DOES THE INTERACTIVE PUSH-PRESENTATION SYSTEM NEARPOD EFFECT STUDENT ENGAGEMENT IN HIGH SCHOOL ANATOMY?

by

Jan Anderson Hirtz

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

Liberty University

2020

DOES THE INTERACTIVE PUSH-PRESENTATION SYSTEM NEARPOD EFFECT STUDENT ENGAGEMENT IN HIGH SCHOOL ANATOMY?

by Jan Anderson Hirtz

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

Liberty University, Lynchburg, VA

2020

APPROVED BY:

David Holder, PhD, Committee Chair

Scott B. Watson, PhD, Committee Member

ABSTRACT

The ability of the United States to succeed and compete successfully in the 21st Century will be directly related to the effectiveness of America's Science, Technology, Engineering, and Math (STEM) education. In 2012 the U.S. President's Council of Advisors on Science and Technology set a goal to add one million STEM college graduates over a 10-year period. Motivation in STEM secondary classrooms is a critical contributor to students entering college in declaring and persisting in a STEM related major. The purpose of this study is to add research findings to the literature regarding means of using technology to increase K12 science motivation. How to increase STEM engagement and achievement has been the subject of much research. Research has shown that interactive lessons using student response systems, including clickers and mobile devices, can increase student engagement. Nearpod gives students the ability to draw and write complex expressions and participate in lecture and reinforcement activities as a class. In this quasi-experimental static-comparison study, we describe the use of Nearpod, a cloud based audience response software application intervention, and its impact on five subscales of motivation in a high school Human Anatomy & Physiology classroom. A total of 38 students from a rural Virginia high school participated in the study. Student engagement was measured using the Science Motivation Questionnaire II (SMQ II). The SMQ II uses a Likert Scale and the scores from the two groups were analyzed using independent *t*-tests in Statistics Package for Social Sciences (SPSS). Results showed Nearpod had a statistically significant increase on student's intrinsic motivation and self-determination. Using an larger sample size would reinforce the results of this study.

Keywords: student response systems, surface tablet, educational apps, interactive push-presentation system, push technology, one-to-one, Nearpod.

Dedication

I would like to dedicate this work to my husband John Hirtz. No words can fully describe how much his support and encouragement have meant to me through this process. He's always been willing to help with anything so that I could pursue this dream. His faith in my relationship with, and guidance through, the Holy Spirit has been unwavering. The devotedness John has to me and our children is God given, and taken for granted much of the time. He's given practical support such as editing, helping me find the words to write, as well as helping with our daily household needs. More importantly when I couldn't see getting to the end, he could, and this was instrumental in helping me move forward. My husband's belief in me and my convictions are paralleled only by my dear parents. This accomplishment is his as well as it is mine.

I would also like to give a special thanks to my sister Jill. She had entered the program before me, and introduced this opportunity into my life. Since then, God has walked faithfully with the two of us, and I thank her for all the support she's given along the way. Jill, along with my husband and parents, have always provided encouragement through words, unwavering love, and confidence in me. My son, Patrick, was less than a year old when I started this degree and my daughter, Maddie, came a year and a half later. I have been blessed beyond measure with three healthy children and a wonderful supportive family. My mother and father have given me a faith in God, and in myself, that has driven me and my decisions all of my life. I know, because of them, I will always think "What can't I do?" if it's His will, and for His glory, it can and will be done!

Acknowledgments

I would like to acknowledge Dr. Holder, Dr. Watson, Dr. Michael, and Mr. Matthews. Dr. Holder has been both an educational and Christian mentor to me. He has encouraged and helped me immensely. Without him I would not have been able to complete this degree. Dr. Holder's passion for students and how to use educational technology to increase our impact on their learning, has inspired me and this body of work. Dr. Watson was invaluable as a committee member, assisting me in both methodology and revisions. I will forever be grateful for his guidance and willingness to serve. Dr. Michael was instrumental in laying out the pathway for completing my degree and for helping me overcome barriers that seemed insurmountable. Through IRB approval, and the final stages of my manuscript, he gave me spiritual as well as practical guidance. Dr. Michael made me feel connected and supported by the department. I thank you all for serving in your different capacities and commit to using this degree for His glory and will.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

Bring Your Own Device (BYOD)

National Center for Education Statistics (NCES)

Science Technology Engineering and Math (STEM)

Student Response Systems (SRS)

Software Applications (Apps)

National Survey on Student Engagement (NSSE)

New South Wales (NSW)

Science Motivation Questionnaire-II (SMQ-II)

CHAPTER ONE: INTRODUCTION

Overview

The increasing penetration of mobile technology into our culture and classrooms has led to a proliferation of applications meant to maximize the effectiveness of this technology in learning. Numerous studies analyzing engagement, interest, and achievement in science show a steady decrease in high school students choosing college majors or career paths in STEM (Science, Technology, Engineering and Math) fields (Schumm & Bogner, 2016). The lack of American graduates to fill the high demand, well-paying STEM jobs has created a push for more engaging instructional technology to amplify science engagement at the secondary level. Active learning strategies have been shown to increase sustained interest in STEM careers for students in middle and high school years (Mohd, Halim, Rasul, Osman & Mohamad, 2019). The relationship between different aspects of science motivation and achievement has been established (Schumm & et. al, 2016; Britner & Pajares, 2006; Ryan & Deci, 2000; Fung, Tan & Chen, 2018). This, paralleled with the exponential growth of educational software applications (Apps), and one-to-one device classroom settings has created an opportunity for impactful research evaluating educational software applications to increase engagement in science (Franco & Patel, 2017). In this chapter, background on the use of student response systems and their evolution to include mobile technology will be explored. Research related to educational technology increasing science engagement and achievement will be discussed. The purpose of this study was to evaluate the impact of using the interactive software application Nearpod on five subscales of student engagement in a high school Human Anatomy & Physiology class.

Background

The use of educational Apps in K12 classrooms is on the rise with little to no research to show their effectiveness (Decuypere, 2019). The logical progression of using Apps that allow for higher levels of communication such as Nearpod is built upon educational research on Student Response Systems (SRS). The National Resource Council in 2000 identified clickers as a promising trend in education and by 2006 over one million clickers were being used in K12 classrooms (Lyubartseva, 2013). An increasing number of schools are adopting one-to-one learning, allowing mobile devices to be used in a variety of instructional modes, including student response systems. Studies have concluded that integrating tablets to serve as the one-to-one mobile technology can contribute to increased student engagement, productivity, collaboration, and critical thinking (Chou, Block & Jesness, 2014). The tablets allow teachers to use Apps as educational tools.

The effective use of SRS's in education to increase engagement and achievement has been well documented (Guthrie & Carlin, 2004). Student response systems have evolved throughout the years from handheld clickers, where students could only answer multiple-choice questions, to Apps that allow higher levels of communication including multistep synthesis of concepts. Apps have been identified as the fastest growing emerging technology in education. "Apps in particular are the fastest growing dimension of the mobile space in the K-12 sector right now, with impacts on virtually every aspect of informal life, and increasingly, potential in almost every academic discipline" (Johnson, Adams, & Cummins, 2012, p.4).

Following the success of one-to-one technology classrooms and the direction toward student-centered 21st century learning environments, the practice of students using applications for communication and assessment in the classroom is a growing progression (Johnson, Adams, Baker, Estrada, & Freeman, 2014). Nearpod, a specific type of one-to-one app, allows pull and push technology for communication including writing, drawing, and interactive lecture as well as real time assessment. Over 1,000,000 students used the app in its first year of deployment (Microsoft.com, 2016).

There is little research to determine students' engagement and learning outcomes using surface tablet apps including Nearpod in K-12 science classrooms (Hirsch-Pasek, Zosh, Golinkoff, Gray, Robb & Kaufman, 2015). Engagement is perceived to exist due to the perceptions of "Digital Natives" (Johnson et. al, 2012 p.4). Johnson describes "Digital Natives" as children raised in a digital age saturated with mobile technology. Few research studies have been performed to correlate surface tablet apps themselves to engagement and learning outcomes in K12 classrooms (NSW Department of Education and Communities, 2013).

Using SRS technology to enhance student interaction has been shown to increase student engagement and achievement. Among the social benefits of one-to-one surface tablet implementation is creating a student-centered learning environment with multiple avenues for project based learning and collaboration (Cochrane, Antonczak, Keegan, & Narayan, 2014). American high school graduates should have 21st Century skills, to include critical thinking, problem solving, collaborative proficiency, career readiness and technology expertise to compete in the global economic market (Wagner, 2008). Interactive technology has been used to decrease anxiety in chemistry classrooms and several reviews of literature show that student engagement is a predictor of learning, personal development, and academic success (Terrion & Aceti, 2012). Educational technology has been shown to increase both intrinsic and extrinsic motivation in high school science classes. (Gambari, Gbodi, Olakanmi & Abalaka, 2016)

Constructivist theory was used as the theoretical framework for this study. Jean Piaget described learning as the processes of accommodation and assimilation of information while interacting with one's own environment (McNergy & McNergy, 2007). Interactive learners construct knowledge out of their own experiences (Slavin, 2012). A constructivist classroom is student-centered where the teacher acts as a facilitator and guide while the learner interacts and manipulates their environment (Slavin, 2012). The ability of the student participate in the lecture using touch screen capability, gives the student an active role in their own learning (Shi, 2016). The Theory of Mobile Learning (TML) is grounded in constructivism and argues that learning is ongoing, and that mobile devices can positively impacting active engagement and learning (Reeves et al., 2017). Piaget and other constructivists proposed that students are active knowledge builders and are learning best when they are physically and mentally engaged (Slavin, 2012). Students drawing or touching the surface tablets to input answers optimizing apps for an interactive experience.

Problem Statement

One-to-one mobile technology in classrooms has created a medium for educational apps to be used in K12 and college classrooms(Ditzer, Hong & Struder, 2016). More than180 billion apps have been downloaded from Apples online store, and the educational sector is the third most popular category (Apple Store Downloads, 2018). Despite the exponential increase in educational apps over the last decade and a half, few research studies, on specific apps, have been done to analyze their effectiveness (Luna-Nevarez & McGovern, 2018). The purpose of this study is to add research findings to the literature on ways to use technology to increase K12 science motivation. Few quantitative studies have been done on specific mobile applications and their impact on student engagement and achievement in K-12 Classrooms. Although there has been much research on teachers' perceptions of mobile devices in the classroom, there is little data on the achievement of the students themselves (Cardoza & Tunks, 2014). Research results on the effectiveness of one-to-one mobile device classrooms is mixed with many studies showing a positive correlation between one-to-one technology and academic achievement (Harper & Milman, 2016). An increasing number of public schools are replacing textbooks and laptops with one-to-one mobile devices, and the availability and number of educational apps available to teachers are growing exponentially (Chou et al., 2014). The problem in the current literature is that the mobile device policies and the incorporated apps for education have been so quickly and broadly integrated that there is little data on the effectiveness of the mobile applications used in these one-to-one mobile device classrooms on student achievement (Johnson et al., 2014). In this study, engagement using push technology through Nearpod will be examined.

There is little research on the integration of apps into curriculum that engage, and allow students to communicate with, class and instructor in real-time using surface tablets. There have been no quantitative studies on the Nearpod app that examine science engagement and academic achievement. This study will add to the research on effectiveness of mobile apps in one-to-one k-12 classrooms, and on engagement (Reeves, Gunter, & Lacey, 2017). This study will also supplement literature on the effective use of apps to increase engagement in science.

Purpose Statement

The purpose of this study was to investigate the impact of emerging technology on student engagement and academic achievement in a high school science class. Nearpod is an app that allows continual interaction and communication of each student with the teacher and the class in an online environment. Nearpod's interactivity and how it affects engagement and achievement was the focus of this study. Nearpod allows students to login into an online environment where they can interact with a multimedia app and subsequently push answers from their device directly to the teacher's desktop for assessment. A few of the interactive features of Nearpod allow students to interact with the lesson through understanding checks, videos, and supplemental material at a pace that the student controls. As most science subjects are scaffolded, it is important to gauge student comprehension frequently and identify struggling students, and correct application of concepts in real time before addressing the next strand in the standard. Through this technology, students are held accountable for their attention and engagement by writing and sending answers to prompts throughout the lecture and guided practice. In this study student engagement through interaction with the push-technology app that allows for real-time informal assessments, was examined.

In this investigation, we used a quantitative experimental design to determine whether the Nearpod app can increase engagement within a Human Anatomy & Physiology classt. The study took place in a rural Virginia high school. The participants included 38 juniors randomly assigned to one of two Human Anatomy and Physiology classes. The hypothesis that when students use an interactive push-presentation application to interact engagement increases was tested. The dependent variable in this study was student engagement. The independent variable was the interactive Nearpod app intervention used in a one-to-one iPad science classroom. (Gall, Gall & Borg, 2007)

Significance of the Study

In this study, we sought to better understand the effects of one-to-one tablets and the use of an interactive push technology app, Nearpod, on student engagement and learning. It is important that this research be conducted to validate teachers' use of pedagogy that is data driven and has shown effectiveness. This app and others like it can be implemented to increase interest and cognition in STEM classrooms. More research on the use of mobile devices and apps and their use in education is important in order to maximize the time and resources allocated to educate students toward STEM careers. The issue of disengagement of science students is a global problem; therefore increasing student participation in STEM careers, continues to be a research focus (Ng & Fergusson, 2019)

Research has substantiated the efficacy of active learning for student engagement and accomplishment in STEM fields (Beier, et al., 2019). Research has shown interactive tactile technology, such as clickers, positively impact student engagement, and that students at the same grade and content level can increase academic achievement (Blood, 2011). Expanding on this research to include surface tablets and apps will align it with current methods of instructional technology resources. This study aimed to build on current literature testing technology as a variable to increase engagement in a high school Human Anatomy and Physiology class. The number of STEM careers are expected to grow three times more than other jobs in the United States (Langdon, McKittrick, Beede, Khan, & Doms, 2011).

