the most studied constructs of EF and is generally measured by incorporating straight memorization and manipulation (or interference) task (Burgess & Shalice, 1996; Lezak, Howieson, & Loring, 2004; Weschsler, 2009). Meanwhile, assessments of inhibition usually measure the ability to inhibit competing responses in the presence of salient and conflicting stimuli (Burgess & Shallice, 1996; Heaton, 1981, Trenerry, Crosson, DeBoe, & Lebere, 1989). Another popular EF process that is researched is the vigiliance/attention construct, which also has several psychometric tests available for various degrees of measurement (Conners, 1995; Greenberg, 1991; Gordon, 1983; Lewis, Kelland, & Kupke; 1990).

The menagerie of tests of EF mentioned above were initially based on their ability to distinguish patients with possible frontal lobe damage (Jurado & Rosselli, 2007). However, these EF tests are problematic since they measure different individual abilities. One study found

a low correlation amongst the EF tests ($r < .40$), which leads doubt to the ability accurately measure the entire construct of EF as a whole (Miyake et al., 2000). Moreover, research from earlier in this chapter highlighted how many of the functions above were identified as lower level cognitive processes that are associated with metacognition. Thus, researchers are beginning to move away from utilizing cognitive ability tests as a definitive predictors of EF and now actively seeking other ways to assess and encapsulate the various symptoms associated across all the processes of EF.

Barkley and Murphy (2011) stated the assumption that these previously used EF tests are invalid and shouldn't be used as indicators for EF deficits. In addition, substantial findings on adults with ADHD indicated that ADHD has an association with EF deficits (Frazier, Demareem, & Youngstrom, 2004). This connection of ADHD and the deficits in EF includes Self-Regulation (Nigg, 2017) and Barkley (2011a) initially developed a definition for EF as "self-regulation across time for the attainment of one's goals (self-interests), often in the context of others." This definition speaks to the importance of SR to manage emotion and behavior in order to intrinsically adapt and achieve a goal. To go even further, Barkley has argued that the primary deficit of ADHD is a failure in self-regulation and suggests that ADHD should be renamed as Executive Functioning Deficit Disorder (Barkley, 2011b).

Barkley (2012) later went on to expand on this definition and further clarify the importance of the hierarchical steps involved to oversee the self-regulatory process, stating that EF is "Partially independent, top-down cognitive functions involved in top-down control of behavior, emotion, and cognition; support goal-directed behavior and cognition; and can be employed for top-down Self-Regulation." And with a solid definition in mind, Barkley wanted to create an assessment that could properly measure the deficits of EF in a wholistic approach and developed

the Barkley Deficits in Executive Functioning Scale (BDEFS); a psychometric scale designed to evaluate EF deficits that may exist the everyday life of adults with ADHD.

The main focus of the BDEFS is to collect an overall view of impairment and deficits across all EF domains instead of focusing on them individually. The origin of the BDEFS assessment is based off Lezak's (1983) original concept which theorized EF could be recognized through observable deficits in social, goal-driven impairment rather than analyzing the differing cognitive abilities in EF like the previous EF tests. A recent study analyzed the BDEFS and found that the scale predicted performance in college better than other tests of EF (Dehili, Prevatt & Coffman, 2017). And because of the deep involvement between ADHD and Self-Regulation, the BDEFS was chosen as the measure for this study since mobile devices are an easily accessible distraction and self-imposed hinderance in today's typical classroom.

Considering the research given on Executive Function to phone usage in a classroom, mobile polling technology is ironically placing a device in the hands of a student with the expectation that they will be attentive and participatory. Students who were once hiding their phone usage under their tray tables will be reaching for the mobile devices more often than before due to an instructor asking them to do so. Stimuli in the forms of texts and social media notifications may be noticed before polling begins, possibly becoming an obstacle to overcome for some students who can't self-regulate their behavior. And while cheating and social etiquette are common concerns for the classroom culture, the landscape of what mobile devices can do has drastically changed since the first iPad or smartphone. The current era of hand-held technology presents a problem for any instructor wishing to use mobile polling as students can have multiple apps open at once while polling occurs. Students can submit a response to a multiple-choice question and easily browse Instagram, sports scores, or view private snaps from Snapchat while

they wait for their classmates. And all of this can be done without the instructor unable to see what activity the students are engaged in. Therefore, there is a need to investigate the self-regulatory processes of these students who become distracted, especially if a teacher is unintentionally providing a tempting opportunity for students to disengage from the class through their mobile devices.

We should ask, "How has the convenience of using their phone in this class hindered their ability to self-regulate?" Or, "How has the classroom environment, the teacher, or other students affected the actions students take to achieve their goals?" This study aims to take the step forward in addressing the possibility of introducing additional distractions when using mobile polling to further validate or reject the purchasing and use of such software.

Research Questions

Today, the rapid pace of technology fosters the development of mobile devices that are far more powerful than smartphones created a decade ago. Social Media has expanded to free apps that are available to any Android or iOS device and up to 60 popular social platforms world-wide. Additionally, 4G coverage throughout the United States is at its highest point, unlimited data plans are common and affordable, and Wi-Fi networks are more available throughout college campuses. The early studies on mobile polling and self-regulation with mobile devices cited above were conducted when mainstream Social Media was limited to Facebook and Twitter. However, the findings from such research has shown that mobile polling is an excellent formative assessment tool that provides direct feedback to the students. With the current boom of Universities spending money and resources to utilize this technology, we should ask if mobile polling is truly beneficial for all students who are asked to use it. Will some students benefit more from mobile polling compared to others? This exploratory study is

designed to determine if there would be differences between the overall academic achievement scores of students with high and low levels of self-regulation:

1. Do students enrolled in courses that utilize the mobile polling technique show higher achievement at the end of the semester than students enrolled in business-as-usual classrooms, controlling for initial achievement?
2. Do students who report higher levels of self-regulation show higher achievement at the end of the semester than students who report lower levels of achievement, controlling for initial achievement?
3. Do students only benefit from mobile polling depending on their level of self-regulation?

CHAPTER 3

METHODS

Participants

Participants for this experimental study were selected due to convenience based on the willingness of an instructor who: 1) had two sections of the same course, and 2) was both comfortable and proficient in integrating mobile polling into one of these sections. The instructor also received brief refresher training from the University's Center for the Advancement of Teaching (CAT) as a form of quality control to ensure the instructor knew how the software should work within their classroom and how to properly design polling slides for formative assessments. The course was an Education course that was open to all Education majors in an urban University located in Philadelphia, Pennsylvania. Both sections of the course were initially taught in-person. However, COVID-19 forced all classes in the University to be moved online at the time.

The polling section had 34 willing participants while the control section had 32 willing participants, bringing the total number of participants of this study to 66. The age range for these participants was 18 to 22 with most of the students being freshmen or sophomore due to the level of the course. In addition, all students had a mobile phone with basic texting capabilities or with the ability to connect to Wi-Fi. Despite the unexpected move to a virtual format, all mobile polling students were able to participate in polling questions with zero issues. Students who participated throughout the entire study were permitted to receive five extra credit points within the course.

Treatment – Mobile Polling

The treatment variable was the use of Mobile Polling after the first test of the semester, roughly six weeks into the course. The scores of the midterm exam in both class sections served as a pre-test to identify any achievement differences prior to the treatment. The instructor utilized mobile polling in one section of their course while teaching the second section with the exact same lecture without the use of polling. The dependent variable is "Overall Achievement" and was determined by the final exam score in the class. Achievement gains were monitored between the two test scores in the course, and the instructor saved the polling reports after every class to show polling participation and attendance throughout the semester.

All students were able to access the University's wireless network for the first week of polling as the classroom had two access points located in the ceiling and several outside of the classroom in the hallway, bolstering the signal strength within their vicinity. Each access point could easily handle up to 100 connections with no effect on upload or download speed. When classes were moved to the virtual format, students who remained on campus could still access the University's secure wireless network, use their own private network, or use 4G data on their phones to participate in mobile polling.

The polling software, known as Poll Everywhere, allowed the instructor to import sample polling questions into Power Point lectures. Students participated in the poll by logging into a specific URL or texting a special code to a number that the instructor set up prior to class. Students did not have to pay to use Poll Everywhere. The instructor used a PowerPoint slide deck for every class, which was held three times a week on Mondays, Wednesdays, and Fridays and then imported four polling questions in each slide deck. The mobile polling group was asked to pull out their phones and respond to the four polling questions throughout the class,

which exposed the mobile polling group to a total of twelve polling questions per week. The polling questions served as a formative assessment to check for understanding on the material being covered. The control group received the same PowerPoint slide deck without the polling slides along with the same lecture and tests. The only difference between the treatment and control group was the use of mobile polling.

Procedure

All participants were told the purpose of the study, how it would be conducted, and then signed a consent form to continue under the premise that their participation in the study would not affect their grade in class unless they opted to receive extra credit points. The consent form is listed at the end of this document under Appendix A. The participants completed the Barkley Deficits in Executive Function Scale (BDEFS) via a weblink sent to the students through their Canvas course. The BDEFS questions are listed at the end of this document under Appendix B.

The questionnaire was used as a quick-screen for self-regulatory traits in regards to metacognition. It was distributed to both the mobile polling and non-mobile polling classes, which was dummy coded as 1 and 0, respectively. Moreover, mobile polling was used after the first test has been given to establish a baseline of where students were currently performing academically in the course. The first test was after the sixth week of class, allowing the use of mobile polling for about nine weeks with the mobile polling section.