Companies have expressed concerns over the lack of qualified graduates in the United States to enter these STEM jobs (Wagner, 2008). Increasing students' confidence and cognitive ability in these fields starts with effective education at the K-12 level. Many schools do not have the funds to provide a one-to-one classroom environment. Not having the one-to-one technology component is, at this point, putting many schools in poorer areas at a disadvantage (Cochrane et al., 2014). If research suggests there is a positive relationship between this technology and student engagement, grants and federal aid could be more effectively allocated to support poorer schools districts in implementing one-to-one technology and app-based instruction. Findings that support these instructional strategies could increase both a school system's rationale and ability to incorporate such technology.

Considering the financial ramifications of incorporating one-to-one surface tablets and app subscriptions, research on the effectiveness of this technology should prove valuable for educational leaders when discussing how budgets should be allocated for technology in their schools. Students in the United States have shown less interest in STEM fields of study compared to their international counterparts (Alade, Lauricella, Beaudoin-ryan & Wartella, 2016). With apps being the highest growing technology sector, students without access to these innovative teaching and learning techniques are at a disadvantage (Johnson, Adams & Cummins, 2012). This study examined the effect of an interactive push-presentation app, Nearpod in a one-to-one tablet Human Anatomy & Physiology classroom.

Research Questions

RQ1: What are the effects of an interactive software application on the intrinsic motivation of high school Human Anatomy & Physiology students?

RQ2: What are the effects of an interactive software application on the self-efficacy of high school Human Anatomy & Physiology students?

RQ3: What are the effects of an interactive software application on the self-determination of high school Human Anatomy & Physiology students?

RQ4: What are the effects of an interactive software application on the grade motivation of high school Human Anatomy & Physiology students?

RQ5: What are the effects of an interactive software application on the career motivation of high school Human Anatomy & Physiology students?

Definitions

1. *Educational Technology Applications* - The study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources (AECT, 1977)
2. *Nearpod* - An application that enables students to answer higher order questions using a touch screen that can be used to draw or write complex expressions and share those answers with the teacher and class in real time (Smith & Madre, 2015).
3. *One-to-One Classroom (1:1)* **-** A classroom where each student has a piece of technology that is provided by the school for participating in class (Stanhope & Corn, 2014)
4. *Engagement* - Six factors derived by the standard measures from the National Survey on Student Engagement (NSSE) including excitement, participation, level of interaction, and enjoyment of tasks associated with lesson (Francescucci & Foster, 2013)
5. *Academic Achievement* - Measured using factors including academic learning time, learning progress, application and demonstration (Frick, Watson, Wang, & Green, 2009).
6. *Mobile learning* – Learning mediated by mobile devices, or mobility of content/resources in the sense that it can be accessed from anywhere (Traxler, 2009)
7. *Touchscreen* - A type of visual display that allows input and control of information through touch (Walker, 2012)

CHAPTER TWO: LITERATURE REVIEW

Overview

This chapter contributes a literature review of recent technology trends in education. Research studies in one-to-one technology, touch-screen tablet technology including iPads, the effects of mobile apps, and the intervention being studied (Nearpod), will be discussed. The foundational theory of Cognitive Constructivism will be examined as it relates to the Nearpod app and its mobile platform capabilities. Cognitive Constructivism will be used to postulate Nearpod as an intervention to increase students' meaningful interaction with their environment and increase engagement (Lee, 2015). Mobile Learning Theory (MLT) has its roots in creating engaging student centered lessons using different mobile technologies. This study will specifically studied 1:1 iPad classrooms. The theory that drove this research was the assumption that if learning is an active process, learners creat new ideas, and can become interactively engaged. Students are able to communicate in real time with lesson and engagement increases. This theory aligns with Constructivism theory. Some examples of technology that aligns with this theory include messaging apps, online assessments, gaming, simulations, virtual reality, interactive podcasting with Short Messaging Service (SMS), and Interactive mobile television and SMS (Nilgun, 2011). Different types of motivation that have been examined and linked to both intrinsic and extrinsic factors will be discussed as they relate to achievement, engagement, and current learning theories. Engagement as a precursor to the different types of motivation, using the SMQ II survey, will be defined. Research related to ways to target different types of motivation for specific outcomes such as self-efficacy, self-determination, and career motivation will be shown. Current trends in research to increase academic achievement, specifically in science it will be aligned with science literacy and related literature on STEM research. Instructional strategies such as flipped classrooms, one-to-one technology, iPads and software app research will be addressed. Educational technology as it relates to engagement will be considered. Finally, challenges to instructional strategies involving one-to-one software application use in classrooms will be discussed.

Theoretical Framework

A study's theoretical framework is a critical component used to create a foundation for the research, as well as guide it. The framework helps determine variables to be examined and statistical relationships that might exist between them. John Dewey is often cited as the philosophical author of constructivism (Gutek & Gutek, 1995). Both Bruner and Piaget are described as philosophers who transformed and constructed cognitive constructivism (Brunner, 1961; Piaget, 1970). This theory of constructivism will be used to frame this study. Mobile learning theories include Constructivism, Problem Based Learning, Behaviorism, Connectivism, Activity theory and many others (Koschmann, Kelson, Feltovich, & Barrows, 1996; Siemens, G., 2004, Nilgun & Metcalf, 2011). Mobile learning is defined differently by different people depending on what is specifically being used and what the goals are. When learning is an activity process where learners construct new ideas, are interactively involved, and are able to communicate with instructor, the learning most aligns with Constructivism theory. Some examples of technology that aligns with this theory include various gaming, virtual 3D apps, different real time messaging capabilities as well as interactive podcasting with Short Messaging Service (SMS), and Interactive mobile television and SMS (Nilgun, 2011). The last two listed are most similar to the Nearpod mobile app platform that was the intervention of this study.

Cognitive constructivist theory is used as the theoretical framework to evaluate the app Nearpod and its' impact on student academic achievement. Jean Piaget described learning as the processes of accommodation and assimilation of information while interacting with one's own environment (McNergy, 2007). Learners construct knowledge out of their own experiences. A constructivist classroom is student-centered and the teacher acts as a facilitator and guide. Scaffolding in learning is essential to the Constructivist model. This model states that students gradually build their own knowledge of subject matter through accumulating experience and the process of maturation. As such, a Constructivist approach gives the student an active role in their own learning. (Shi, 2016)

The Theory of Mobile Learning (TML) is grounded in Constructivism and argues that learning is ongoing, and that mobile devices extend that learning outside the classroom (Reeves et al., 2017). Piaget and other constructivists proposed that students are active knowledge builders and are learning best when they are physically and mentally engaged which suggests that optimizing apps must be designed to include mental scaffolding with students actively engaged, not just tapping or swiping (Hirsch-Pasek et al., 2015). Constructivism depicts an active learner and an environment rich in hands on learning. The Pew Research Center (PRC) published findings that at the end of 2016, 95% of Americans owned mobile devices and 77% of those devices were smart phones with app capability. Students become engaged when they are active learners using devices that they would use normally to communicate and search for information. Apps in a one-to-one classroom that deliver content, enrichment interactives, and assessments create and optimize an active learning environment. (Pew Research Center, 2017)

Technology that is mobile enables students to acquire 21st century skills and construct their knowledge anytime and anywhere that is convenient. These devices facilitate collaboration and enable authentic, context-specific learning (Lewis, Zhao, & Montclare, 2012). Using iPads and Nearpod in unison creates many advantageous authentic learning experiences, virtual field trips for example. Websites including 3D models of molecules can be linked to the Nearpod lesson. Learning is no longer confined to students raising their hand for an answer or needing expensive laboratory equipment. Virtual labs in Human Anatomy & Physiology are a new trend in both secondary and college courses (Pyatt & Sims, 2012). Virtual experiences can be seamlessly integrated into a Nearpod lesson by simply linking a website into the presentation.

Constructivism and active learning offer a valuable rationale for why iPads with touch technology can increase both engagement and academic achievement (Lee, 2015). Students' ability to swipe, touch, draw, and write create an immediate kinesthetic visual response that optimizes the interaction between themselves and their mobile environment. Cooley (2004) coined the term "tactile vision" in which vision is "activated by the hand and its engagement with the device, as a result of which seeing becomes tactile and is no longer limited to the eyes in the touchscreen interface" (Lee, 2015, p. 731). A lecture environment where tactile vision, where audio and guidance from the teacher is given, may lead to increased engagement and achievement. Nearpod facilitates this type of optimal multi-sensory interaction between students and their lesson. Nearpod facilitates a multi-sensory interaction between students and their lesson creating a rich, student-centered lesson which Constructivists view as vital for learning. The concept of students being able to interact in a meaningful way through touch gives theoretical credence to why students learn and engage more effectively with touchscreen tablets compared to laptops (Lee, 2015).

Along with Constructivism, Bandura's Social-Cognitive Theory is used as a guiding framework that evolves from the students' interaction with their mobile environment and class. Bandura's Social Cognitive Theory predicates that optimal learning takes place when a social construct is made for the students (Bandura, 1989). Nearpod functions as an online content delivery and assessment tool allowing students to communicate throughout the lesson. Nearpod lessons have features that include sending photos, text, drawings, and review of concepts through interactive polling or gaming. There is also a feature that allows students to collaborate in teams, elevating their social interaction. Using student response systems with apps such as Nearpod allows students and teacher to engage by showing all responses collectively, with real time individual or group assessment by the instructor. Bandura described learning as optimal when subjects are in a social interactive environment watching and copying other individuals (Bandura, 1989). Introducing interactive push-presentation applications and making a classroom where every students' response is seen, optimizes social interactions in the class and can positively change both behavior and learning.

Nearpod allows the students to communicate in real time with the lesson, each other, and the teacher, producing a unique social paradigm. Nearpod, by nature, anthropomorphizes the learning technology. Since the lesson relies on students' real time interactions, it forms a continually unique and evolving response model. It intrinsically constructs an infinitely variable Agent as described by Moreno (Moreno, Meyer, Spires & Lester, 2001).

Moreno posits that in a technology-based lesson students learn more when it is conferred in a social agency environment. This implies that students may become increasingly engaged with Nearpod when compared to other apps because it organically produces a social agent that the students and teachers are building together (Moreno & Mayer, 2001).

Related Literature

Science Technology Engineering and Math. In 2011, the National Center for Educational Statistics (NCES) reported that the nation's high school graduates were not sufficient in number to support the growing requirement for STEM jobs in the United States; there were not enough American high school graduates following STEM paths in college (Nord et al., 2011). More recently, in 2016 the NCES reported that 29 countries had higher average scores than the United States in mathematics, and 22 had higher average scores in science, at the secondary school level (Kena et al., 2016). The rise in demand for graduates in STEM careers is a continuing trend, and research suggests that engagement of high school students toward academic achievement in these areas of study is crucial to the development of long term interest in these curriculums.

McDonald, in a review of STEM initiatives, reports two repeating themes from research that suggest engagement and academic achievement are key (McDonald, 2016). The first is the importance of engaging students in math and science at the secondary educational level. The second was the implementation of effective instructional strategies to increase student interest and academic achievement. One-to-one technology can increase engagement, confidence and proficiency in science (Hesser & Schwartz, 2013). Current efforts in high schools across the nation are incorporating new technology to enhance students' conceptual knowledge and skills in science (Smith, Trygstad, & Banilower, 2016).

Background. To enhance science skills and conceptual knowledge teachers have incorporated digital technologies into their lessons that provide both intrinsic and extrinsic motivation. These technologies have made it possible to create highly interactive experiences that engage learning in STEM subjects. Technologies available for science classrooms include probe-ware that can be attached to a device to collect and analyze data, tools for collaborating and communicating within a group, and websites that allow students to conduct virtual labs either individually or in groups (Ng, 2014). Using tools that students are familiar with increases their engagement and achievement of skills needed for future STEM classes.

The shortage of students following STEM careers has led to educational research to determine factors that could increase interest in these fields. Broman and Simon (2015), asked 495 high school chemistry students what they thought could improve their experience in class. From this study, the authors grouped answers into one of five categories based on students' strategies when choosing a subject. The first reason students cited to take chemistry was that they needed it for a future career. Their aspirations required them to take the course. Students suggested frequently that teachers make their lessons student centered and relate their lessons to everyday life. The second reason cited was based on self-image and identity. If they believed themselves to be smart, they were more likely to take a rigorous course like chemistry. The third reason cited was tactical as related to their grades. For example, it would be easier to get an A in art compared to chemistry. The fourth factor was experiential, based on how their past science classes influenced their decision to take chemistry. If they did well in a lower level science such as physical science, they were more likely to choose chemistry as a subject choice. The fifth t choice strategy was outside influence. What their friends were taking, had a large impact on what subjects the students chose. The results of the study showed the "importance of the teacher and the structure of the lesson" and the need for student centered STEM classrooms. The perceived usefulness for future career and student enjoyment were the top two reasons for taking chemistry cited by students. (Broman & Simon, 2015)

Technology in Education. In the last decade, there has been a continual increase in the use of educational technology to engage students and increase academic achievement. Research has suggested that if a teacher can better engage their students, academic achievement will increase. Background on mobile one-to-one classrooms and the evolution toward apps in education will be discussed. With the preponderance of digital devices in our society, mobile devices and apps are quickly changed the landscape of our educational institutions. Mobile devices including iPads and other tablets have been purchased in great numbers for one-to-one classroom use around the nation in school districts and university's alike (Reeves et al., 2017). Since 1996, more than 10 billion dollars has been spent by the United States government on technology for education (Blackwell, 2013). This does not include what districts themselves have invested in their own technology infrastructure and devices. To date there is not enough evidence based research to conclusively say whether technology increases educational learning (Cheung & Slavin, 2013).

Background information on technology in education is important for putting in perspective the significance of this study. The current literature is mixed on the effects of technology and its relationship to engagement and academic achievement. Due to the youth industry of the mobile app market in education and the swiftness with which apps are being incorporated into classrooms, research has lagged. This study addresses this gap in literature for both touch-screen one-to-one effects and the incorporation of mobile app platforms for content delivery, guided practice, and assessment, specifically STEM classrooms (Alade et al., 2016). Technology can play important roles in personalizing learning environments by differentiation and personalization of content. In this way, technology can enhance students' interaction with a subject and increase student success. The importance of how technology can be incorporated into sound pedagogy to enhance instruction and increase students' 21st century skills is great (Wagner, 2008). Increasing student's confidence, ability, and interest in math and science is of great importance (McDonald, 2016).

A study by Gambari in 2016, with over 100 participants, showed that using either computer simulations or computer tutorials for instruction increased both intrinsic and extrinsic motivation in high school chemistry students when measured by the Chemistry Motivational Questionnaire (CMQ). The CMQ is a questionnaire adapted from the SMQ II used in this study to measure motivation in an anatomy and physiology class. This increase in intrinsic and extrinsic motivation was also shown to have a direct effect on achievement as measured by the Chemistry Achievement Test (CAT). The researchers also used interviews and classroom observation to qualitatively measure motivation. The results were analyzed using Braun and Clark approach (2006). Another important factor examined in this study was gender. Results showed no significant difference in either motivation or achievement based on gender. (Gambari, Gbodi, Olakanmi, & Abalaka, 2016).

One to One mobile learning. Technology and the digital revolution have changed the way people live, communicate, and learn. Education technology and its' integration into pedagogy in public schools has been vastly studied (Delgado, Wardlow, McKnight, & O'Malley, 2015). Strategies in which technology has been incorporated into education to increase engagement and academic achievement include Online Learning, Bring Your Own Device (BYOB), Flipped Learning, Blended Learning, and Game-Based Learning (GBL) (Delgado, 2015). Literature reviews have concluded that student engagement is a predictor of student achievement and academic success, and should therefore be maximized (Terrion & Aceti, 2012).

To increase engagement, Classroom Response Systems (CRS) and Student Response Systems (SRS) have become mainstream technology. This technology facilitates individual accountability, readiness, and learning (Jones, Crandall, Vogler & Robinson, 2013). Student engagement using SRS has been well studied both quantitatively and qualitatively (Shapiro, 2009; Morling, McAuliffe, Cohen & Di Lorenzo, 2008), and with the symbiotic use of interactive whiteboards, this technology has evolved into a useful tool to increase engagement, achievement, and individual participation.

SRS and clickers were the first one-to-one technology introduced in K-12 schools. Initially, responses with clickers were restricted to multiple choice answering. Later, more sophisticated levels of communication such as Likert scale responses and texting became available. Decreasing costs of tablets and prevalence of high-speed wireless connectivity has contributed to the growing trend of one-to-one tablet technology in K-12 classrooms (Harper & Milman, 2016). Mobile apps compliment one-to-one tablet computing and have been the fastest growing technology sector in education, making them an obvious target for research studies on engagement and achievement in education (Johnson et al., 2012).

iPads and mobile apps. The evolution from desktop computers to iPad carts has been a recent trend in one-to-one computing (Zhang, Trussell, Gallegos, & Asam, 2015). Lower cost, ease-of-use of the touch screens, portability, and longevity of battery life are only a few of the reasons stated by Zhang. There are over one million apps between the Apple and Android stores to date (Zhang et al, 2015). Approximately 80,000 apps are designed and promoted as educational (Hirsh-Pasek et al., 2015). Due to the fast incorporation and evolution of educational apps, many teachers struggled to determine which apps are best suited to their instruction. Research studies on the effectiveness of apps in K-12 science education have been scarce. This makes research on specific app intervention crucial for future incorporation of this technology into sound pedagogical practices (McKay & Ravenna, 2016).

The educational quality of an app rests on its ability to engage students in learning (Hirsch-Pasek et al., 2015). Three elements of app design that optimize engagement include contingent interactions, extrinsic motivation and feedback, and intrinsic motivation (Hirsch-Pasek et al., 2015). The contingent interactions that apps and mobile devices support include the physical touching, swiping, or tapping that give an immediate response. Extrinsic motivations that mobile stimulate are praise by the teacher, and rewards such as a grade. Intrinsic rewards include an increase of knowledge, and the pride of feeling successful in class. (Hirsch-Pasek et al., 2015)

Nearpod app. Nearpod is a mobile app that can be used in one-to-one classrooms, and will be tested in this study as an intervention to increase student engagement and achievement in high school Human Anatomy & Physiology. Nearpod is a web based tool where teachers can upload their lecture (PowerPoint, Word document, or PDF) and insert supplemental enrichment videos or understanding checks (Botzakis, 2015). Nearpod allows students to interact with the teacher and class by having the students' answers, in text or drawing format, to be sent to the teacher's device from which it can be on white board. Students can write and draw responses to multi-step questions and the teacher can assess which steps individuals are struggling with and correct immediately (Delacruz, 2014; Smith & Madre, 2015).

Nearpod allows students to show their work immediately to a teacher's computer or tablet for assessment and correction. This increases participation and immediate assessment feedback (Delacruz, 2014). Nearpod facilitates a multi-sensory interaction between students and their lesson creating a rich, student-centered lesson which Constructivists view as vital for learning (Nilgun, 2011). The Nearpod gives teachers the ability to maximize engagement by increasing students opportunities to respond, and by providing a platform for real-time effective feedback (McKay & Ravenna, 2016)

When teachers prompt their classes with questions, it is usually the same students that are willing to raise their hands and participate. Research indicates that if a teacher asks a class as a whole a question, only two thirds on average have thought about an answer (Bergmann & Sams, 2012). This type of questioning and answering gives a very narrow snapshot of the classes mastery of content. A teacher asking a question to a student by name could embarrass or induce anxiety for him. Nearpod has the ability to engage and give individual real-time feedback to both teacher and student. It ensures that all students in a classroom are interactive and held accountable. Each student has the same number of opportunities to respond, responses can be given to the teacher anonymously, and feedback is in real-time and interactive kinesthetically (McKay & Ravenna, 2016).

Engagement. The definition and concept of engagement has evolved over the last few decades. In 2009, Skinner suggested emotional factors be combined with behavioral constructs to define student engagement (Skinner, Kindermann, & Furrer, 2009). Presently the most widely accepted definition of engagement, when relating its effect on achievement, includes behavioral, emotional, and cognitive strands (Groccia, 2018; Fredricks, Blumenfeld & Paris, 2004).

Behavioral engagement can be defined as positive behavior and following instructions in class. It is also defined as the absence of off-task and disruptive behavior. It is a measure of involvement and includes concentration, effort, and level of interaction physically such as asking questions and participating in discussions (Fredricks et al., 2004). Emotional engagement refers to a student's affective behaviors in class such as mood, interest, and anxiousness. Cognitive engagement is defined by Fredrick as how invested the student is psychologically in their learning. This is represented by self-regulation, ability to problem solve, and an inclination to be challenged intellectually. Cognitive engagement can be described as a student being invested and strategic in learning (Fredricks et al., 2004).

Due to the gap in achievement between U.S. students and other nations in academics, research to elucidate strategies for increasing academic achievement has proliferated (Grabau & Ma, 2017). Research has shown positive effects on achievement when engagement and motivation are increased (Grabau & Ma, 2017). If educators can find effective and meaningful ways to increase engagement, the gap between U.S. students' and other nations academic achievement should wane (Grabau & Ma, 2017).

Motivation. Motivation to learn science has been described as "an internal state that arouses, directs, and sustains science-learning behavior" (Glynn, Brickmam, Armstrong & Taasoobshirazi, 2011, p. 2). Students' decreasing interest in studying science at the college level has been suggested to be directly proportional to their lack of success and motivation in primary and secondary science classes (Schmid & Bogner, 2017). For this study the SMQ II was used to measure student motivation. The SMQ II measures five constructs for motivation including: Intrinsic motivation, career motivation, self-determination, self-efficacy, and grade motivation. A clearer understanding of how strategies increase the motivation of students toward science is needed to improve pedagogy in science education courses. This increase in motivation is essential to increasing the number of students graduating with STEM degrees (Young, Wendel, Esson, & Plank, 2018).

Intrinsic and Extrinsic Motivation. Research supports a more modern, complex knowledge of motivation although no single strategy or type of motivation promises academic achievement, knowing the types of motivation that works most effectively based on age, gender, subject, and goal can be valuable in determining appropriate pedagogy (Toshalis, & Nakkula, 2012). Teaching strategies and different mobile technologies providing intrinsic and extrinsic motivation have been used and studied to determine best educational technology uses, to increase learning effectiveness (Zaccone & Pedrini, 2019). According to Self Determination Theory (SDT), the well-being of a student is a result of satisfying their need to feel able to complete a task and do well in it. This sense of competence gives a learner intrinsic motivation. SDT postulates that intrinsic motivation is followed by extrinsic motivations such as grade determination, and career motivation. This theory suggests that intrinsic and extrinsic motivation are a continuum. Some research suggests that without intrinsic motivation a student can't be motivated extrinsically (Cerasoli, & Ford, 2014). Engaging students individually requires connecting and providing them with a sense of competency which gives rise to self-determination and active learning (Toshalis et al, 2012).

Engagement and Motivation. Researchers have used various models describing the phenomenon of engagement as having three, four or six distinct aspects. (Harbour, Evanovich, Sweigart & Hughes, 2015). The reciprocal and predictive realtionship between motivation and engagement has been well established (ChanMin, Seung, Cozart & Lee, 2015). When students are motivated they are more likely to engage, conversely when students are engaged they are more likely to be motivated (Kim, Park, Cozart & Lee, 2015). The extent to which students contribute to the instructional paradigm through their own expression of motivation has been described as an important form of classroom engagement and motivation. Research in engagement has expressed a direct correlation between a student's motivation and educational outcomes (Reeve & Lee, 2013). The National Research Council & Institute of Medicine has described engagement and motivation as synonyms that are interchangeable (Truly, 2004).

Reeves (2014) studied how changes in engagement changed motivation. A total of 351 high school students in urban Korean Schools participated in the study. Students completed Likert questionnaires three times in a 17 week semester. The variables being measured were psychological need satisfaction, self-efficacy, mastery goals, and classroom engagement. Achievement was measured using end of subject tests. Different questionnaires were used for engagement and motivation. Results demonstrated that engagement and motivation showed a strong correlation (Reeves & Lee, 2014).

Engagement and Education. A nationwide emphasis on academic achievement measured by high-stakes testing has sparked much research on student engagement. Continued studies on increasing achievement by increasing engagement have shown a positive correlation between the two (Harbour et al., 2015). Engagement has been defined as a two-faceted construct involving both a psychological and behavioral component, the psychological component being identification (feeling of belonging), and the behavioral component being participation (Finn, 1993).

Engagement has also been described as having three components; behavioral, emotional, and cognitive. Behavioral engagement was delineated as a student's interaction, participation in the classroom. Emotional engagement was described as influencing student connectedness to the school, peers, and teachers. Cognitive engagement was described as referring to students level of effort and willingness to participate (Fredricks, Blumenfeld & Paris, 2004). Engagement is now commonly used as a predictor of academic achievement and progress (Harbour et al., 2015).

Teachers' lessons, instructions, philosophy, and classroom environment have a major impact on promoting student engagement. Active participation, peer identification in a classroom setting, and a student's effort, is closely related to their teacher's behavior. Effective teaching behaviors that maximize engagement include positive modeling, giving students opportunities to respond, and meaningful feedback (Harbour et al., 2015). Modeling has been described as demonstrating or implementing a specific skill or desired actions while also performing and describing the actions and decision making process simultaneously. Giving students opportunities to respond is part of any successful instructional strategy. Making that response meaningful, to foster active participation, has been linked to an increase in student academic achievement (Partin, Robertson, Maggin, Oliver & Wehby, 2010).

A third instructional strategy that maximizes student engagement is frequent and effective feedback given by the teacher. Meaningful feedback has been shown to offer positive effects on engagement, and thus achievement, and to increase positive behavior. One review examined over 180,000 individual studies on the effects of feedback and engagement, and concluded that effective feedback is among the most significant strategies a teacher can use to positively affect engagement, academic achievement, and positive classroom behaviors. (Hattie & Timperly, 2007).