The instructor of the course was present when the participants were briefed to assure the awarding of extra credit points for those who volunteered to participate in the study. The questionnaire was delivered via web link and could be completed on any mobile device or laptop. The questionnaire did not have a time limit for completion. If a student was not present at class, the web link was out sent by email to ensure all students had the chance to complete the

questionnaire. Eight students (for from each section) were not present on the day of the questionnaire being given but elected to join the study, completing the web link after the first day of polling was conducted. Confidentiality was assured to the participants that their answers would only be seen by me and not shared with anyone. Each student in each group was assigned a number by the teacher, and the number was entered into the questionnaire by the student when they completed it. Only the teacher had the legend to determine the numbering system of the class roster, only to ensure extra credit points are awarded to the corresponding participant when they complete the questionnaire and to identify their grades at the end of the semester. The legend was not shared to ensure identities where confidential. Results were downloaded from Google Forms and exported to excel, which was then imported into SPSS. Groupings were made based on the results for each section. There are no ethical considerations for this study given the protections provided and the fact that it was granted IRB approval

As one final measure, the Poll Everywhere reports that were collected at the end of each class could show other detailed metrics such as which students participated in the questions and which students got the answer right. This information could have provided further analysis for the mobile polling group in the event the findings are significant.

Data Analysis

The Barkley Deficits in Executive Functioning Scale contains 89 Likert scale questions measured on a 4-point scale of escalating severity: Never/Rarely, Sometimes, Often, or Very Often. This scale is broken down into five subdomains: Self-Management to Time, Self-Organization/Problem Solving, Self- Restraint/Inhibition, Self-Motivation, and Self-Regulation of Emotions. Every subdomain with the exception of Self-Regulation of Emotion presents relatively strong reliability and validity (Barkley, 2011a). The responses from this questionnaire

will generate a raw score for each student while the class section will determine if they are part of the mobile polling group or the control group.

The Self-Management to Time scale relates to procrastination, difficulty setting goals, difficulty using foresight to plan events, and self-discipline (Barkley, 2011a). The sub-domain of Self-Management to Time contains 21 questions and was shown in a validation study to have an internal consistency rating of .949. In the present sample, the Cronbach alpha for Self-Management to Time was .91. Self-Organization/Problem Solving includes themes like being easily confused, difficulty in expression of thoughts, unable to sustain concentration, and trouble organizing thoughts (Barkley, 2011a). Self-Organization/Problem Solving contains 24 questions and generated an internal consistency rating of .958 in the validation study and .895 in the present study. The scale for Self-Restraint/Inhibition targets low tolerance for frustration, difficulty changing behavior when given feedback about mistakes, not inhibiting emotions or comments to others, and being unaware of others' perspectives about a problem or a situation (Barkley, 2011a). The Self-Restraint/Inhibition portion of the BDEFS contains 19 questions and has an internal consistency rating of .93 in the validation study and .826 in the current study. The subdomain of Self-Motivation relates to not being able to delay rewards or satisfaction, being dependent on others, difficulty resisting urges to do leisure activities, and not putting in as much effort as others (Barley, 2011a). The Self-Motivation section contains 12 questions and had internal consistency score of .914 in the validation study and .892 in the present study. Lastly, the Self-Regulation of Emotion scale consists of themes like over-reacting emotionally, not being able to redirect emotions into more positive outlets and having a pessimistic attitude while feeling strong emotions (Barkley, 2011a). The Self-Regulations section consists of 13 questions and had an internal consistency score of .946 in the validation study and .885 in the

present study. Overall, the combined total EF summary score had internal consistency scores of .918 and a .964 in present study.

There are various ranges of scores for each domain and for the total EF summary score pending on demographical data. The BDEFS scale has 12 score sheets associated with it: one for each sex within each of the four age groups (ages 18-34, 35-49, 50-64, and 65-81), plus one score sheet for these age groups where both sexes were combined. In the scoring manual, Barkley encourages the latter score sheets based on both sexes combined since it provides a far larger sample of adults at that age group and hence is likely to be more representative of the population at that age group than the gender based score sheets. Barkley states that the sex differences found in the normative sample were relatively minor and did not occur on all specific domain scores. Where they were present, the sex differences were most apparent at the extreme upper end of the distributions and not at the normal ranges. For this reason, the combined gender score sheet will be used for age group 18-34, as no participant in either section was older than 34. The correlating BDEFS score sheet will be listed as "Appendix C" in the Appendices section at the end.

The score sheet has columns that displays a range of potential raw scores. Each domain of the BDEFS also has their own range. However, these scores are typically used for clinical diagnosis and will not be considered for the purpose of this study. Instead, the raw scores from each domain will be added up as the total EF summary score and will be used as the primary measure for determining a person's level of self-regulation. Moreover, a column of percentiles is visible which represents the percentage of the general population is located on the left side of the score sheet. The percentiles that reflect the normal range of deficits are displayed as ranges 1-25, 26-50, and 51-75 due to the fact that the scores in these quartiles generally have little clinical

significance other than to indicate that a participant's EF is not abnormal. However, the scores in 76% and above take on clinical significance as indicators of clinical deficiencies and higher associated risks for impairment. Therefore, this study identified participants who received a total EF summary score of 167 or higher as those with low-self regulation compared to their peers.

Once each section completed the questionnaire, all data was downloaded into excel Google Form's export features. Because the two class sections were hosted at different times, two separate Google reports were created. This method made it easier to manage the sections and run individual statistics on the groups. The datasheets were saved onto an encrypted hard drive and then the results were uploaded into SPSS. Each section had a grouping variable known as "treatment" in SPSS, with "0" being the control group while "1" will be the treatment group.

The first research question, "Do students enrolled in courses that utilize the mobile polling technique show higher achievement at the end of the semester than students enrolled in business-as-usual classrooms, controlling for initial achievement?" was answered using a Two Variable Hierarchical Regression. The first step was to establish the Independent Variable known as "initial achievement" from the scores of the midterm exam in the course. The second step required dummy coding for each section for the condition as the second Independent Variable known as "treatment" (1 = polling and 0 = business as usual). Controlling for the initial achievement, the Dependent Variable was the "final exam grade" in each section as mobile polling was introduced after the first test to one the treatment group.

The second research question, "Do students who report higher levels of self-regulation show higher achievement at the end of the semester than students who report lower levels of achievement, controlling for initial achievement?" was answered with another Two Variable Hierarchical Regression as above. The first step used the "initial achievement" variable as

established above, and the second step used the "overall EF score" variable from the BDEFS. Controlling for the initial achievement, the Dependent Variable was again the "final exam grade" at the end of the semester.

The third research question, "Do students only benefit from mobile polling depending on their level of self-regulation?" was answered by a 2 (condition: polling, no polling) x 2 (self-regulation: high, low) ANCOVA with "Initial Achievement" as the covariate. The goal was to find a significant interaction where the mean for high-self-reg + polling participants were significantly higher than all other groups. A lower score on the BDEFS (166 or lower) would categorize the participant as a person with high SR.

CHAPTER 4

RESULTS

The current chapter is organized into three subsections. First, the plan of analyses is outlined along with the descriptive statistical information on the two classes, their achievement, and their total EF summary scores. Secondly, the three analyses that were conducted to answer the three main research questions will be presented in order. Lastly, the chapter will conclude with some supplemental data analyses specifically on Research Question 2.

Descriptive Statistics

Prior to any analyses, it was discovered that the data for final exam grade was not normally distributed. Two low scoring outliers existed, one from each group, which were windsorized in an effort to make the distribution normal. The two scores, a 74 and a 67, were changed to the next lowest score in the distribution, which was an 80. Thusly, the range for the final exam scores became 80 to 100 points.

Despite these efforts to normalize the data and reduce bias, a large number of final exam scores over 95 are affecting the distribution and moderately skewing the data left at -.665 and kurtosis at -.315. Table 1 below shows a histogram that depicts the final exam scores for both groups and displays the extraordinarily high scores form the sample. Table 2 shows the Shapiro-Wilk test of normality ($p = .000$) that signifies the data deviates from a normal distribution. While the outliers were windsorized to reduce bias, it was determined that lowering the higher scores would unfairly skew the results and worsen the distribution further. Moreover, the statistical methods applied for the research questions do not assume normality for either predictors or the outcome. However, the issue with the outliers needed to be addressed and

positive skew may make it difficult to identify significant covariates since overall variance in the final grades is somewhat truncated.

Table 1. Histogram of Sample Final Exam Grade Scores (*N* = 66)

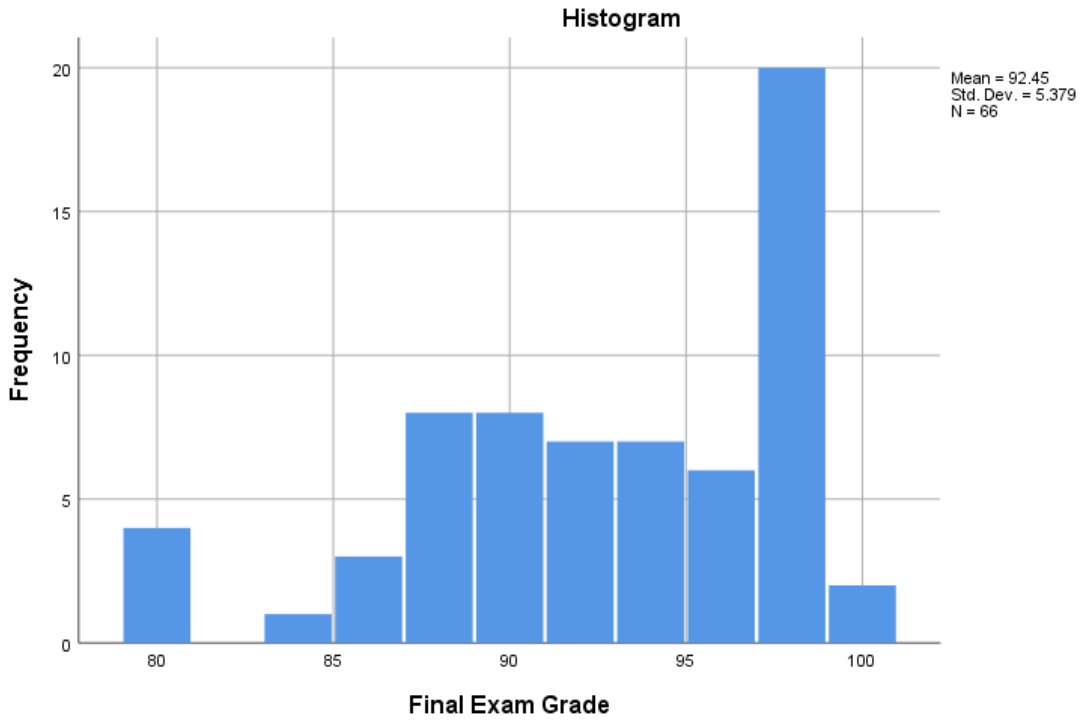


Table 2. Sample Tests for Normality (*N* = 66)

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Final Exam Grade	.139	66	.003	.913	66	.000

a. Lilliefors Significance Correction

Descriptive statistics for initial achievement and final exam grade for both groups are located below in Table 3. The descriptive statistics are then broken down by polling and non-polling groups in Table 4. There was a slight increase for the mean from Initial Achievement to

Final Exam Grade in both the polling and non-polling group of roughly 1 point, and both groups had similar mean averages for the pre-test. The overall sample size had a marginal mean increase of 1.5 points.

Table 3. Sample Pre & Post-Test Data (*N* = 66)

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Initial Achievement	66	71	101	90.95	5.771
Final Exam Grade	66	80	100	92.45	5.379
Valid N (listwise)	66				

Table 4. Statistics by Polling Group

Group Statistics

	Treatment	N	Mean	Std. Deviation	Std. Error Mean
Initial Achievement	Mobile Polling	34	90.47	6.111	1.048
	Control	32	91.47	5.436	.961
Final Exam Grade	Mobile Polling	34	92.00	5.057	.867
	Control	32	92.94	5.741	1.015

Table 5 below details the descriptive statistics of Overall EF scores across the Sample. Table 6 below breaks down the overall EF score between both the polling and non-polling group. According to the estimates of skewness and kurtosis, both groups were normally distributed and had no homogeneity issues due to similar sample sizes in groups. The means for each group (M = 173 for control; M = 176 for polling) were relatively close and both higher than cut off point of 167 as per the BDEFS score chart.

Table 5. Sample Overall EF Score

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Overall EF Score	66	107	276	174.83	36.269
Valid N (listwise)	66				

Table 6. Overall EF Score by Group

Descriptives

	Treatment			Statistic	Std. Error
Overall EF Score	Control	Mean		173.41	6.371
		95% Confidence Interval for Mean	Lower Bound	160.41	
			Upper Bound	186.40	
		5% Trimmed Mean		172.65	
		Median		167.50	
		Variance		1298.701	
		Std. Deviation		36.037	
		Minimum		107	
		Maximum		264	
		Range		157	
		Interquartile Range		41	
		Skewness		.338	.414
		Kurtosis		.038	.809
	Mobile Polling	Mean		176.18	6.341
		95% Confidence Interval for Mean	Lower Bound	163.27	
			Upper Bound	189.08	
		5% Trimmed Mean		174.22	
		Median		176.50	
		Variance		1367.241	
		Std. Deviation		36.976	
		Minimum		124	
		Maximum		276	
		Range		152	
		Interquartile Range		54	
		Skewness		.663	.403
		Kurtosis		.194	.788

Below, Table 7 shows the breakdown of students who were categorized as by high or low self-regulation across both course sections, with 31 students scoring below 167 on the BDEFS questionnaire and therefore higher in self-regulation levels. Table 8 further shows the distribution of high and low SR students in between the polling and non-polling groups, which was almost split evening between the two groups. Lastly, Table 9 displays further data on the high/low SR groups, highlighting that the range of scores for the low SR participants was almost twice as large compared to the high SR group (low SR Range = 106, high SR range = 58).

Table 7. High/Low SR Group by Overall EF Score

Case Processing Summary

		Cases					
		Valid		Missing		Total	
	SelfRegulationLevel	N	Percent	N	Percent	N	Percent
Overall EF Score	Low Self Regulation	35	100.0%	0	0.0%	35	100.0%
	High Self Regulation	31	100.0%	0	0.0%	31	100.0%

Table 8. Descriptive Statistics by High/Low SR and Groups

Descriptive Statistics

Dependent Variable: Final Exam Grade

Treatment	SelfRegulationLevel	Mean	Std. Deviation	N
Control	Low Self Regulation	94.31	4.332	16
	High Self Regulation	91.56	6.733	16
	Total	92.94	5.741	32
Mobile Polling	Low Self Regulation	91.74	4.897	19
	High Self Regulation	92.33	5.407	15
	Total	92.00	5.057	34
Total	Low Self Regulation	92.91	4.761	35
	High Self Regulation	91.94	6.038	31
	Total	92.45	5.379	66

Table 9. Descriptive Statistics by High/Low SR

Descriptives

	SelfRegulationLevel			Statistic	Std. Error
Overall EF Score	Low Self Regulation	Mean		202.03	4.358
		95% Confidence Interval for Mean	Lower Bound	193.17	
			Upper Bound	210.89	
		5% Trimmed Mean		199.96	
		Median		192.00	
		Variance		664.793	
		Std. Deviation		25.784	
		Minimum		170	
		Maximum		276	
		Range		106	
		Interquartile Range		38	
		Skewness		1.162	.398
		Kurtosis		1.092	.778
	High Self Regulation	Mean		144.13	2.894
		95% Confidence Interval for Mean	Lower Bound	138.22	
			Upper Bound	150.04	
		5% Trimmed Mean		144.89	
		Median		149.00	
		Variance		259.716	
		Std. Deviation		16.116	
		Minimum		107	
		Maximum		165	
		Range		58	
		Interquartile Range		29	
		Skewness		-.532	.421
		Kurtosis		-.688	.821

Lastly, table 10 below shows the Correlations between Initial Achievement, Final Exam Grade, and Overall EF Score, demonstrating that the three variables are not correlated.

Table 10. Correlation Table for Pre-test, Post-Test, and Overall EF Score

Correlations

		Final Exam Grade	Initial Achievement	Overall EF Score
Pearson Correlation	Final Exam Grade	1.000	.378	-.030
	Initial Achievement	.378	1.000	-.120
	Overall EF Score	-.030	-.120	1.000
Sig. (1-tailed)	Final Exam Grade	.	.001	.405
	Initial Achievement	.001	.	.168
	Overall EF Score	.405	.168	.
N	Final Exam Grade	66	66	66
	Initial Achievement	66	66	66
	Overall EF Score	66	66	66

Analyses by Research Question

In the following section, the three research questions will be restated into three separate sub-sections. Each sub-section will describe the statistical method utilized and provide relevant tables as necessary.

Research Question 1:

"Do students enrolled in courses that utilize the mobile polling technique show higher achievement at the end of the semester than students enrolled in business-as-usual classrooms, controlling for initial achievement?"

The first research question was answered using a Two Variable Hierarchical Regression. The first step was to establish the Independent Variable known as "initial achievement" from the scores of the midterm exam in the course. The second step required dummy coding for each section for the condition as the second Independent Variable known as "treatment" (1 = polling

and 0 = business as usual). Controlling for the initial achievement, the Dependent Variable was the "final exam grade" in each section as mobile polling was introduced after the first test to one the treatment group.

Using SPSS, Initial Achievement was entered into Block 1 of a typical linear regression, creating a model where Initial Achievement is the sole predictor of the Final Exam Grade. Then, the treatment variable was added in block 2, creating a second model that included both initial achievement and the treatment variable. This was done to see the difference in R square between the two models to better understand how much variance could be explained by the treatment variable when added. The first model revealed that initial achievement was a significant predictor of academic achievement (p = .002, R^2 = .143). The second model with treatment added in revealed that mobile polling was not a significant predictor of academic achievement (p = .638, R^2 = .146). Below, Table 11 displays the summary of the model and Table 12 shows the coefficient data.

Table 11. Hierarchical Regression Model for Treatment

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.378[a]	.143	.129	5.019	.143	10.660	1	64	.002
2	.382[b]	.146	.119	5.049	.003	.224	1	63	.638

a. Predictors: (Constant), Initial Achievement

b. Predictors: (Constant), Initial Achievement, Treatment

c. Dependent Variable: Final Exam Grade

.

Table 12. Coefficient Data for Treatment

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	60.425	9.830		6.147	.000					
	Initial Achievement	.352	.108	.378	3.265	.002	.378	.378	.378	1.000	1.000
2	(Constant)	61.137	10.004		6.111	.000					
	Initial Achievement	.348	.109	.373	3.191	.002	.378	.373	.372	.992	1.008
	Treatment	-.590	1.248	-.055	-.473	.638	-.088	-.059	-.055	.992	1.008

a. Dependent Variable: Final Exam Grade

Research Question 2:

"Do students who report higher levels of self-regulation show higher achievement at the end of the semester than students who report lower levels of self-regulation, controlling for initial achievement?"

The second research question was answered with another Two Variable Hierarchical Regression. With "initial achievement" already established, the next step was to create the "overall EF score" variable from the BDEFS polling questionnaire. The data was downloaded from Poll everywhere into excel, and each participant had their scores computed using the SUM formula. There was no missing data for any participant. The dependent variable remained as "final exam grade".

Like the previous hierarchical regression, Initial Achievement was entered into Block 1 of an Ordinary Least Squares linear regression in SPSS, creating a model where Initial Achievement is the sole predictor of the Final Exam Grade. From there, the overall EF score variable was added in block 2, creating a second model that included both initial achievement and the overall EF score variable. Again, this was done to see the difference in R square between the two models to better understand how much variance could be explained by the overall EF score variable when added. With initial achievement remaining the same (p = .002,

R^2 = .143), the second model with overall EF score added in revealed that self-regulation was not a significant predictor of academic achievement (p = .896, R^2 = .143). Moreover, it had zero effect on the variance as denoted by R Square and the R Square change. Below, Table 13 shows the hierarchical regression model results and Table displays the coefficient data for Overall EF Score.