Research on the role of school engagement has shown it to be a predicter of academic achievement in high school aged students (Chase, Hillard, Geldorf, Warren & Lerner, 2014). Chase found that behavioral school engagement was the greatest predictor of GPA. A similar study found that engagement positively predicted standardized test scores in 8th grade students (Chase, Hilliard, Geldhof, Warren, & Lerner, 2014). Studies have also shown a bigger picture wherein students who are engaged in high school, not only achieve academically at their current level, but go on to be happier, more successful human beings (Kizildag, Demirtas-Zorbaz, & Zorbaz, 2017)

Engagement in Science. As stated previously, the gap in general academic achievement when comparing students from the U.S. to other nations is substantial; the gap in science achievement is even more pronounced (Grabau & Ma, 2017). U.S. science achievement as measured by the Program for International Student Assessment (PISA), administered by the Organization for Economic Cooperation and Development (OECD), continues to rank below the international average (OECD, 2016). The deficiency in science achievement and the inability to fill STEM jobs with U.S. graduates has led to an increase in research on how to increase engagement and achievement concurrently. Grabau and Ma (2017), to further understand this correlation, investigated nine aspects of science engagement. They examined the relationship between the aspects of science engagement on school climate and science achievement. The nine aspects considered were: conception of science engagement, science self-efficacy, science self-concept, enjoyment of science, general interest in science, instrumental motivation for science, future-oriented science motivation, general value of science, personal value of science, and science-related activities (Grabau & Ma, 2017). Results showed that all nine aspects of science engagement studied were positively, and statistically significantly correlated with science achievement. Eight out of the nine aspects examined showed a medium or large effect size. This study added to the research that an increase in science engagement can increase science achievement (Grabau & Ma, 2017).

The purpose of a study done by Ucar &Sungur (2017), was to analyze the relationships between goal structures in terms of four aspects of engagement. Seven hundred and seventy-seven students from nine public schools were administered an engagement questionnaire and science achievement test after being subjected to the same science curriculum. Engagement was broken down into four constructs; behavioral, emotional, cognitive, and agentic. Agentic engagement has been defined as the learner's contribution to their own mastery of subject material (Reeve, 2012). The findings have suggested that increasing engagement is a significant requirement for increasing academic achievement in seventh-grade science classrooms. Autonomy support, self-efficacy, evaluation, and motivating tasks have all led to a rise in engagement. Results revealed that of all constructs of engagement measured, agentic engagement was the only strand not to be reciprocally related to achievement (Ucar & Sungur, 2017).

Engagement and Technology. The No Child Left Behind Act of 2002 (NCLB), had many goals, one of which, was to eliminate the digital divide and have all students, despite race, sex, or socioeconomic status, technologically literate by eighth grade. The President's Council of Advisors on Science and Technology deemed interactive software and mobile devices to be promising emergent educational technology (PCAST, 2012). Technology has connected Digital Natives to the classroom by creating active learning classrooms. Technology includes digital devices, websites, and software applications. Research on technology in education, one-to-one classrooms, blended learning environments, and classrooms with student response systems can increase engagement and achievement when used thoughtfully (Wang et al., 2014).

Student response systems, such as clickers or web-based apps, increase interactivity and give students more opportunities to respond and receieve feedback (Wang et al., 2014). These types of technologies increase engagement by supporting communication, interactivity, and by promoting active participation by each student. In a study done at the University of Wisconsin, faculty using student response systems responded overwhelmingly to an increase in engagement in their classrooms. Ninety-five percent of faculty agreed that when students engaged with the class interactively through this technology, engagement increased (Lyubartseva, 2013).

Research has suggested that mobile apps increase engagement (Radley, 2016; Hirsh-Pasek, 2015). A study done by Flower, showed the Good Behavior Game App to decrease off-task behavior and increase engagement in a high school algebra class. The three classrooms studied as the experimental group demonstrated large effect sizes with significant decreases in disruptive behaviors when the Good Behavior Game app was used (Flower, McKenna, Muething, Bryant, & Bryant, 2014). The educational quality of an app rests on its ability to engage students in learning (Hirsch-Pasek et al., 2015).

A causal comparative study examining the use of WhatsApp in a blended learning environment showed increased engagement and participation compared to a control group with face to face learning only, but by a small margin and in only a single course with a small sample size (Barhoumi, 2015). A case study on mobile learning in a 9th grade Geography class explored integration of one-to-one iPads to observe the impact on student engagement. Their findings included a positive impact of iPad integration on student engagement. Researchers stated, "We have witnessed firsthand, how engrossed the students were with their iPads" (Chou, et al., 2012, p.23). These authors recommended more research on one-to-one learning and how this technology can better be used to engage students.

In contrast, Hoffman (2013) found that student's engagement decreased when using iPads and off task behavior increased when using iPads. When given an individual task, the ease with which students could interact through email and internet with the iPads resulted in off-task behavior. The paper-pencil group showed greater levels of engagement in their activity (Hoffman, 2013). The need for apps that include built in classroom management functions is crucial. The Nearpod app gives teachers the ability to recognize when a student is off-task. In the left corner of the screen, there is a green icon for the class with the number of students logged onto the session. If students are off task and open internet or email, the icon turns red and the number of students that remain in the session is displayed.

Technologies present unique opportunities for teachers to optimize student engagement and adapt to the changing needs of students. As technology is made more available to teachers and students, the form of lecture and delivery of content as well as assessment and feedback has the possibility of increasing students' interactivity and engagement (Terrion & Aceti, 2012). Technology has changed education. Growth in the amount of resources and funding allocated to provide students with a 21st century education is ongoing. Results of studies on the effectiveness of using technology in classrooms have been mixed, but overwhelming data supports the argument that when technology is used effectively, it can transform a traditional classroom into an engaging, interactive one (Delgado et al., 2015). A trend to provide one-to-one device ratios in classrooms has been stimulated by research demonstrating that hands-on-learning increases engagement and achievement (Khaddage, Mulller, & Flintoff, 2016).

Achievement. Since the initiation of NCLB , high stakes testing and annual yearly progress measures have stressed states, districts, counties, educational leadership, teachers, and students with a demand to show academic achievement on the tests in order to remain autonomous and funded by the government. Efforts to improve achievement have been the subject of extensive research (Harris, Al-Bataineh & Al-Bataineh, 2016). Many studies have focused on increasing engagement in response due to the amount of research showing a correlation between engagement and achievement. Schools have searched for means to eliminate the digital divide and incorporate technology into curriculum in meaningful effective ways (Reeves et. al, 2017). Most data collected on technology integration and its effect on achievement has been conducted in higher education. There is a need to research effects of specific technology on achievement research in k12 classrooms (Reeves et. al, 2017).

Achievement in Education. The Program of International Student Assessment (PISA) tests the academic achievement of U.S. students and compares their scores to students in 72 other educational systems around the world. This test examines science, reading, and mathematics literacy. In 2015, U.S. 15 year old’s in public school averaged a score of 496 in science, which ranked 24th among the other participating countries. This showed a deficit compared to 18 educational systems, and higher than 39. There was little difference in scores with 12 countries. (Kastberg, Chan & Murray, 2016). The U.S. spends more per student than most of the countries that outperformed ranked in the top 20. In mathematics the results were worse, ranking U.S. students 38th out of the 72 (Kastberg et al., 2016). In a report released by the National Center for Education Statistics (NCES), approximately 55% of fourth graders "Liked learning science" (Stephens, Warner, & Harner, 2015, p. VI)

Large achievement gaps in the U.S. are also seen within the nation and appear related to income inequality. Students that are on free and reduced lunch score lower on national science tests (U.S. Department of Education, 2015). These achievement gaps have been attributed to differences in educational opportunities. Lower income counties typically have fewer resources and less ability to attract experienced teachers due to lower pay (Morgan, Farkas, Hillemeir, & Maczuga, 2015). Students in these lower income counties are prone to receive lower-quality educational experience (Morgan et al., 2016). Research on technology and one-to-one technology integration in lower income schools have shown promising results for leveling the educational playing field (Harris et al., 2016).

Technology and Academic Achievement. With the increase of one-to-one tablet use in schools, many math teachers are using apps to engage and teach their students (Haydon, Hawkins, Denune, Kimener, & McCoy, 2012). Due to the recent introduction of apps in education, little research has been done to gauge the effectiveness of apps on academic achievement (Zhang et al., 2015). An exploratory study was conducted using a quantitative pretest posttest design in an inclusive 4^{th} grade class in a public elementary school in the southwestern United States. The introduction of 3 math apps for supplemental practice showed an increase in scores when compared to the control group. Although this study used a small sample size (n=17) and focused on the effectiveness of app intervention when used to help struggling learners close the achievement gap with typical learners, the study showed promise for apps and their use in increasing general academic achievement. (Zhang et al., 2015).

A study in New Zealand by Fallon (2013), with 18 Kindergarten students, concluded that using iPads and apps thoughtfully can increase both engagement and learning (Fallon, 2013). Likewise, Kucirkova (2014) found that when using a storytelling app with 41 preschool-aged children, student engagement and learning of information increased (Kucirkova, Messer, Sheeby, & Fernandez, 2014). Reeves (2017) used a quasi-experimental static-group design to study the effects of a multitude of apps on academic achievement throughout a school year. Participants included two classes of 28 students in a rural public charter school in Florida. The experimental group received guided instruction using mobile apps on iPads for 7 months. Results showed significantly higher Phonological Awareness and Mathematics measures for the students using apps on iPads. Conversely, the students in the experimental group did not score significantly higher with regards to Print Knowledge or Oral Language (Reeves et al., 2017).

A quantitative pretest posttest study was employed to gauge the effects of iPad use on students' academic achievement amoung 104 fifth grade math students in a public school in Virginia. For nine weeks, half of the students (the experimental group) used iPads for supplemental practice. The disparity between pretest and posttest was not significantly increased for the students who had access to iPads for practice (Carr, 2012). A similar pretest posttest study using an app called Wechat as an interactive translation tool was done to evaluate the Impact of this app on student academic achievement (Zijuan, Gaofeng, & Le., 2017). Both graded tests and questionnaires were used in analyzing the results. The experimental group of 30 students increased their posttest scores significantly, compared to the control group. Analysis of the questionnaires also showed a positive correlation to student achievement and use of translator app.

Technology in Science Instruction. Much research has been done on one-to-one technology in STEM. It has been reported that using iPads and apps, including video games, could increase STEM learning between 7 to 40 % (Mayo, 2009). Such a large range strongly implies individual apps need to be tested further to gauge their impact. Games can be exciting to students at first, but that excitement might dwindle after an extended length of time. This research also showed a decrease in the learning gap between higher functioning and lower functioning students. While optimal for students at lower levels, the game apps must differentiate to keep the higher functioning students engaged and learning (Mayo, 2009).

Research using iPads and 6 apps in chemistry was done to create a paperless chemistry class (Hesser & Schwartz, 2013). Among the apps used were electronic laboratory notebook and an analytical app complementing the probe-ware used. The labs were all simulated. The sample size of the group was 20 chemistry honor students. An assessment survey was used. It was observed that students had a steep learning curve when using the iPads in the lab, and that lab procedures took more time than a traditional course. The feedback from the survey, though, showed an increase in student engagement. Some advantages noted were the lower cost of iPads compared to personal computers, that the apps gave the students the ability to write and draw, and the overall mobility of the apps on iPads. Integration of one-to-one iPads with different science applications will need more research and time to determine the most effective ways to use this technology to achieve academic success (Reeves et al., 2017)

Doceri and Connect Alone were used in unison in a high school chemistry classroom (Silverberg, Tierney, & Bodek, M., 2014). This combination of apps allowed students to draw and connect in a synchronous or asynchronous online environment. Doceri enabled the students to draw on the iPads and send to the teacher by using Connect Alone. It is also a platform for the teacher's content delivery. The teacher can also record lessons for use later. Although this combination has been reported as engaging, no data was given to support this claim. The survey results showed that the synchronous use of Doceri in class was similarly as effective for students using it at home asynchronously. The study did not give a sample size or any information about the population other than it being a chemistry class (Silverberg et al., 2014).

The emergence of apps and mobile learning, is particularly exciting as it relates to science instruction. They offer the opportunity to decrease expenditures on expensive laboratory apparatus and the safety provisions that go along with a real lab setting. The labs can be done virtually while teaching the same concepts and skills utilizing much less expensive apps (Heilbronner, 2014). Currently many science teachers in K12 must often forgo lab experiments due to lack of supplies and equipment. Apps that can be used to complete virtual labs are sometimes free or a fraction of the cost of the necessary scientific instruments. App based student labs can keep up with current techniques and new technologies without having to revamp their science labs and equipment (Heilbronner, 2014).

Challenges in Education. The challenge of recruiting and retaining sufficient numbers of qualified teachers has led to a teacher shortage in the U.S. (Cobbold, 2010). This shortage is not unique to America; many countries are facing the same problem. There is disagreement among states concerning the definition of a "qualified teacher". The NCLB defines a qualified teacher as a person who has acquired a state certification or a passing score on a teacher examination and who receives continual professional development, but allows each state to determine what a "qualified" teacher is (Cochran-Smith, 2003, p. 96). Specifically, qualified teachers in secondary math and science classrooms are at the top of the list of positions needing to be filled. The reasons for teacher shortages are not new. They include low salary compared to persons with similar educational investments, rising early retirement of veteran teachers, low morale, lack of supports, stress due to high stakes testing, attrition, and a decreasing college graduate pool. (Steinke & Putman, 2007).