Table 13. Hierarchical Regression Model for Overall EF Score

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.378[a]	.143	.129	5.019	.143	10.660	1	64	.002
2	.378[b]	.143	.116	5.058	.000	.017	1	63	.896

a. Predictors: (Constant), Initial Achievement

b. Predictors: (Constant), Initial Achievement, Overall EF Score

c. Dependent Variable: Final Exam Grade

Table 14. Coefficient Data for Overall EF Score

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	60.425	9.830		6.147	.000					
	Initial Achievement	.352	.108	.378	3.265	.002	.378	.378	.378	1.000	1.000
2	(Constant)	59.866	10.778		5.555	.000					
	Initial Achievement	.354	.109	.380	3.232	.002	.378	.377	.377	.985	1.015
	Overall EF Score	.002	.017	.015	.131	.896	-.030	.017	.015	.985	1.015

a. Dependent Variable: Final Exam Grade

Research Question 3:

"Do students only benefit from mobile polling depending on their level of self-regulation?"

Despite the lack of finding any significant effect with mobile polling or self-regulation thus far, the third research was answered by a 2 (condition: polling, no polling) x 2 (self-regulation: high, low) ANCOVA with "Initial Achievement" as the covariate. The original goal

was to find a significant interaction where the mean for high-self-reg + polling participants were significantly higher than all other groups. Yet based on the descriptive statistic data from Table 8 presented earlier in this chapter, the highest mean for achievement was by the low SR control group (M = 94.31) followed by the high SR polling group (M = 92.33). The other two groups were not far off as low SR polling came in third (M = 91.74) and high SR control as the lowest mean for achievement (M = 91.56). Moreover, there were no homogeneity issues with the variance, and Table 14 below shows that there were no significant effects for Treatment, $F(1, 61) = .242$, $p = .625$, Self-Regulation Level, $F(1, 61) = 2.122$, $p = .150$, or the interaction effect of Treatment and Self-Regulation, $F(1, 61) = .949$, $p = .334$.

Table 15. Tests of Between-Subjects Effects for Treatment and SR

Tests of Between-Subjects Effects

Dependent Variable: Final Exam Grade

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	351.004[a]	4	87.751	3.500	.012	.187	14.000	.836
Intercept	864.555	1	864.555	34.484	.000	.361	34.484	1.000
InitialAchievement	273.032	1	273.032	10.890	.002	.151	10.890	.901
Treatment	6.055	1	6.055	.242	.625	.004	.242	.077
SelfRegulationLevel	53.202	1	53.202	2.122	.150	.034	2.122	.300
Treatment * SelfRegulationLevel	23.800	1	23.800	.949	.334	.015	.949	.160
Error	1529.360	61	25.071					
Total	566038.000	66						
Corrected Total	1880.364	65						

a. R Squared = .187 (Adjusted R Squared = .133)

b. Computed using alpha = .05

Supplemental Analysis

After reviewing the output for Research Question 2, further statistical analysis was warranted to verify a different analysis other than hierarchical regression would yield different result. It is always possible that in a pre-post design, different patterns among the pre-post means for the groups might be hidden using the regression approach. A secondary option was to

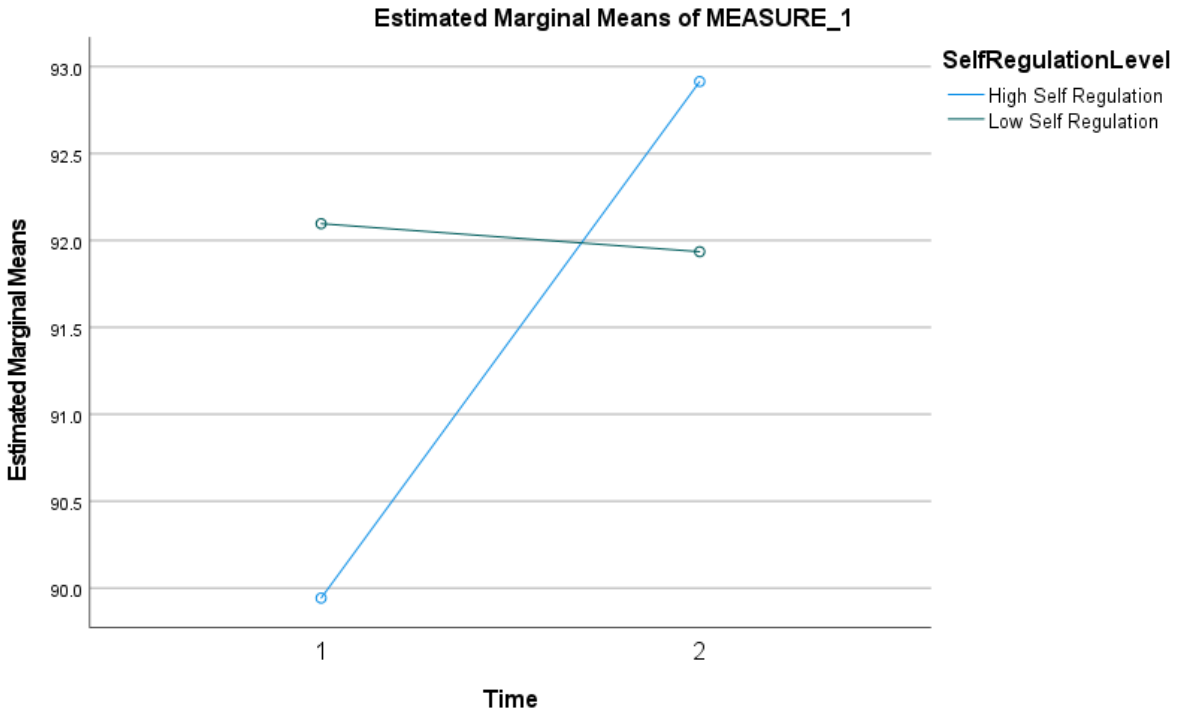
analyze the same data using a Repeated Measures ANOVA and see how the students changed over time from the Midterm (Initial Achievement) to the Final Exam Grade in regards to their Overall EF Score. A new variable labeled "Time" was created in SPSS to capture and display the effect between the pre-test and post-test. Table 16 below shows the descriptive statistics for Initial Achievement and Final Exam Grades by High/Low SR levels, noting that High SR students had a lower mean on the midterm and then a higher mean on the final exam. Meanwhile, the mean for Low SR students had a small decrease in score between the midterm and final exam. Table 17 shows a plot of this analysis to better visualize the difference in scores over time between High and Low SR groups.

Table 16. Descriptive Statistics for Pre-Test and Post-Test by High/Low SR levels

Descriptive Statistics

	SelfRegulationLevel	Mean	Std. Deviation	N
Initial Achievement	High Self Regulation	89.94	6.338	35
	Low Self Regulation	92.10	4.908	31
	Total	90.95	5.771	66
Final Exam Grade	High Self Regulation	92.91	4.761	35
	Low Self Regulation	91.94	6.038	31
	Total	92.45	5.379	66

Table 17. Plot Graph of Achievement over Time by Self-Regulation Levels



Both assumptions of Sphericity and Homogeneity of Variances were met with no issues found in variance in between groups. Table 18 below shows differences of effects between Time alone and Time and Self-Regulation together. When SR is accounted for across time, statistical significance is found (p = .040). However, Table 19 displays the tests between-subject effects, which highlights that that Self-Regulation by itself was not significant (p = .611) and explained only .4% of the variance (Partial Eta Squared = .004). The interaction shows no change for the low self-regulation students pre to post, but a significant increase in performance for the high self-regulation students. Note that the low self-regulation students were already performing at a high level (M = 92). They presumably did not see the need to change their approach to the class. The high self-regulation students however, may have altered their approach to the class after receiving their midterm grades.

Table 18. Effect of Means across Time and Time with Self-Regulation

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Time	Pillai's Trace	.052	3.522[b]	1.000	64.000	.065	.052
	Wilks' Lambda	.948	3.522[b]	1.000	64.000	.065	.052
	Hotelling's Trace	.055	3.522[b]	1.000	64.000	.065	.052
	Roy's Largest Root	.055	3.522[b]	1.000	64.000	.065	.052
Time * SelfRegulationLevel	Pillai's Trace	.064	4.377[b]	1.000	64.000	.040	.064
	Wilks' Lambda	.936	4.377[b]	1.000	64.000	.040	.064
	Hotelling's Trace	.068	4.377[b]	1.000	64.000	.040	.064
	Roy's Largest Root	.068	4.377[b]	1.000	64.000	.040	.064

a. Design: Intercept + SelfRegulationLevel
Within Subjects Design: Time

b. Exact statistic

Table 19. Tests of Between-Subjects Effects by Self-Regulation Levels

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	1106435.593	1	1106435.593	25530.428	.000	.997
SelfRegulationLevel	11.351	1	11.351	.262	.611	.004
Error	2773.627	64	43.338			

In addition, it is also possible that any effects of self-regulation might be obscured by measurement imprecision of the Barkley Deficit of Executive Function Scale (BDEFS). Students who do differ in some aspects of self-regulation might be judged comparable when a large number of insensitive questions are added together. And if respondents in this study differ from those in the normative sample for the BDEFS, perhaps particular scale items are not forming coherent scales, which one again introduces further measurement imprecision. These findings brought up the notion that the measure itself, the overall score of EF according to the Barkley Deficit of Executive Function Scale, may not be suitable in this particular study. Though

Barkley touts the clinical significance found in using an overall scoring system based on age and gender, this usage of a total score essentially weighs all five sub-scales inside BDEFS the same. Moreover, all of the subscales have a different number of questions in each section. While the number of participants was low for this study, it was determined that a post-hoc exploratory factor analysis should be conducted on each sub-scale, attempting to find which questions in each section load together and which ones don't.

For Subscale 1: Self-Management to Time, fourteen questions out of the original twenty-one loaded highly under the same factor. For Subscale 2: Self-Organization and Problem Solving, thirteen questions out of the original twenty-four loaded highly under the same factor. For Subscale 3: Self-Restraint/Inhibition, six questions out of the original nineteen loaded highly under the same factor. For Subscale 4: Self-Motivation, nine questions out of twelve loaded highly under the same factor. And for Subscale 5: Self-Regulation, eight questions out of thirteen loaded highly under the same factor. The following tables below show the Cronbach Alpha for each truncated subscale, the questions inside the truncated subscale, and the reliability of each of these questions in the new subscale, specifically showing what the Cronbach Alpha would be if the question was deleted. It was of interest of significant associations between self-regulation and achievement might emerge using the sub scores of the truncated, more precise scales.