Many researchers have found that retaining experienced teachers can be more effective than focusing on recruiting new ones (Steinke & Putman, 2007). A focus on teacher job satisfaction and improving morale are two means of addressing the issue. Technology educators site lack of understanding and support for equipment and training as a continual frustration (Steinke & Putman, 2007). Teachers are given digital devices but little training or time to integrate the new technology into their lessons. A lack of a teacher's self-efficacy in the use of technology in instruction can have negative effects on job satisfaction and performance (Elstad & Christophersen, 2017).

Challenges to Educational technology. Some factors in the successful integration of mobile technology into instruction include teacher's knowledge, skills and training, as well as accessibility to technology, confidence level, and pedagogical beliefs. For technology to be used thoughtfully and effectively requires a change in teachers', students', and educational leaders' attitudes and thoughts on pedagogy and instructional practices (Vantanartiran & Karadeniz, 2015). Time and money for training continue as the two main challenges restricting the incorporation of technology into classrooms (Eppard, Nasser, & Reddy, 2016). Without teachers receiving proper training or time to incorporate what they've learned into their lessons they cannot optimize the potential of the technology afforded them. The effectiveness of the technology is limited. Incorporating a one-to-one initiative has many benefits as mentioned earlier but also many challenges. (Eppard et al., 2016)

Challenges to Mobile learning. There are many challenges to mobile learning and one-to-one classrooms. These include funding, management, a school's bandwidth, teacher perceptions, pedagogical & economical concerns, as well as lack of research to justify expenditure of resources (Khaddage et al., 2016; Tucker, 2016; Eppard et al., 2016). Despite many positive studies that correlate technology and engagement, teachers are still reluctant to allow their students to use mobile devices in a formal classroom setting (Khaddage, Lanham, & Zhou, 2009). Teachers have fears of losing control of the classroom as well as valid safety concerns. This leaves traditional teacher-centered learning in place in many classrooms, which research has shown does not engage students (Khaddage et al, 2016). Teachers have expressed the need for professional development and time needed to incorporate mobile devices and apps into their lessons (Eppard et al., 2016). Another challenge to mobile learning is off-task behavior of students. When smart mobile devices first appeared on the market, most K12 education banned the use of them in classrooms. By 2014, 85% of school districts had some type of bring your own device (BYOD) policy, permitting students to use them for academic purposes when allowed by their teacher (Heilbroner, 2014).

Challenges to Using Software Applications (apps).

App, is the abbreviation for software applications that are used on mobile devices such as, tablets and smart phones. Software applications have been running on personal computers (PC's) since the beginning of the technological age but the term App is usually used for mobile devices rather than PC's (Zhang et al., 2015). The speed and development at which mobile applications have been incorporated into everyday life as well as education has led to many challenges. Challenges for educational leadership, teachers and all stakeholders involved in a student's education include funding, professional development, accessibility, and classroom behavior management, (Zhang et al., 2015).

A hurdle to incorporating mobile technology and app use into the classroom is the amount of money needed to gain access to apps, as well as bandwidth needed. Increases in security and training of teachers and students will require resources and time away from teaching content (Jones, 2014). One of the main challenges to using apps in K-12 education is being able to identify which apps are educationally sound. Examples of sound evaluating criteria include credibility of authors, the reviews, and who has sponsored the app (Jonas-Dwyer, Clark, Celenza, & Siddiqui, 2012). A critical challenge is for teachers to adopt technology, including apps, that can be implemented into effective pedagogy. The instruction should guide the app rather than the app guiding instruction. Digital Promise is an initiative brought about by the White House to find emerging technologies that have been tested and show promise for education. Government, schools, and businesses are charged with the task of evaluating and suggesting technologies that have evidence of success (Ditzer, Hong & Struder, 2016). Research on apps in education is needed to elucidate best practices in the mobile one-to-one learning classrooms.

Summary

The theory of Constructivism was used to guide this study of Neapod, , as a mobile educational intervention, to elucidate its effects on students' active learning with their lesson that increase engagement (Lee, 2015). The assumption that learning is an active process, and that learners create new ideas, and can become interactively engaged is the basis of Constructivism. With Nearpod, students are able to communicate in real time with their teacher and the lesson. Creating active student centered learning has been shown to increase engagement.

A review of literature shows little research done to specifically gauge the effects of Nearpod on engagement in high school classrooms. Research suggests that poor academic outcomes, especially at the secondary level, is due to a lack of engagement. The link between engagement and positive student outcomes is reported in literature (Thomas, Pinter, Carlisle, & Gorn, 2015; Lei, Cui & Zhou, 2018). Constructivism and the Mobile Learning Theory (MLT) is the theoretical framework that guided this study. Research suggests that mobile apps and one-to-one classrooms can increase engagement (Radley, Dart, & O'Handley, 2016; Hirsh-Pasek, 2015). The educational quality of an app rests on its ability to engage students in learning and the teacher's ability to use it effectively (Hirsch-Pasek et al., 2015). Nearpod, with its content delivery method and interactive push technology was examined to elucidate the influences on engagement in a high school Human Anatomy & Physiology.

Mobile learning in science classrooms can offer virtual labs that give real life experience, and hands on activities that can increase motivation and decrease the need for expensive laboratory apparatus (Heilbronner, 2014). Nearpod is an App that can be used to embed virtual experiences, including virtual labs, and virtual 3D fieldtrips that engage the student and places the teacher in a facilitator role. The advantages of creating 1:1 learning classrooms with iPads or tablets compared to personal computers, are that tablets start much quicker, are much cheaper and easier to maintain. A teacher can manage an tablet cart were specific apps can be requested for particular classroom teachers cart. With tablets, students have the ability to write and draw, and interact easily with the user friendly interface. As stated earlier, integration of one-to-one classrooms, need more research, to determine the most effective ways to use this App technology to achieve engagement and academic success (Reeves et al., 2017).

This study addresses the gap in literature for both touch-screen one-to-one effects and the incorporation of mobile app platforms for content delivery, guided practice, and assessment, in STEM classrooms (Alade et al., 2016). Technology can play important roles in personalizing learning environments by differentiation and personalization of content. In this way, technology can enhance students' interaction with a subject and increase student success. The importance of how technology can be incorporated into sound pedagogy to enhance instruction and increase students' 21st century skills is great (Wagner, 2008). Increasing student's confidence, ability, and interest in math and science is of great importance (McDonald, 2016) Studies have shown that engagement changes motivation. Intrinsic and extrinsic motivation such as need satisfaction, self-efficacy, mastery goals, and classroom engagement. demonstrated that engagement and motivation increased academic achievement (Reeves & Lee, 2014).

Studies have showed that using mobile technologies can effectively increase both intrinsic and extrinsic motivation in high school science students. The increase in motivation has also shown to have a positive effect on achievement in science. Both qualitative and quantitative methods have shown that an increase in motivation, increases achievement. Results of studies on motivation with regard to gender have been mixed. An active student centered classroom created using researched based educational technologies has been shown to increase intrinsic motivation, self-determination, and can increase extrinsic motivation such as grade and career motivation. This research is important to apply to STEM classrooms in an effort to create a pipeline for high demand, high paying jobs that would go unfilled by our American students.

The steady increase of one-to-one tablet use in schools, many eachers are currently using apps to engage and teach their students (Haydon, Hawkins, Denune, Kimener, & McCoy, 2012). Due to the number of educational apps being created in such a short amount of time, research on specific educational Apps and their effectiveness lags behind (Zhang et al., 2015). Teachers need App research to be able to make data driven, informed decisions on the best, most effective educational technology used in their classrooms. A challenge for teachers in adopting technology, including apps, is the lack of evidence that the technology can be implemented as an effective strategy to increase active learning. Educational leaders agree that the instruction should guide the use of an app rather than the app guiding instruction. There is a national initiative to discover emerging technologies that have been researched and tested that show effectiveness in k-12 science education (Ditzer, Hong & Struder, 2016).

The lack of qualified graduates in the United States to enter these STEM jobs, puts America at a Global disadvantage (Wagner, 2008). Increasing students' self-efficacy and skill in these hard to fill fields, begins with effective engaging science education at the K-12 level. If research suggests a positive relationship between specific educational technology, and student engagement, financial resources at both the county, state, and nation level can be more intentionally allocated. Challenges to mobile learning include funding, professional development, accessibility, and classroom behavior management, (Zhang et al., 2015).

There have been varying levels of success of one-to-one classrooms, most have been positive (Ditzer et al., 2016). Increasing one-to-one tablet use in k-12 schools has led to higher use of apps to engage and teach students. Due to the recent introduction of apps in education, little research has been done to gauge the effectiveness of apps on academic achievement (Zhang et al., 2015). Research studies using apps in K-12 are too few and have shown mixed results. More studies need to be done to fill this gap in literature. This study adds to the research on educational technology and apps used to increase active learning, motivation, and achievement in science.

CHAPTER THREE: METHODS

Overview

The purpose of this quantitative study was to discover the effects of Nearpod, a push-interactive presentation system, on student engagement in a high school anatomy and physiology class. Chapter three discusses methodology used and rationale behind the research design chosen, as well as the statistical analysis used. The research questions and hypotheses associated with this study will be considered. Information detailing the setting and participants will be addressed. Finally, instrumentation, procedures, and information on the statistical analysis will be narrated.

Design

A quasi-experimental static-group comparison design was used to determine the effects of a mobile app, Nearpod, on student's engagement in an anatomy and physiology class.
A quasi-experimental static-group comparison design is a between-subjects design and is appropriate when participants have not been randomly assigned to a group by the researcher (Gall, Gall & Borg, 2007). A posttest only static group design is suggested when the administration of a pretest might possibly effect the experimental treatment (Gall, 2007 p. 409). The students in the study had been assigned by guidance to sections due to scheduling in an educational environment. The lessons, activities, and environments of the control and test group were kept constant to increase the internal validity of the results. This research design has been used in similar study's including one measuring dependent variables such as intrinsic motivation, where a pretest might sensitize participants to the variable being studied (Gall, 2007). Intrinsic motivation will be one of the subscales of engagement that will be tested in this study. Similar

educational research using motivation as a dependent variable as well as a small sample size close to 60 have been reported in literature (Patrick, B, Hisley, & Kempler, 2000).

Research Questions

RQ1: Is there a difference between high school students' *intrinsic motivation* who use Nearpod to interact with the lesson and those that do not?

RQ2: Is there a difference between high school students' *self-efficacy* who use Nearpod to interact with the lesson and those that do not?

RQ3: Is there a difference between high school students' *self-determination* who use Nearpod to interact with the lesson and those that do not?

RQ4: Is there a difference between high school students' *grade motivation* who use Nearpod to interact with the lesson and those that do not?

RQ5: Is there a difference between high school students' *career motivation* who use Nearpod to interact with the lesson and those that do not?

Hypotheses

$H_0$1: There will be no statistically significant difference between learner's intrinsic motivation who utilized a push-interactive presentation system, Nearpod, and those that do not as measured by the Post SMQII questionnaire

$H_0$2: There will be no statistically significant difference between learner's self-efficacy who utilized a push-interactive presentation system, Nearpod, and those that do not as measured by the Post SMQII questionnaire.

$H_0$3: There will be no statistically significant difference between learner's self-determination who utilized a push-interactive presentation system, Nearpod, and those that do not as measured by the Post SMQII questionnaire.

$H_0$4: There will be no statistically significant difference between learner's grade motivation who utilized a push-interactive presentation system, Nearpod, and those that do not as measured by the Post SMQII questionnaire.

$H_0$5: There will be no statistically significant difference between learner's career motivation who utilized a push-interactive presentation system, Nearpod, and those that do not as measured by the Post SMQII questionnaire.

Participants and Setting

The participants for the study was drawn from a convenience sample of high school students located in a rural county in southcentral Virginia during the fall semesters of 2018 and school year. The county has roughly 12,000 citizens, with 70% of them having high school diplomas. The county is a lower-to-middle income setting with an average income of $34,000 per year (Virginia Employment Commission, 2017). The largest employer in this county is the public-school system.

For this study, the number of participants sampled was 48 which exceeded the required minimum for a large effect size. According to Gall et al. (2007, p. 145). Forty students are the required minimum for a large effect size with statistical power of .7 at the .05 alpha level. The sample population came from the one high school with an approximate student body of 500. This includes approximately 1% Asian, 3% Hispanic, 45% African American and 51% Caucasian students. There is a (47:53) female to male ratio. The sample population for this study will be comprised of both African American Students (6) and Caucasian students (32) enrolled in Human Anatomy & Physiology in their 11th year of high school. The participants will be comprised of both female (29) and male students (9). Students seeking an advanced diploma are enrolled in Human Anatomy & Physiology as a 4th science elective required for graduation with this status. The prerequisites for this course include earth science, biology, and chemistry. There were two sections of Anatomy and Physiology offered, both in the fall semester. Lessons for the unit were designed by researcher to keep material presented as constant as possible. The in-class activities, homework and reinforcement also remained consistent between the two classes (Appendix E).

Instrumentation

Reliable instruments are required to compare students' engagement in science. The instrument used to elucidate student's engagement will be the Science Motivation Questionnaire II (SMQ-II) developed by Shawn Glynn (Glynn, Brickman, Armstrong, & Taasoobshirazi, 2011). The SMQ-II is an instrument designed to measure motivation of both college and high school students to learn science content. The SMQ-II was developed to measure motivation in science for both students with science and non-science majors (Appendix F). This instrument measures 5 subscales of engagement including intrinsic motivation, self-efficacy, self-determination, grade motivation, and career motivation. Each subscale has 5 Likert scale questions assigned to it. The questions related to each subscale were asked intermittently throughout the questionnaire (Appendix I).

The SMQ II consists of 25 questions and used a five-point Likert scale that ranged from Always to Never. Responses were as follows: Always = 4, Often = 3, Sometimes = 2, Rarely = 1, and Never = 0. Each subscale of motivation had 5 questions assigned to it. The highest possible score for each subscale is 20 points and would represent a high level of engagement related to that subscale. The lowest possible score would be zero, which would equate to no engagement. The internal validities for each of the scales, assessed by Cronbach's alphas are given in Table 1 and are specified per question in Appendix I. Values of Cronbach's alpha ranged from .81 to .92 indicating sufficient reliability (Glynn at al., 2011). Permission to use the SMQ-II is shown in Appendix G.

Table 1
Cronbach Alphas for SMQ-II Factors

Factor	Cronbach's α
Intrinsic Motivation	.89
Self-efficacy	.83
Self-determination	.88
Grade motivation	.92
Career Motivation	.81

Procedures

Institutional Review Board (IRB) approval for the study was submitted to Liberty University (see Appendix A). After IRB approval, the request to do research was sent to the Superintendent of the county that outlined the study's significance, proposed participants, and procedures (see Appendix B). Permission from the county was given for the study (appendix C) After receiving approval at the county level and from my principal, a meeting with the superintendent, principal, and myself took place to discuss the parameters and significance of the study. Any questions or concerns from administration were addressed. A letter with consent form will be written and approved went out to parents and guardians requesting permission that students participate in the study (Appendix D). Students were given a week to bring the signed forms back to their teacher and were given a 100 homework grade if form was turned in signed or not signed.

An outline of the research procedures and steps taken to insure integrity of instruction as well as the student's welfare was given to parents and administration. Only data from the students with guardian permission was used in this study. A total of 38 student's in both classes returned forms with permission given by guardian. This student took the survey but results were removed by classroom teacher. Signed consent forms will be kept in a locked file cabinet in researchers home office. The teacher in the test group used Nearpod, in a one-to-one classroom intermittently in lessons, and as formative assessments in real time. All students completed Nearpod's standard introduction lesson. Students in the Nearpod group practiced using the Nearpod application to answer questions related to previous unit including multiple choice questions, draw it and open ended questions. This increased students familiarity and proficiency with the application. The study followed class sessions for three weeks, each week had a three 90-minute period and two 70-minute periods. The lesson plans for these weeks can be found in appendix E. At the end of three weeks' students from both the control and the test group took the SMQ II. After testing, data was redacted by corresponding teacher, erasing student names and identifiers. The data relating to the SMQ II survey was analyzed to determine the effects of the intervention on the different subscales of engagement.

Data Analysis

To test each of the null hypotheses, independent samples *t*-tests (*t* tests) were performed. Independent samples *t*-tests are an appropriate analysis to use when you have one ordinal dependent variable and are analyzing the difference between two groups means (Gall et al., 2007; Warner, 2007). Due to there being five separate independent *t*-tests, a Bonferroni correction was used to assign an appropriate alpha level ($p < .01$) (Armstrong, 2014; Cohen, 1988; Cronbach, 1951). This will decrease the likelihood of a Type 1 error due to multiple *t*-tests. Independent sample *t*-tests will be used to calculate the *t* statistic and will be compared to *t* critical. If the calculated statistic is less than *t* critical the null hypotheses for the subscale in question will be rejected. An effect size using eta squared will be reported. The researcher used Statistics Package for the Social Science (SPSS) to perform the *t* tests and to check for violations of the assumptions including normality, equality of variance, and absence of any extreme outliers (Warner, 2013).

Data will be initially screened for anomalies and extreme outliers using box and whisker plots. To test the Assumption of Normality a Shapiro-Wilks will be used due to the sample size being less than 50 (Sharma, 2002). Levene's Test of Equality of Error Variances will determine if the Homogeneity of Variance assumption can be assumed (Rovai et al., 2013). Eta squared (η^2) will be calculated to determine effect size for the null hypotheses that were rejected due to the results of the independent sample *t*-tests (Gall et al., 2007; Warner, 2013). The effect size measures the strength of the effect. The results of the statistical analysis will be reported and analyzed in Chapter 4.

CHAPTER FOUR: FINDINGS

Overview

The purpose of this quantitative study was to determine if there was any statistically significant difference in intrinsic motivation, self-efficacy, self-determination, grade motivation, or career motivation students between students who interacted with the lesson using Nearpod, and those that did not as measured by the SMQ II. In this chapter statistical analysis will be completed to analyze the effects of Nearpod on engagement in a K12 science class. Results of data and analysis will be discussed as they relate to the research questions and hypotheses.

Research Questions

RQ1: Is there a difference between high school students' *intrinsic motivation* who use Nearpod to interact with the lesson and those that do not?

RQ2: Is there a difference between high school students' *self-efficacy* who use Nearpod to interact with the lesson and those that do not?

RQ3: Is there a difference between high school students' *self-determination* who use Nearpod to interact with the lesson and those that do not?

RQ4: Is there a difference between high school students' *grade motivation* who use Nearpod to interact with the lesson and those that do not?

RQ5: Is there a difference between high school students' *career motivation* who use Nearpod to interact with the lesson and those that do not?

Null Hypotheses

H_01: There will be no statistically significant difference between learner's intrinsic motivation who utilized a push-interactive presentation system, Nearpod, and those that do not as measured by the Post SMQII questionnaire

$H_0$2: There will be no statistically significant difference between learner's self-efficacy who utilized a push-interactive presentation system, Nearpod, and those that do not as measured by the Post SMQII questionnaire.

$H_0$3: There will be no statistically significant difference between learner's self-determination who utilized a push-interactive presentation system, Nearpod, and those that do not as measured by the Post SMQII questionnaire.

$H_0$4: There will be no statistically significant difference between learner's grade motivation who utilized a push-interactive presentation system, Nearpod, and those that do not as measured by the Post SMQII questionnaire.

$H_0$5: There will be no statistically significant difference between learner's career motivation who utilized a push-interactive presentation system, Nearpod, and those that do not as measured by the Post SMQ II questionnaire.

Descriptive Statistics

Research Question 1: Intrinsic Motivation

RQ1: Is there a difference between high school students' *intrinsic motivation* who use Nearpod to interact with the lesson and those that do not?

Null Hypothesis

$H_0$1: There will be no statistically significant difference between anatomy and physiology students' *intrinsic motivation* who utilized a push-interactive presentation system, Nearpod, and those that do not as measured by the Post SMQII questionnaire

Data Screening

Data screening was conducted on each groups dependent variable. The researcher sorted the data on each variable and scanned for anomalies. No data errors or anomalies were observed.

Box and whisker plots showed no extreme outliers. See Figure 1 for box and whisker Plots.

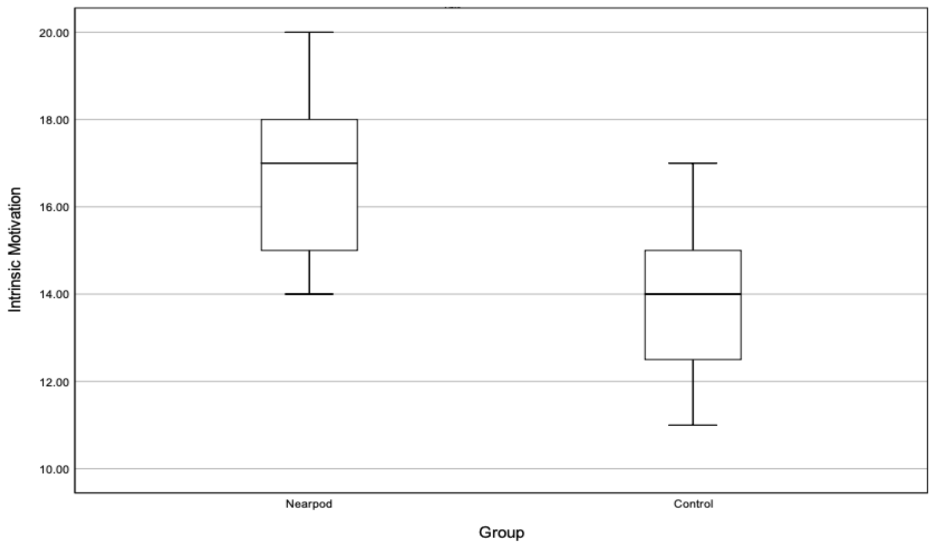

Figure 1. Box and whisker plots for intrinsic motivation.

Descriptive Statistics

Descriptive statistics were obtained on the intrinsic motivation scores from the SMQ II survey for both the Nearpod and Control groups. Descriptive statistics pertaining to the intrinsic motivation questions are shown in Table 3.

Table 2.
Descriptive Statistics for Intrinsic Motivation

Group	N	Minimum	Maximum	Mean	Std. Deviation
Nearpod	18	14	20	16.6667	2.08637
Control	20	11	17	13.9500	1.70062

Assumption Testing

Assumption of Normality

An Independent Samples t-test assumes normality for both groups. This assumption was examined using Shapiro-Wilks due to the small sample size. The results show that normality can be assumed. ($p > .05$). See Table 4.

Table 3.
Tests of Normality: Intrinsic Motivation

Group	Kolmogorov-Smirnova			Shapiro-Wilks		
	Statistic	df	Sig.	Statistic	df	Sig.
Nearpod	.122	18	.200	.907	18	.077
Control	.132	20	.200	.947	20	.329

Assumption of Homogeneity of Variance

To test the assumption of homogeneity a Levene's Test of Equality of Error Variances was performed. Results showed that this assumption had been met ($p > .05$). See Table 5 for results.

Table 4
Levene's Test of Equality of Error Variances: Intrinsic Motivation

	Levene Statistic	df1	df2	Sig.
Based on Mean	1.015	1	36	.321

Results: Intrinsic Motivation

An Independent Samples *t*-test was conducted to determine if there was a statistically significant difference in intrinsic motivation between students in an anatomy and physiology class, who use Nearpod to interact with lesson and those that do not. The researcher rejected the null hypothesis at the 99% confidence level where $t(36) = 4.418$, $p = .000$. Eta square equaled ($\eta^2 = .352$). The effect size was large. Eta squared was calculated using the formula $\eta^2 = t^2/(t^2 + df)$. There was a statistically significant difference between the student's intrinsic motivation when using Nearpod (*M* = 16.7, *SD* = .492) and students that did not (*M* = 13.9, *SD* = .380). The magnitude of the effect was large. See Table 6 for Independent Samples t-test results.

Table 5
Independent Samples t-test: RQ1

			SMQ II Intrinsic Motivation	
			Equal variances assumed	Equal Variances not assumed
Levene's Test		F	1.015	
for equality of		Sig	.321	
Variances		t	4.418	4.370
t-test for equality		df	36	32.888
of Means		Sig .(2-tailed)	.000	.000
	Mean Difference		2.71667	2.71667
	Std. Error Difference		.61849	.62164
	99% Confidence	Lower	1.46960	1.45177
	Interval of the	Upper	3.96373	3.98157

Research Question 2: Self Efficacy

RQ2: Is there a difference between high school students' *self-efficacy* who use Nearpod to interact with the lesson and those that do not?

Null Hypothesis

$H_0$2: There will be no statistically significant difference between anatomy and physiology students' *self-efficacy* who utilized a push-interactive presentation system, Nearpod, and those that do not as measured by the Post SMQII questionnaire

Data Screening

Data screening was conducted on each groups dependent variable. The researcher sorted the data on each variable and scanned for anomalies. No data errors or anomalies were observed. Box and whisker plots showed no extreme outliers. See Figure 2 for box and whisker plots.

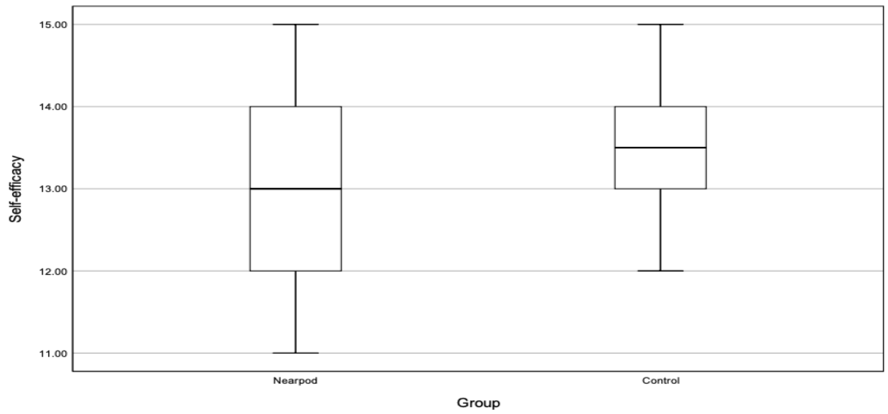

Figure 2. Box and whisker plots for self-efficacy data.

Descriptive Statistics

Descriptive statistics were obtained on the self-efficacy scores from the SMQ II survey for both the Nearpod and Control groups. Descriptive statistics pertaining to the self-efficacy questions are shown in Table 7.