Table 20. Cronbach Alpha for Truncated Subscale 1: Self-Management to Time

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.912	.913	14

Table 21. Questions and Alpha data for Truncated Subscale 1

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q1Procrastinate or put off doing things until the last minute:	27.30	57.199	.608	.521	.907
Q2Poor sense of time:	28.18	58.582	.588	.458	.908
Q3Waste or mismanage my time:	27.86	58.427	.626	.471	.906
Q6Have trouble planning ahead or preparing for upcoming events:	28.55	60.498	.554	.447	.909
Q8Can't seem to accomplish the goals I set for myself:	28.32	58.528	.649	.544	.906
Q10Can't seem to hold in mind things I need to remember to do:	28.12	59.616	.490	.339	.911
Q11Can't seem to get things done unless there is an immediate deadline:	28.05	55.183	.712	.568	.903
Q13Have trouble motivating myself to start work:	27.55	57.698	.641	.555	.906
Q14Have difficulty motivating myself to stick with my work and get it done:	27.82	56.120	.778	.727	.900
Q15Not motivated to prepare in advance for things I know I am supposed to do:	27.97	57.199	.659	.495	.905
Q17Have trouble doing what I tell myself to do:	28.11	57.481	.657	.586	.905
Q19Lack of self-discipline:	28.17	57.156	.651	.534	.905
Q20Have difficulty arranging or doing my work by its priority or importance; can't "prioritize" well:	28.33	59.118	.528	.367	.910
Q21Find it hard to get started or get going on things I need to get done:	27.85	58.469	.587	.418	.908

Table 22. Cronbach Alpha for Truncated Subscale 2: Self-Organization/PS

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.895	.897	13

Table 23. Questions and Alpha data for Truncated Subscale 2

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q28Unable to come up with or invent as many solutions to problems as others seem to do:	25.15	48.407	.527	.437	.890
Q29Find myself at a loss for words when I want to explain something to others:	25.23	47.717	.592	.467	.887
Q30Have trouble putting my thoughts down in writing as well or as quickly as others:	25.06	45.627	.624	.476	.886
Q31Feel I am not as creative or inventive as others of my level of intelligence:	25.11	46.312	.547	.467	.891
Q32In trying to accomplish goals or assignments, I find I am not able to think of as many ways of doing things as others:	25.18	48.643	.548	.475	.889
Q33Have trouble learning new or complex activities as well as others:	25.35	46.754	.605	.549	.887
Q34Have difficulty explaining things in their proper order or sequence:	25.55	47.636	.646	.708	.885
Q35Can't seem to get to the point of my explanations as quickly as others:	25.12	46.908	.657	.552	.884
Q36Have trouble doing things in their proper order or sequence:	25.59	48.215	.613	.654	.887
Q37Unable to "think on my feet" or respond as effectively as others to unexpected events:	25.24	49.017	.491	.387	.892
Q42Easily confused:	25.06	46.827	.613	.447	.886
Q43Can't seem to sustain my concentration on reading, paperwork, lectures, or work:	24.70	48.030	.532	.505	.890
Q45I don't seem to process information as quickly or as accurately as others:	25.12	45.585	.764	.661	.879

Table 24. Cronbach Alpha for Truncated Subscale 3: Self-Restraint/Inhibition

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.826	.831	6

Table 25. Questions and Alpha data for Truncated Subscale 3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q47Make decisions impulsively:	8.44	7.789	.647	.434	.788
Q53Change my plans at the last minute on a whim or a last minute impulse:	8.55	8.006	.597	.481	.800
Q54Fail to consider past relevant events or past personal experiences before responding to situations (I act without thinking):	9.03	8.399	.710	.578	.776
Q59Trouble following the rules in a situation:	9.39	9.689	.528	.357	.814
Q63I don't look ahead and think about what the future outcomes will be before I do something (I don't use my foresight):	9.15	9.207	.546	.351	.809
Q64I engage in risk taking activities more than others are likely to do:	8.92	8.379	.589	.425	.800

Table 26. Cronbach Alpha for Truncated Subscale 4: Self-Motivation

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.892	.894	9

Table 27. Questions and Alpha data for Truncated Subscale 4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q67Do not put as much effort into my work as I should or than others are able to do:	13.86	22.304	.680	.543	.877
Q68Others tell me I am lazy or unmotivated:	14.38	22.024	.668	.497	.878
Q70Things must have an immediate payoff for me or I do not seem to get them done:	14.29	24.116	.516	.355	.889
Q71Have difficulty resisting the urge to do something fun or more interesting when I am supposed to be working:	13.35	22.815	.528	.316	.891
Q72Inconsistent in the quality or quantity of my work performance:	14.18	22.182	.702	.593	.876
Q73Unable to work as well as others without supervision or frequent instruction:	14.38	22.670	.724	.660	.875
Q74I do not have the willpower or determination that others seem to have:	14.14	21.689	.725	.646	.874
Q75I am not able to work toward longer term or delayed rewards as well as others:	14.15	21.854	.760	.687	.871
Q76I cannot resist doing things that produce immediate rewards even if they are not good for me in the long run:	14.06	22.427	.575	.409	.887

Table 28. Cronbach Alpha for Truncated Subscale 5: Self-Regulation

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.885	.888	8

Table 29. Questions and Alpha data for Truncated Subscale 5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q78Overreact emotionally:	13.58	21.233	.596	.472	.879
Q81Have trouble calming myself down once I am emotionally upset:	13.88	21.370	.686	.548	.868
Q82Cannot seem to regain emotional control and become more reasonable once I am emotional:	14.21	20.877	.753	.642	.861
Q83Cannot seem to distract myself away from whatever is upsetting me emotionally to help me calm down. I can't refocus my mind to a more positive framework:	13.83	21.556	.631	.472	.874
Q84Unable to manage my emotions in order to accomplish my goals successfully or get along well with others:	14.45	22.436	.700	.555	.868
Q85I remain emotional or upset longer than others:	14.08	21.363	.714	.559	.865
Q88I am not able to evaluate an emotionally upsetting event more objectively:	14.20	22.345	.644	.555	.872
Q89I cannot redefine negative events into more positive viewpoints when I feel strong emotions:	14.09	22.638	.549	.503	.881

Each new subscale had their truncated questions computed using an exploratory factor analysis to gather factor loadings for each question. Below are the tables for the five subscales and their factor loadings.

Table 30. Factor Matrices for Subscale 1 & 2

Factor Matrix[a]

	Factor 1
Q1Procrastinate or put off doing things until the last minute:	.642
Q2Poor sense of time:	.616
Q3Waste or mismanage my time:	.655
Q6Have trouble planning ahead or preparing for upcoming events:	.575
Q8Can't seem to accomplish the goals I set for myself:	.676
Q10Can't seem to hold in mind things I need to remember to do:	.513
Q11Can't seem to get things done unless there is an immediate deadline:	.744
Q13Have trouble motivating myself to start work:	.674
Q14Have difficulty motivating myself to stick with my work and get it done:	.817
Q15Not motivated to prepare in advance for things I know I am supposed to do:	.691
Q17Have trouble doing what I tell myself to do:	.695
Q19Lack of self-discipline:	.685
Q20Have difficulty arranging or doing my work by its priority or importance; can't "prioritize" well:	.553
Q21Find it hard to get started or get going on things I need to get done:	.620
Q28Unable to come up with or invent as many solutions to problems as others seem to do:	.544
Q29Find myself at a loss for words when I want to explain something to others:	.628
Q30Have trouble putting my thoughts down in writing as well or as quickly as others:	.664
Q31Feel I am not as creative or inventive as others of my level of intelligence:	.578
Q32In trying to accomplish goals or assignments, I find I am not able to think of as many ways of doing things as others:	.561
Q33Have trouble learning new or complex activities as well as others:	.641
Q34Have difficulty explaining things in their proper order or sequence:	.699
Q35Can't seem to get to the point of my explanations as quickly as others:	.701
Q36Have trouble doing things in their proper order or sequence:	.662
Q37Unable to "think on my feet" or respond as effectively as others to unexpected events:	.517
Q42Easily confused:	.649
Q43Can't seem to sustain my concentration on reading, paperwork, lectures, or work:	.573
Q45I don't seem to process information as quickly or as accurately as others:	.812

Extraction Method: Principal Axis Factoring.

a. 1 factors extracted. 4 iterations required.

Table 31. Factor Matrices for Subscale 3, 4, & 5

Q47Make decisions impulsively:	.714
Q53Change my plans at the last minute on a whim or a last minute impulse:	.669
Q54Fail to consider past relevant events or past personal experiences before responding to situations (I act without thinking):	.798
Q59Trouble following the rules in a situation:	.586
Q63I don't look ahead and think about what the future outcomes will be before I do something (I don't use my foresight):	.609
Q64I engage in risk taking activities more than others are likely to do:	.654

Extraction Method: Principal Axis Factoring.

a. 1 factors extracted. 5 iterations required.