Table 6
Descriptive Statistic: Self-efficacy

Group	N	Minimum	Maximum	Mean	Std. Deviation
Nearpod	18	11	15	13.000	1.23669
Control	20	12	15	13.600	1.53000

Assumption Testing

Assumption of Normality

An Independent Samples t-test assumes that data is normality distributed for both groups.

This assumption was examined using Shapiro-Wilks due to the small sample size. The results show that normality could not be assumed. ($p < .05$). See Table 8. Since normality could not be assumed both an Independent *t*-test and a Mann Whitney *U* Test were completed. A Mann-Whitney *U* is an appropriate nonparametric test comparing the means between two groups, and the assumption of normality has not been met and the two groups distribution curves have similar skewness.

Table 7
Tests of Normality: Self-efficacy

	Kolmogorov-Smirnova			Shapiro-Wilks		
Group	Statistic	df	Sig.	Statistic	df	Sig.
Nearpod	.235	18	.010	.883	18	.029
Control	.238	20	.004	.880	20	.018

Assumption of Homogeneity of Variance

To test the assumption of homogeneity a Levene's Test of Equality of Error Variances was performed. Results showed that this assumption had been met ($p > .05$). See Table 9 for results.

Table 8.
Levene's Test of Equality of Error Variances: Self-efficacy

	Levene Statistic	df1	df2	Sig.
Based on Mean	1.137	1	36	.293

Results: Self Efficacy

An Independent Samples *t*-test as well as an Independent Samples Whitney Mann *U* test was conducted to determine if there was a statistically significant difference in self-efficacy between students in an anatomy and physiology class, who use Nearpod to interact with lesson and those that do not. The independent t-test results, *t*(36) = -1.69, *p* = .162 indicated that there was no statistically significant difference between the student's self-efficacy, as measured by the SMQ II, when using Nearpod (*M* = 13, *SD* = 1.23) and students that did not (*M* = 13.6, *SD* = 1.53). See Table 10 for Independent Samples *t*-test results. A Mann-Whitney test also indicated that there was no statistically significant difference between the student's self-efficacy, as measured by the SMQ II, when using Nearpod (Mdn = 13.00) and students that did not (Mdn = 13.60) , *U*= 142.5, *p* = .249. The results of both the Independent Samples *t*-test and the Whitney Mann led to the researcher rejecting the null hypothesis at the 99% confidence level.

Table 9
Independent Samples t-test: RQ2

			SMQ II Self-efficacy	
			Equal variances assumed	Equal Variances not assumed
Levene's Test		F	1.137	
for equality of		Sig	.293	
Variances		t	-1.694	-1.669
t-test for equality		df	36	31.631
of Means		Sig .(2-tailed)	.162	.1
	Mean Difference		-.6000	-.6000
	Std. Error Difference		.35425	.35941
	99% Confidence	Lower	-1.31845	-1.33244
	Interval of the	Upper	.11845	.13244

Research Question 3: Self Determination

RQ3: Is there a difference between high school students' *self-determination* who use Nearpod to interact with the lesson and those that do not?

Null Hypothesis

$H_0$3: There will be no statistically significant difference between anatomy and physiology students' *self-determination* who utilized a push-interactive presentation system, Nearpod, and those that do not as measured by the Post SMQ II questionnaire

Data Screening

Data screening was conducted on each groups dependent variable. The researcher sorted the data on each variable and scanned for anomalies. No data errors or anomalies were observed. Box and whisker plots showed no extreme outliers. See Figure 3 for box and whisker plots.

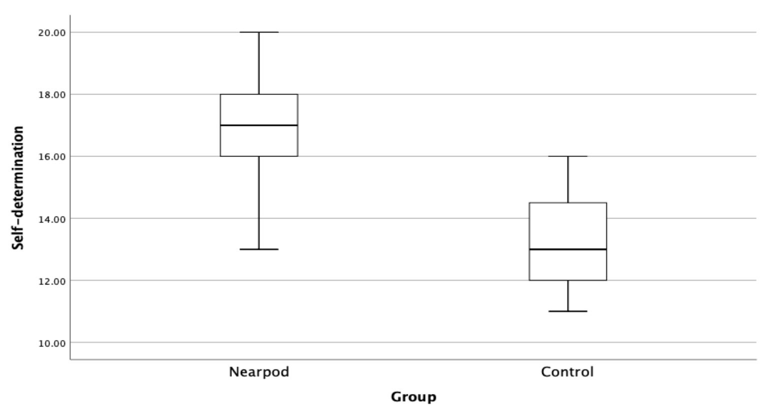

Figure 3. Box and whisker plots for self-determination.

Descriptive Statistics

Descriptive statistics were obtained on the self-determination scores from the SMQ II survey for both the Nearpod and Control groups. Descriptive statistics pertaining to the self-determination questions are shown in Table 11.

Table 10

Descriptive Statistic: Self-determination

Group	N	Minimum	Maximum	Mean	Std. Deviation
Nearpod	18	13	20	16.6111	1.97541
Control	20	11	16	13.3500	1.42411

Assumption Testing

Assumption of Normality

An Independent Samples *t*-test assumes that data is normality distributed for both groups. This assumption was examined using Shapiro-Wilks due to the small sample size. The results show that normality can be assumed. ($p > .05$). See Table 12.

Table 11

Tests of Normality: Self-determination

	Kolmogorov-Smirnova			Shapiro-Wilks		
Group	Statistic	df	Sig.	Statistic	df	Sig.
Nearpod	.156	18	.200	.940	18	.292
Control	.147	20	.200	.944	20	.290

Assumption of Homogeneity of Variance

To test the assumption of homogeneity a Levene's Test of Equality of Error Variances was performed. Results showed that this assumption had been met ($p > .05$). See Table 13 for results.

Table 12

Levene's Test of Equality of Error Variances: Self Determination

	Levene Statistic	df1	df2	Sig.
Based on Mean	1.292	1	36	.263

Results: Self Determination

An Independent Samples *t*-test was conducted to determine if there was a statistically significant difference in self-determination between students in an anatomy and physiology class, who use Nearpod to interact with lesson and those that do not. The researcher rejected the null hypothesis at the 99% confidence level where $t(36) = 5.882$, $p = .000$. Eta square equaled ($\eta^2 = .490$). The effect size was large. Eta square was calculated using the formula $\eta^2 = t^2/(t^2 + df)$. There was a statistically significant difference between the student's self-determination, as measured by the SMQ II, when using Nearpod ($M = 16.61$, $SD = 1.97$) and students that did not ($M = 13.35$, $SD = .313$) . See Table 14. for Independent Samples t-test results.

Table 13
Independent Samples t-test: RQ3

			SMQ II Self Determination	
			Equal variances assumed	Equal Variances not assumed
Levene's Test for equality of Variances		F	1.292	
		Sig	.263	
t-test for equality of Means		t	5.882	5.783
		df	36	30.64
		Sig (2-tailed)	.000	.000
	Mean Difference		3.26111	3.26111
	Std. Error Difference		.55441	.56395
	99% Confidence Interval of the	Lower	2.13672	2.11038
		Upper	4.38550	4.41185

Research Question 4: Grade Motivation

RQ4: Is there a difference between high school students' *grade motivation* who use Nearpod to interact with the lesson and those that do not?

Null Hypothesis

H_04: There will be no statistically significant difference between anatomy and physiology students' *grade motivation* who utilized a push-interactive presentation system, Nearpod, and those that do not as measured by the Post SMQ II questionnaire

Data Screening

Data screening was conducted on each groups dependent variable. The researcher sorted the data on each variable and scanned for anomalies. No data errors or anomalies were observed. Box and whisker plots showed no extreme outliers. See Figure 4 for box and whisker plots.

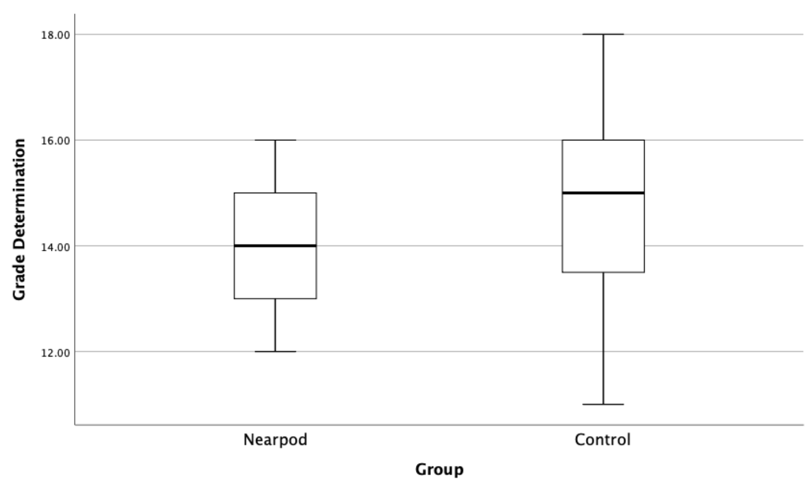

Figure 4. Box and whisker plots for grade motivation.

Descriptive Statistics

Descriptive statistics were obtained on the grade determination scores from the SMQ II survey for both the Nearpod and Control groups. Descriptive statistics pertaining to the self-determination questions are shown in Table 15.

Table 14
Descriptive Statistic: Grade Determination

Group	N	Minimum	Maximum	Mean	Std. Deviation
Nearpod	18	11	20	13.8889	1.23140
Control	20	11	18	14.5500	1.98614

Assumption Testing

Assumption of Normality

An Independent Samples t-test assumes that data is normality distributed for both groups. This assumption was examined using Shapiro-Wilks due to the small sample size. The results show that normality can be assumed. ($p > .05$). See Table 16.

Table 15
Tests of Normality: Grade Motivation

	Kolmogorov-Smirnova			Shapiro-Wilks		
Group	Statistic	df	Sig.	Statistic	df	Sig.
Nearpod	.203	18	.049	.918	18	.117
Control	.141	20	.200	.952	20	.392

Assumption of Homogeneity of Variance

To test the assumption of homogeneity a Levene's Test of Equality of Error Variances was performed. Results showed that this assumption had been met ($p > .05$). See Table 17 for results.

Table 16
Levene's Test of Equality of Error Variances: Grade Motivation

Levene Statistic	df1	df2	Sig.

Based on Mean	3.489	1	36	.070

Results: Grade Motivation

An Independent Samples *t*-test was conducted to determine if there was a statistically significant difference in self-determination between students in an anatomy and physiology class, who use Nearpod to interact with lesson and those that do not. The researcher failed to reject the null hypothesis at the 99% confidence level where $t(36) = -1.216$, $p = .232$. There was no statistically significant difference between the student's grade motivation, as measured by the SMQ II, when using Nearpod ($M = 13.8889$, $SD = 1.23140$) and students that did not ($M = 14.5500$, $SD = 1.98614$) . See Table 18 for Independent Samples *t*-test results.

Table 17
Independent Samples t-test: RQ4

			SMQ II Grade Motivation	
			Equal variances assumed	Equal Variances not assumed
Levene's Test for equality of Variances		F	4.436	
		Sig	.070	
		t	5.882	5.783
t-test for equality of Means		df	36	32.143
		Sig (2-tailed)	.232	.222
	Mean Difference		-6.6111	-6.6111
	. Error Difference		.54346	.53054
	99% Confidence Interval of the	Lower	-1.74329	-1.74161
		Upper	.44107	.41439

Research Question 5: Career Motivation

RQ5: Is there a difference between high school students' *career motivation* who use Nearpod to interact with the lesson and those that do not?

Null Hypothesis

$H_0$5: There will be no statistically significant difference between anatomy and physiology students' *career motivation* who utilized a push-interactive presentation system, Nearpod, and those that do not as measured by the Post SMQ II questionnaire

Data Screening

Data screening was conducted on each groups dependent variable. The researcher sorted the data on each variable and scanned for anomalies. One outlier from the control group was observed and removed from data and not used in analysis. Box and whisker plots
See Figure 5 for box and whisker plots.

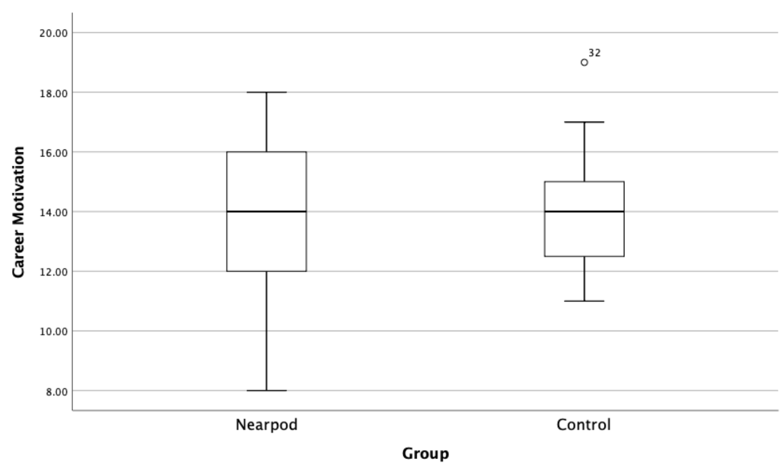

Figure 5. Box and whisker plots for career motivation.

Descriptive Statistics

Descriptive statistics were obtained on the career motivation scores from the SMQ II survey for both the Nearpod and Control groups. Descriptive statistics pertaining to the career-determination questions are shown in Table 19.