Q67Do not put as much effort into my work as I should or than others are able to do:	.713
Q68Others tell me I am lazy or unmotivated:	.702
Q70Things must have an immediate payoff for me or I do not seem to get them done:	.548
Q71Have difficulty resisting the urge to do something fun or more interesting when I am supposed to be working:	.558
Q72Inconsistent in the quality or quantity of my work performance:	.755
Q73Unable to work as well as others without supervision or frequent instruction:	.778
Q74I do not have the willpower or determination that others seem to have:	.782
Q75I am not able to work toward longer term or delayed rewards as well as others:	.821
Q76I cannot resist doing things that produce immediate rewards even if they are not good for me in the long run:	.603

Q78Overreact emotionally:	.635
Q81Have trouble calming myself down once I am emotionally upset:	.730
Q82Cannot seem to regain emotional control and become more reasonable once I am emotional:	.817
Q83Cannot seem to distract myself away from whatever is upsetting me emotionally to help me calm down. I can't refocus my mind to a more positive framework:	.672
Q84Unable to manage my emotions in order to accomplish my goals successfully or get along well with others:	.754
Q85I remain emotional or upset longer than others:	.752
Q88I am not able to evaluate an emotionally upsetting event more objectively:	.686
Q89I cannot redefine negative events into more positive viewpoints when I feel strong emotions:	.601

To compute factor scores for each participant, each factor loading was multiplied against each respondent's score for each question of a subscale and the products were added together. This was done using the excel spreadsheet created by Poll Everywhere at the beginning of the study. All questions that were not a part of the new truncated subscale were deleted from the spreadsheet, and then a new column was created at the end of each subsection. This column contained a formula that was created to multiply each factor loading to a participant's response (1-4) within each subscale of the BDEFS, thus creating a properly weighted score. The formula would then add each weighted score to create a new subscale score. This formula was applied down the column to all scores for each student in that subscale. An example of the excel formula

is listed below and would repeat until all subscale questions were included. This approach was deemed preferable to simply finding the average across the scale items since that approach weighs each item the same. The factor analytic approach improves precision by giving more weight to items that loaded more strongly on the subscale.

=((factor loading 1 * participant answer) + (factor loading 2 * participant answer) + (factor loading 3 * participant) + (factor loading 4 * participant answer))

The new scores were imported into SPSS under five new variables: Scale1Fac, Scale2Fac, Scale3Fac, Scale4Fac, and Scale5Fac. The second research question was revisited using the same Hierarchical Regression model. With initial achievement controlled for, the next step included the five new subscale variables while the dependent variable remained as final exam grade. The dependent variable remained as "final exam grade". Table 32 below consists of the new descriptive statistics for initial achievement, final exam grade, and all five new subscale variables. Table 33 shows the correlation table for the same seven variables.

Table 32. Descriptive Statistics for Pre-Test and Post-Test by new Subscale Scores

Descriptive Statistics

	Mean	Std. Deviation	N
FinalExamGrade	92.45	5.379	66
InitialAchievement	90.95	5.771	66
Scale1Fac	19.83562121	5.423131286	66
Scale2Fac	17.22630303	4.751863511	66
Scale3Fac	7.245393939	2.353412775	66
Scale4Fac	10.91077273	3.728154969	66
Scale5Fac	11.25963636	3.744470317	66

Table 33. Correlation Table for Pre-Test and Post-Test by new Subscale Scores

Correlations

		FinalExamGrade	InitialAchievement	Scale1Fac	Scale2Fac	Scale3Fac	Scale4Fac	Scale5Fac
Pearson Correlation	FinalExamGrade	1.000	.378	-.070	-.025	-.224	-.124	.139
	InitialAchievement	.378	1.000	-.229	-.125	-.035	-.172	.097
	Scale1Fac	-.070	-.229	1.000	.460	.413	.657	.150
	Scale2Fac	-.025	-.125	.460	1.000	.261	.603	.412
	Scale3Fac	-.224	-.035	.413	.261	1.000	.588	.175
	Scale4Fac	-.124	-.172	.657	.603	.588	1.000	.331
	Scale5Fac	.139	.097	.150	.412	.175	.331	1.000
Sig. (1-tailed)	FinalExamGrade	.	.001	.287	.420	.035	.161	.132
	InitialAchievement	.001	.	.032	.158	.391	.084	.220
	Scale1Fac	.287	.032	.	.000	.000	.000	.114
	Scale2Fac	.420	.158	.000	.	.017	.000	.000
	Scale3Fac	.035	.391	.000	.017	.	.000	.080
	Scale4Fac	.161	.084	.000	.000	.000	.	.003
	Scale5Fac	.132	.220	.114	.000	.080	.003	.
N	FinalExamGrade	66	66	66	66	66	66	66
	InitialAchievement	66	66	66	66	66	66	66
	Scale1Fac	66	66	66	66	66	66	66
	Scale2Fac	66	66	66	66	66	66	66
	Scale3Fac	66	66	66	66	66	66	66
	Scale4Fac	66	66	66	66	66	66	66
	Scale5Fac	66	66	66	66	66	66	66

Table 34 below shows the model summary and the difference in R square between the two models to better understand how much variance could be explained by the five subscale variables when added. The first model still reveals that initial achievement was a significant predictor of academic achievement (p = .002, R^2 = .143). The second model with the new subscales added in revealed that mobile polling was not a significant predictor of academic achievement (p = .350, R^2 = .218). However, Table 35 shows the coefficient data for the subscales and shows that Subscale 3: Self-Restraint/Inhibition is almost significant (p = .064). Thus, the improved precision of the subscales did reveal a hidden pattern. Had the overall achievement means not been so high (in other course on campus with lower averages), it is possible subscale 3 might have been significant.

Table 34. Hierarchical Regression Model for Truncated BDEFS Subscales

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.378[a]	.143	.129	5.019	.143	10.660	1	64	.002
2	.467[b]	.218	.139	4.991	.076	1.140	5	59	.350

a. Predictors: (Constant), InitialAchievement

b. Predictors: (Constant), InitialAchievement, Scale3Fac, Scale5Fac, Scale1Fac, Scale2Fac, Scale4Fac

c. Dependent Variable: FinalExamGrade

Table 35. Coefficient Data for Truncated BDEFS Subscales

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	60.425	9.830		6.147	.000					
	InitialAchievement	.352	.108	.378	3.265	.002	.378	.378	.378	1.000	1.000
2	(Constant)	60.641	10.950		5.538	.000					
	InitialAchievement	.353	.112	.378	3.143	.003	.378	.379	.362	.914	1.094
	Scale1Fac	.126	.155	.127	.812	.420	-.070	.105	.093	.540	1.852
	Scale2Fac	-.012	.174	-.010	-.068	.946	-.025	-.009	-.008	.560	1.785
	Scale3Fac	-.624	.331	-.273	-1.885	.064	-.224	-.238	-.217	.632	1.581
	Scale4Fac	-.033	.283	-.023	-.116	.908	-.124	-.015	-.013	.343	2.914
	Scale5Fac	.206	.187	.143	1.101	.275	.139	.142	.127	.784	1.276

a. Dependent Variable: FinalExamGrade

With the Subscale 3: Self-Restraint/Inhibition showing more promising results, one more hierarchical regression was run with Subscale 3 being the only predictor variable for the final exam grade while controlling for initial achievement. Table 36 displays the model summary with subscale 3 as the second model (p = .067, R^2 = .187) and shows that Self-Restraint/Inhibition accounts for 4.5% of the variance. While it may not be a statistically significant result, the truncated subscale 3 is a better predictor than using the Overall EF score.

Table 36. Hierarchical Regression Model for Truncated BDEFS subscales

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.378[a]	.143	.129	5.019	.143	10.660	1	64	.002
2	.433[b]	.187	.162	4.925	.045	3.468	1	63	.067

a. Predictors: (Constant), InitialAchievement

b. Predictors: (Constant), InitialAchievement, Scale3Fac

c. Dependent Variable: FinalExamGrade

CHAPTER 5

CONCLUSION

The purpose of this study was broken down into three separate goals. The first was to determine the effects of using mobile polling software in regards to overall academic achievement compared to a class that doesn't use mobile polling. The second was to determine if students who report higher levels of self-regulation shower higher academic achievement than students who report lower levels of self-regulation. The third was to determine if mobile polling helps all students learn more or only some based on their level of self-regulation. The study had a total of 66 participating college students between two separate course sections. One section utilized Poll Everywhere, a mobile polling application that provides assessment questions and feedback, during their lectures while the other section served as the control group. Moreover, all participants completed the Barkley Deficits in Executive Functioning Scale (BDEFS) which assessed their level of self-regulation. However, a decision was made to further breakdown the BDEFS into the five subscales for better analysis. Below are the main findings from the data collected to answer the research questions.

Main Findings

One key finding from this study was that mobile polling, collapsed across self-regulation levels and was used for nine weeks, appeared to have no statistically significant effect on academic achievement at the end of the semester. The only significant predictor throughout the entire study was the initial achievement variable, which was the scores from the midterm exam. Once this was controlled for, the treatment variable was shown to have less than 1% of the variance explained. Therefore, the study failed to reject the null hypothesis that mobile polling had no effect on academic achievement.

The question is why mobile polling failed to have an effect in this study when some prior studies found an effect (Kim, 2020; Sun, 2014). Recall that mobile polling is often used as a form of formative assessment to give students and the instructor a sense of whether a key point that the instructor present was properly understood. Mobile polling is a very popular technique in the sciences because it is often the case that key concepts are a little difficult to grasp and students often form misconceptions. In the current study, the concepts may have been easier to grasp and the instructor may have been more skilled at presenting the material than some instructors in the sciences. If so, then mobile polling may not have been necessary and may not have had any added value.

A second explanation is the notion of ceiling effects. Because the average grades were in the low 90s, the full range of performance may have been restricted. Reductions in variance have the effect of decreasing the finding of significant predictors. So, once again had the study been conducted in the sciences which on the present campus the GPAs tend to be much lower, an effect for mobile polling could be seen? Moreover, could an IRT modelling approach which differentially weights performance on the midterm with respect to passing particular questions spread the scores out?

A third explanation pertains to the notion of dosage. Any time a treatment appears to not have an effect, it is often useful to consider whether it might have had an effect over the course of a longer stretch of time such as an entire semester or academic year.

From the standpoint of the Opportunity-Propensity model, instruction using polling was hypothesized to be an enhanced educational opportunity for students. But students had to have the propensity to benefit from this opportunity (Byrnes, 2020). In the present case, two aspects of propensity were measured in students: their initial knowledge and their degree of self-regulation.

The present findings suggest an interesting nuance in the theory. It is possible that highly knowledgeable students did not need mobile polling since their metacognition was sufficiently advanced that they did not need formative assessments (i.e., weekly polls) to know how to study and how to take notes in class. In this sense, the added polling did not create an enhanced opportunity for them.

The second key finding from this study was that self-regulation, measured with the use of the BDEFS system, was not a significant predictor of academic achievement. When initial achievement was controlled for, the Overall EF score from the BDEFS system revealed that self-regulation appeared to have no effect on the variance as denoted by R Square and the R Square change in the regression model. However, the fact that differing pre-post patterns might have been obscured using the regression approach prompted usage of a Repeated Measures ANOVA which did find an interaction between the repeated measures factor and degree of self-regulation. The highly self-regulated students actually performed worse on the midterm than the low self-regulated students. Their performance apparently sparked a change in their behavior such that only they showed a significant increase from the midterm to the final. Moreover, the fact that BDEFS weighs all questions the same through five subscales prompted a factor analysis to find out what questions loaded under the same factor in each subscale. The results improved but did not produce significant results. Subscale 3, which relates to the traits of Self-Restraint and Inhibition, was better than using Overall EF scores but was not a significant predictor variable. Therefore, this study failed to reject the null hypothesis that overall Self-Regulation had no effect on academic achievement, but several interesting nuanced findings for self-regulation did emerge Note that one prior study showed that there was no relation between a measure of intelligence and self-regulated learning (Byrnes, Miller & Reynolds, 1999). Perhaps one does not have to be

particularly self-regulated with high levels of competence or if the material is easier to grasp. A course that contains difficult concepts to comprehend could possibly yield better results.

The third key finding from this study was that the interaction between mobile polling and high levels of self-regulation did not significantly affect academic achievement. In fact, the highest mean came from the completely opposite group as expected, which was students in the control group with lower levels of self-regulation. While the highly self-regulated students from the mobile polling group were the second highest mean, the data shows that students did not benefit from mobile polling at all, regardless of their level of self-regulation. Therefore, this study failed to reject the null hypothesis that mobile polling would not benefit any student despite a high level of self-regulation. Again, this finding could support the contextual feature of the O-P model that suggests that one only needs to be self-regulated and receive formative assessments in certain contexts. In a related way, Barkley (2013) agrees that children with ADHD only have difficulty in demanding contexts that they find boring.

It was expected that mobile polling might serve as a distraction and not be effective in promoting higher achievement. This result would have emerged with the control group performing better than the treatment group because only the latter who have been distracted. The inclusion of the self-regulation variable was to see whether only the low self-regulation students would have shown a decrease in performance midterm to final. The latter finding did not occur as well.

Granted, there is a separate mound of research that focuses on distractions from mobile devices and how they are detrimental to a classroom setting. Previous studies show that professors who allow cell phones within a classroom can experience detrimental effects to students' overall academic performance (Bugeja, 2007; Froese et al, 2012). Another notable

study reported more than 80% of students across multiple Universities use their phone at least once per class and that students generally believe this to be an acceptable practice (Berry & Westfall, 2015). While it was not directly observed that students were on their devices in class outside of mobile polling questions, it's unreasonable to think an instructor is able to see what everyone is doing behind their desks during a lecture. Nevertheless, one would assume that a student who possess the ability to self-regulate their behavior in class, establish the goal of getting a good grade, and who has the metacognitive ability to maintain and stay on track in reaching said goal would likely attain a higher level of academic achievement.

Previous studies have found that Self-regulation is positively associated with achievement and contains several processes such as planning, attention control, and self-evaluation (Dillen & Papies, 2015; Winne, 1995; Zimmerman, 1998; Zimmerman & Risemberg, 1997). Research has also found that the learning achievement for students significantly improved when self-regulation strategies were introduced and routinely utilized (Montague, 2007; Porath & Bateman, 2006). And with a suitable design in place, studies have shown that a learner's ability to self-regulate can be improved with the proper usage of classroom technology such as clickers and mobile devices (El-Bishouty, Ogata, Ayala, & Yano, 2010; Sha, Looi, Chen, Seow, & Wong, 2012). With this understanding, mobile polling was used three times a week for half a semester to get students accustomed to using such a resource. While the study did not check for improvement in a student's perceived ability to self-regulate at the end of the semester, the continuous occurrence of mobile polling is an opportunity for a student to check their learning and give them key insight on what they know and what they don't. Therefore, it would come down to a student's internal propensity factors, specifically self-regulation, to take advantage of the opportunity to improve their learning.

Limitations & Future Directions

To further explain the context of the findings above, there were several limitations that occurred during the study which may have affected the results. The biggest limitation was due to the outbreak of COVID-19 in Spring 2020. After the midterm was given to both course sections, mobile polling was implemented the following week in March. Only one week of polling was conducted in the University classroom before the school was forced to shut down, moving all courses online effective immediately. The urban city where the University resides had restrictions emplaced for two weeks at the time as well. There was uncertainty around when the school would re-open and if face-to-face classes would resume in the same manner as before. The instructor and research team discussed if the study could continue and tested the usage of mobile polling through an online format. The instructor was able to share her screen, revealing the PowerPoint and polling questions to the polling group with no issue, and all students were able to participate with their mobile devices remotely with few technological issues.

However, the online format was not the original intent of this study and was forced upon the participants. Students and Faculty alike attempted to adjust to the usage of virtual lectures, and the University implemented a policy that allowed students to take courses for Pass/Fail, sparing their GPA from being harmed as the new learning environment was not ideal and could possibly hinder some students from doing well in their courses. While numerous accommodations were made to help all students through the stressful adjustment, the students lost many of the on-campus resources normally available to them, including the close proximity of their peers and classmates. It is unclear on how grave the effects were of the unexpected jump to online as some students may have been affected more than others. On top of that, the instructor had to make significant changes to the course and the way it was taught, encountering

problems that arose in regards to understanding content that did not arise when the class was face to face. Moreover, the midterm was an in-class exam while the final exam was delivered online. Because of this, students would have access to notes, PowerPoints, and the ability to google search anything they desired. Arguably, students could have worked with another student or provided answers to a friend in the class. This final exam limitation alone could better explain the phenomenal scores achieved on the final exam.

This leads to the next limitation that was brought up in relation to the literature review: did students experience change to their self-regulation levels after being moved online? Did they feel they were more focused by being home or was it more of a distraction? We are unsure of what prior experiences students had with online classes before the pandemic or the adjustment to living at home while taking college courses. The move to an online format arguably requires a form of discipline and self-regulation to be successful as the students are now isolated from classmates. It is possible that a student who was initially categorized with a low level of self-regulation could have improved their ability to self-regulate because it was necessary to do so. On the other hand, it is possible that a highly regulated student could become more distracted at home since they are not physically in a classroom with a teacher. Every home environment is different and not always ideally set up for taking online courses. Various speeds of internet connectivity, distractions from family members, and increased levels of temptation could impact a learner in these settings. It is impossible for us to know if students were checking email, using their phone out of sight from their webcam, or browsing social media on their phone or on their computer screen while they sat quietly with their microphones muted in an online classroom. It's also possible that a student could turn off their webcam and leave the room entirely, and the instructor would have no way to tell.

Another limitation to note was that the instructor was unable to always get through four polling questions per class as the pace of instruction was often slowed down within the virtual environment. More discussion occurred between the students and instructor to ensure that the information was understood, which slowed the pace of the class considerably. Half of the classes only got to three polling questions instead of four, and the instructor utilized this information to see how well the class understood the material. The polling feedback allowed the instructor to go over some of the material that was misunderstood, just like any instructor using mobile polling would, however this did impact the continuous delivery of four polling questions per class.

Despite the lack of significant findings within the data, the study has made some important discoveries. First, mobile polling was able to be utilized outside of the classroom in an online environment with limited issues. The important part of this is to note that the instructor was well versed in technology and has taught online classes prior to being forced to do so. Secondly, the experience and willingness to continue using the polling product highlighted the gap of knowledge that existed in the polling section. The feedback from mobile polling provided both the instructor and the students an idea of where the class was at in terms of mastery. Lastly, the BDEFS survey is highly touted in other studies and produced a surprisingly impressive distribution within the sample, however it should be noted that the subscales should not be overlooked.

Future studies should consider recreating this study in a class that is fully online from the beginning to measure the effects of mobile polling in online environments. Because of COVID-19, the first half of the course was taught in person and the midterm was given in class. The methodology of instruction changed drastically in the second half along with the final exam

being given online, which could have affected final academic achievement. An online course that has an online midterm and an online exam would with the same method instruction throughout would be crucial in maintaining validity. Moreover, testing the use of mobile polling in classroom environment after the pandemic would be ideal, though it is uncertain of what a "normal" class will be like when Universities open up in-person classes again. Class sizes could be much smaller and exercising various social distancing protocol, however such refinements may impact in-class distractions as well. In addition, it would also be helpful to compare the use of mobile polling in courses from other disciplines (e.g., biology, physics) in which the material may be harder to grasp, the instructors impose harsher grading techniques, and tend not to be as supportive ("other-regulating" scaffolders) as education faculty. Furthermore, the international studies highlight achievement gaps in our school systems, so perhaps that is a population where future research should focus their sights on the use of educational technology such as mobile polling when classes are permitted to resume. Finally, the BDEFS model should be used as part of the pre-and-post test process to see if a student's level of Self-Regulation changes. A "one-time take" of such a questionnaire may not be completely accurate as life outside the classroom could have impacted a person's view of themselves and their habits on that singular day.

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APPENDIX A

CONSENT FORM

Title of research: Mobile Polling and Self-Regulation: How Students Are Tempted with Distractions

Investigator and Department: Jim Byrnes and Lee Hardin, Department of Education: Teaching and Learning

Why am I being invited to take part in this research?

You are invited to take part in this study because you are enrolled in an Education Course that is taught by an instructor who has another section, and one of the sections is using a Mobile Polling software called Poll Everywhere.

What should I know about this research?

- The research will be explained to you by one of the investigators.
- The decision to take part in the study is entirely yours.
- You may choose to not to take part.
- You may agree to take part initially and later change your mind.
- Your decision will not be held against you.
- You may ask any and all questions you like before you make a decision.

Who can I talk to about this research?

If you have questions, concerns, or complaints, or think the research has hurt you, contact the research team at tuf33624@temple.edu.

This research has been reviewed and approved by an Institutional Review Board. You may talk to them at (215) 707-3390 or e-mail them at: irb@temple.edu for any of the following:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You have questions about your rights as a research subject.
- You want to get information or provide input about this research.

Why is this research being done?

This research is being conducted in order to better understand if mobile polling benefits all students who use it and if self-regulation plays a factor in mobile polling and overall academic achievement.

How long will I be in this research?

We expect this research to go until the end of the semester.

What happens if I agree to be in this research?

All students in the class will complete all assignments and tasks as part of the course. By agreeing to participate in the study, you are allowing the research team to use your work as data.

What happens to the information collected for this research?

To the extent allowed by law, we limit the viewing of your personal information to people who have to review it. We cannot promise complete secrecy. The IRB, Temple University, Temple University Health System Inc. and its affiliates, and if applicable, regulatory agencies, such as the Food and Drug Administration and the Department of Health and Human Services may inspect and copy your information.

All documents collected will be safely kept in a password protected file and computer and will not be released to anyone outside of the research team. All documents will be de-identified through the use of pseudonyms so that your identity cannot be determined.

Can I be removed from this research without my OK?

You can be removed from this research by either the person in charge of this research or the sponsor without your approval. Possible reasons for removal include withdrawing from the course or university or not completing the information needed.

What else do I need to know this research?

N/A

Signature Block for Adult Subject Capable of Consent

Your signature documents your permission to take part in this research.

Signature of subject	Date
Printed name of subject	
Signature of person obtaining consent	Date

Printed name of person obtaining consent

APPENDIX B

BARKLEY DEFICIT OF EXECUTIVE FUNCTION SURVEY

(The following survey questions were sent to the participants via Google Forms)

Instructions: How often do you experience each of these problems? Please select the number for each item that best describes your behavior DURING THE PAST 6 MONTHS. (1 = Never or Rarely; 2 = Sometimes; 3 = Often; 4= Very Often)

Section 1

1. Procrastinate or put off doing things until the last minute:
2. Poor sense of time:
3. Waste or mismanage my time:
4. Not prepared on time for work or assigned tasks:
5. Fail to meet deadlines for assignments:
6. Have trouble planning ahead or preparing for upcoming events:
7. Forget to do things I am supposed to do:
8. Can't seem to accomplish the goals I set for myself:
9. Late for work or scheduled appointments:
10. Can't seem to hold in mind things I need to remember to do:
11. Can't seem to get things done unless there is an immediate deadline:
12. Have difficulty judging how much time it will take to do something or get somewhere:
13. Have trouble motivating myself to start work:
14. Have difficulty motivating myself to stick with my work and get it done:

15. Not motivated to prepare in advance for things I know I am supposed to do:
16. Have trouble completing one activity before starting into a new one:
17. Have trouble doing what I tell myself to do:
18. Difficulties following through on promises or commitments I may make to others:
19. Lack of self-discipline:
20. Have difficulty arranging or doing my work by its priority or importance; can't "prioritize" well:
21. Find it hard to get started or get going on things I need to get done:

Section 2

How often do you experience each of these problems? Please select the number for each item that best describes your behavior DURING THE PAST 6 MONTHS. (1 = Never or Rarely; 2 = Sometimes; 3 = Often; 4= Very Often)

22. I do not seem to anticipate the future as much or as well as others:
23. Can't seem to remember what I previously heard or read about:
24. I have trouble organizing my thoughts:
25. When I am shown something complicated to do, I cannot keep the information in mind so as to imitate or do it correctly:
26. I have trouble considering various options for doing things and weighing their consequences:
27. Have difficulties saying what I want to say:
28. Unable to come up with or invent as many solutions to problems as others seem to do:
29. Find myself at a loss for words when I want to explain something to others:
30. Have trouble putting my thoughts down in writing as well or as quickly as others:

31. Feel I am not as creative or inventive as others of my level of intelligence:
32. In trying to accomplish goals or assignments, I find I am not able to think of as many ways of doing things as others:
33. Have trouble learning new or complex activities as well as others:
34. Have difficulty explaining things in their proper order or sequence:
35. Can't seem to get to the point of my explanations as quickly as others:
36. Have trouble doing things in their proper order or sequence:
37. Unable to "think on my feet" or respond as effectively as others to unexpected events:
38. I am slower than others at solving problems I encounter in my daily life:
39. Easily distracted by irrelevant events or thoughts when I must concentrate on something:
40. Not able to comprehend what I read as well as I should be able to do; have to reread material to get its meaning:
41. Cannot focus my attention on tasks or work as well as others:
42. Easily confused:
43. Can't seem to sustain my concentration on reading, paperwork, lectures, or work:
44. Find it hard to focus on what is important from what is not important when I do things:
45. I don't seem to process information as quickly or as accurately as others:

Section 3

How often do you experience each of these problems? Please select the number for each item that best describes your behavior DURING THE PAST 6 MONTHS. (1 = Never or Rarely; 2 = Sometimes; 3 = Often; 4= Very Often)

46. Find it difficult to tolerate waiting; impatient:
47. Make decisions impulsively:

48. Unable to inhibit my reactions or responses to events or others:
49. Have difficulty stopping my activities or behavior when I should do so:
50. Have difficulty changing my behavior when I am given feedback about my mistakes:
51. Make impulsive comments to others:
52. Likely to do things without considering the consequences for doing them:
53. Change my plans at the last minute on a whim or a last minute impulse:
54. Fail to consider past relevant events or past personal experiences before responding to situations (I act without thinking):
55. Not aware of things I say or do:
56. Have difficulty being objective about things that affect me:
57. Find it hard to take other people's perspectives about a problem or situation:
58. Don't think about or talk things over with myself before doing something:
59. Trouble following the rules in a situation:
60. More likely to drive a motor vehicle much faster than others (excessive speeding):
61. Have a low tolerance for frustrating situations:
62. Cannot inhibit my emotions as well as others:
63. I don't look ahead and think about what the future outcomes will be before I do something (I don't use my foresight):
64. I engage in risk taking activities more than others are likely to do:

Section 4

How often do you experience each of these problems? Please select the number for each item that best describes your behavior DURING THE PAST 6 MONTHS. (1 = Never or Rarely; 2 = Sometimes; 3 = Often; 4= Very Often)

65. Likely to take short cuts in my work and not do all that I am supposed to do:
66. Likely to skip out on work early if my work is boring to do:
67. Do not put as much effort into my work as I should or than others are able to do:
68. Others tell me I am lazy or unmotivated:
69. Have to depend on others to help me get my work done:
70. Things must have an immediate payoff for me or I do not seem to get them done:
71. Have difficulty resisting the urge to do something fun or more interesting when I am supposed to be working:
72. Inconsistent in the quality or quantity of my work performance:
73. Unable to work as well as others without supervision or frequent instruction:
74. I do not have the willpower or determination that others seem to have:
75. I am not able to work toward longer term or delayed rewards as well as others:
76. I cannot resist doing things that produce immediate rewards even if they are not good for me in the long run:

Section 5

How often do you experience each of these problems? Please select the number for each item that best describes your behavior DURING THE PAST 6 MONTHS. (1 = Never or Rarely; 2 = Sometimes; 3 = Often; 4= Very Often)

77. Quick to get angry or become upset:
78. Overreact emotionally:
79. Easily excitable:
80. Unable to inhibit showing strong negative or positive emotions:
81. Have trouble calming myself down once I am emotionally upset:

82. Cannot seem to regain emotional control and become more reasonable once I am emotional:
83. Cannot seem to distract myself away from whatever is upsetting me emotionally to help me calm down. I can't refocus my mind to a more positive framework:
84. Unable to manage my emotions in order to accomplish my goals successfully or get along well with others:
85. I remain emotional or upset longer than others:
86. I find it difficult to walk away from emotionally upsetting encounters with others or leave situations in which I have become very emotional:
87. I cannot rechannel or redirect my emotions into more positive ways or outlets when I get upset:
88. I am not able to evaluate an emotionally upsetting event more objectively:
89. I cannot redefine negative events into more positive viewpoints when I feel strong emotions:

APPENDIX C

BDEFS SCORE SHEET

BDEFS-LF: Self-Report Score Sheet for Raw Scores (Ages 18–34, Males and Females Combined)

Name: _____ Age: _____ Sex: _____ Date: _____

Raw Score Ranges and Percentiles

%	Self-Management to Time	Self-Organization/ Problem Solving	Self-Restraint	Self-Motivation	Self-Regulation of Emotions	Total EF Summary Score	ADHD-EF Index	%
99+	71–84	77–96	60–76	36–48	47–52	258–356	33–44	99+
98	63–70	67–76	57–59	32–35	42–46	233–257	31–32	98
97	61–62	63–66	53–56	31	40–41	229–232	30	97
96	60	60–62	50–52	29–30	38–39	214–228	29	96
95	58–59	58–59	49	—	36–37	207–213	28	95
94	57	56–57	47–48	28	35	202–206	27	94
93	56	54–55	45–46	27	34	198–201	26	93
92	—	52–53	44	26	33	—	25	92
91	55	51	43	25	32	196–197	—	91
90	54	—	42	24	31	194–195	—	90
89	53	50	41	—	30	190–193	24	89
88	—	—	39–40	—	—	188–189	—	88
87	52	49	—	—	29	185–187	—	87
86	—	48	—	23	—	182–184	23	86
85	51	—	38	22	28	180–181	—	85
84	50	—	—	—	—	179	—	84
83	48–49	47	—	21	—	178	—	83
82	—	—	—	—	27	176–177	—	82
81	47	—	—	20	—	174–175	22	81
80	46	—	—	—	26	172–173	—	80
79	45	46	—	—	—	171	—	79
78	—	45	37	19	—	170	—	78
77	44	—	—	—	—	169	21	77
76	43	—	—	—	—	167–168	—	76
51–75	35–42	35–44	28–36	15–18	18–25	133–166	18–20	51–75
26–50	28–34	27–34	23–27	13–14	15–17	110–132	14–17	26–50
1–25	21–27	24–26	19–22	12	13–14	89–109	11–13	1–25