Table 18
Descriptive Statistic: Grade Determination

Group	N	Minimum	Maximum	Mean	Std. Deviation
Nearpod	18	8	18	13.7222	2.76119
Control	29	11	17	13.7368	1.59311

Assumption Testing

Assumption of Normality

An Independent Samples *t*-test assumes that data is normality distributed for both groups. This assumption was examined using Shapiro-Wilks due to the small sample size. The results show that normality can be assumed. ($p > .05$). See Table 20.

Table 19
Tests of Normality: Grade Motivation

	Kolmogorov-Smirnova			Shapiro-Wilks		
Group	Statistic	df	Sig.	Statistic	df	Sig.
Nearpod	.155	18	.200	.922	18	.137
Control	.154	19	.200	.950	19	.397

Assumption of Homogeneity of Variance

To test the assumption of homogeneity a Levene's Test of Equality of Error Variances was performed. Results showed that this assumption had been met ($p > .05$). See Table 21 for results.

Table 20
Levene's Test of Equality of Error Variances: Career Motivation

	Levene Statistic	df1	df2	Sig.
Based on Mean	3.290	1	35	.078

Results: Career Motivation

An Independent Samples *t*-test was conducted to determine if there was a statistically significant difference in self-determination between students in an anatomy and physiology class, who use Nearpod to interact with lesson and those that do not. The researcher failed to reject the null hypothesis at the 99% confidence level where $t(35) = -0.02$, $p = .984$. There was no statistically significant difference between the student's career motivation, as measured by the SMQ II, when using Nearpod ($M = 13.7222$, $SD = 2.76119$) and students that did not ($M = 13.7368$, $SD = 1.59311$) . See Table 22 for Independent Samples *t*-test results.

Table 21
Independent Samples t-test: RQ5

		SMQ II Career Motivation	
		Equal variances assumed	Equal Variances not assumed
Levene's Test for equality of Variances	F	3.290	
	Sig	.078	
t-test for equality of Means	*t*	-.020	1.020
	df	35	26.888
	Sig (2-tailed)	.984	.985
	Mean Difference	-.01462	-.01462
	. Error Difference	.73610	.74642

99% Confidence	Lower	-1.50899	1.47975
Interval of the	Upper	-1.54645	1.51721

Results

Results of the statistical analysis are depicted in Table 23. Two of the five null hypotheses were rejected and were shown to have a large effect size. Both intrinsic motivation and self-determination showed to be effected by use of the interactive Nearpod app to interact with lecture. Grade motivation, career motivation and self-efficacy were unaffected by the intervention. Discussion of these results, limitations of the study and recommendations for future research will be discussed in Chapter 5.

Table 22
Results of Independent Samples t-Tests

Null Hypothesis	Reject	Failed to Reject	Eta Squared
$H_0$1: Intrinsic motivation	x		.352
$H_0$2: Self-efficacy		x	.074.
$H_0$3: Self-determination	x		.490
$H_0$4: Grade motivation		x	.049
$H_0$5: Career motivation		x	.001

CHAPTER FIVE: CONCLUSIONS

Overview

This chapter will summarize the findings of this study, the implications, limitations, and suggestions for further research will be discussed. Answers to research questions will be reviewed along with their implications. Limitations of this study will be considered. Recommendations for further research based on the outcome of this study will be presented.

Discussion

As stated previously, in 2012 the U.S. President's Council of Advisors on Science and Technology set a goal to add one million STEM college graduates over a 10-year period. Motivation in STEM secondary classrooms is a crucial to achieving this goal (Simon et al., 2015). How to increase STEM engagement and achievement has been the subject of much research (Reider et al., 2016; Schmid, 2017). Research has shown that interactive lessons using student response systems, can increase academic achievement and student engagement (Thomas, 2015). This study adds to the growing educational technology research to improve engagement in STEM classrooms. Specifically, this quantitative study examined the effects of an interactive software application on students achievement and engagement in a 11th grade science class. A total of 38 students participated in the study. Academic achievement was measured by analyzing the data collected from scores on a unit test between a class that used Nearpod to interact with the lesson and a class that did not. Student engagement was measured by using the Science Motivation Questionnaire II (SMQ II) (Glynn, 2011). Results showed Nearpod had a statistically significant increase on specific types of intrinsic and extrinsic motivation.

The correlation between different aspects of motivation and science achievement is well established (Schumm et al, 2016). Motivation has been described as having both levels or degrees as well as orientation or type of motivation (ChanMin, et al., 2015). A student can be highly motivated but have different constructs associated with that motivation. A student could be motivated by a grade or approval from a teacher or parent; extrinsic motivation. Alternatively, a student could also be highly motivated because they feel they are skilled at the subject and it gives them pride in themselves to do well; Intrinsic motivation. Research suggests that students are motivated by a combination of both intrinsic and extrinsic factors. (Ryan & Deci, 2000)

Research questions from this study related to different subscales of motivation. Intrinsic motivation is performing some task because it is inherently interesting and enjoyable. Interactivity, through gamification, has been shown to increase students' intrinsic motivation, and increase classroom participation (Ding, Er, & Orey, 2018). Steady declines in student motivation is a major concern for STEM education, and understanding ways to increase intrinsic motivation, including subject interest and enjoyability is crucial (Young, 2018). Regarding intrinsic motivation, the SMQ II asks questions related to curiosity, interest, value, and pleasure. Other intrinsic motivational constructs used in the SMQ II include self-determination and self-efficacy. (Glynn et al., 2011)

The SMQ II uses five subscales of motivation including both intrinsic and extrinsic factors. Extrinsic motivators are effected by the drive for tangible outcomes and external compensation. Motivation has both levels or degrees as well as orientation or type of motivation (Ryan & Deci, 2000). Two extrinsic factors, the SMQ II examines are grade motivation and career aspirations. In an educational setting these outcomes are differentiated between short term goals such as grades, and long term goals such as a future career (Schumm & Bogner, 2016).

Research question one asked; What are the effects of an interactive software application on intrinsic motivation? Five Likert scale questions related to intrinsic motivation were included; I enjoy learning science; Learning science makes my life more meaningful; Learning science is interesting; I am curious about discoveries in science; The science I learn is relevant. Results showed that there was a statistically significant difference in intrinsic motivation for the Nearpod group when compared to the control group. Calculation of Eta Squared showed the magnitude of the effect to be large. The increase in intrinsic motivation as measured by the SMQ II, indicated that Nearpod increases intrinsic motivation, which the SMQ II measures as curiosity, value, and pleasure in learning science. Experts believe that increasing interest, value and pleasure in science classrooms can improve students self-efficacy in science and could lead to increased enrollment in science career pathway (Ryan & Deci, 2000; Mohd et al., 2019)

Research question two asked; What are the effects of an interactive software application on self-efficacy? Self-efficacy is defined as an intrinsic motivation factor that refers to an individual's perception of their own competence to complete a task with a desired outcome (Schumm & Bogner, 2016). Bandura's social-cognitive theory postulates that if an individual believes they can achieve a certain goal, they are more motivated to learn (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001). Questions on the SMQ II relating to self-efficacy included; I believe I can master science knowledge and skills; I am confident I will do well on science tests; I believe I can earn a grade of "A" in science; I am confident I will do well on science labs and projects; I am sure I can understand science.

Results showed that there was no statistically significant increase in self-efficacy between the Nearpod group and control. The lack of increase in self-efficacy for the Nearpod group could be explained by the technology itself being a confounding variable. Different teachers and students have different technological abilities and comfort levels with educational technology. This study constituted an initial use of Nearpod for both teachers and students and the unfamiliarity may have skewed the results for student self-efficacy.

Self-determination in an educational environment, has been described as a student's perception of control over their own learning (Schumm & Bogner, 2016). It is defined as a combination of beliefs, skills and knowledge a student has that motivates them to learn autonomously; the motivation to be a self-directed learner (Denney & Daviso, 2012). Denney and Deviso argued it is a critical component of any educational research on motivation and achievement. Studies have shown the use of technology and mobile applications can increase self-determination (Jeno, John-Arvid & Vandvik, 2017). Much research suggests that autonomy-supportive classrooms foster students' self-determination motivation and engagement (Patall, Hooper, Vasquez, Pituch & Steingut, 2018).

Research question three asked; What are the effects of an interactive software application on self-determination? Questions on the SMQ II relating to self-determination included; I study hard to learn science; I spend a lot of time learning science; I prepare well for science tests, I put enough effort into learning science; I use strategies to learn science well. Results showed a statistically significant increase in self determination of students when using Nearpod compared to students that did not. The magnitude of the effect was a large.

Extrinsic motivation is performing a task because of a tangible outcome (Ryan & Deci, 2000). In an educational setting these outcomes include short term goals such as grades, and long term goals such as a future career (Schumm & Bogner, 2016). Extrinsic motivators are effected by the drive for tangible outcomes and external compensation. Motivation has been directly associated with positive academic outcomes (Ryan & Deci, 2000). Two extrinsic factors examined were grade motivation and career aspirations.

Research question four asked; What are the effects of an interactive software application on grade motivation? Questions on the SMQ II related to grade motivation included; Scoring high on science tests and labs matter to me; Getting a good science grade is important to me; It is important I get an "A" in science; I think about the grade I will get in science; I like to do better than other students on science tests. Results showed no significant increase in grade motivation when students used Nearpod compared to students that did not.

Research question five asked; What are the effects of an interactive software application on career motivation? Questions on the SMQ II relating to career motivation included; Understanding science will benefit me in my career; My career will involve science; I will use science problem solving skills in my career; Learning science will help me get a good job; Knowing science will give me a career advantage. Results showed no statistically significant increase in career motivation for students that used Nearpod, compared to those that did not.

Implications

The findings of this research suggests that use of digital interactive software can increase intrinsic motivation and achievement in secondary science classrooms. Motivation in science at the secondary level is a critical component to students entering college in a STEM related major (Simon et al, 2015). Means to increase STEM interest, proficiency, and career interest have been the aim of much research (Reider et al, 2016). The results of this study, agree with previous research findings, suggesting that active learning can be achieved through the intentional use of software applications and educational technology (Beier et al., 2019). The results of this study and others, reasonably suggest that facilitating student participation in lessons through interactive technology such as Nearpod, make students active learners, which may increase intrinsic motivation, self-determination and achievement in secondary science (Shahrokni, 2017). This study also agrees with findings that self-efficacy and career motivation are correlated and might take longer periods of intervention, to have significant impacts (Shi, 2016).

Limitations

The limitations of this study included sample size, teacher differences, and differences between groups including gender variation. There are varying opinions on the minimum number of participants needed for a posttest quantitative experimental design. The minimum sample size with a medium effect at a significance level of.05 and a statistical power of .7, would be 100 participants (Gall et al, 2007 , p. 175). If a researcher expects a large effect with the same parameters, the minimal sample size is 40 (Gall et al, 2007, p. 175). Small sample size studies lead to large standard error and wide confidence intervals. This can lead to imprecise estimates of magnitude (Hackshaw, 2008). The convenience sampling as well as teacher differences, create non-equivalent treatment groups. The gender variation between groups might further decrease the internal reliability and validity of present study (Zaccone, & Pedrini, 2019) Random assignment with a larger sample size might further corroborate the results of this study. The small sample size, as well as the lack of equivalent groups by convenience sampling decreases the internal validity of this study (Rovai et al, 2013). Due to these limitations, the results should be interpreted with caution.

Recommendations for Future Research

Although there are numerous studies on educational technology, more research focusing on cloud based interactive apps in a one-to-one setting should be done. At the completion of this study, there were only two studies, reported in literature, having tested the effects of Nearpod on learning (Delacruz, 2014; McClean & Crowe, 2017). Delacruz conducted a qualitative study showing an increase in engagement in elementary guided reading classes. McClean reported on the use of Nearpod, from another qualitative study, using students in their second year of pharmacy school. Results were similar; use of Nearpod increased overall engagement (McClean et al., 2017). In a recent article released by Nearpod, the cloud based application is currently being used by seven million students in over 60% of K-12 U.S. districts (Nearpod, 2019). This being considered, more quantitative research to examine the effectiveness of Nearpod in early science courses could yield important insight into the most effective methods to increase motivation and achievement in science. Educational leadership and teachers need data driven pedagogy to increase engagement and achievement, to increase scientific literacy, and to create a pipeline of students pursuing STEM careers. Quantitative studies using larger sample sizes, different science courses, and over longer periods of time will help elucidate Nearpod's effects on learning.

REFERENCES

Alade, F., Lauricella, A, Beaudoin-Ryan, L., & Wartella E. (2016). Measuring with Murray: Touchscreen technology and preschoolers' STEM learning. *Computers in Human Behavior*, *62*(1), 433-441. doi:10.1016/j.chb.2016.03.080

Armstrong, R. A. (2014). When to use the Bonferroni correction. *Ophthalmic and Physiological Optics, 34*(5), 502-508. doi:10.1111/opo.12131

Association for Educational Communications and Technology (AECT), (1977). The definition of educational technology. Washington, DC: author. Retrieved from http://ocw.metu.edu.tr/file.php/118/molenda_definition.pdf

Barhoumi, C. (2015). The effectiveness of WhatsApp mobile learning activities guided by activity theory on students' knowledge management. *Contemporary Educational Technology.* *6*(3), 221-238.

Bandura, A., Barbaranelli, C., Caprara, G. V., & Pastorelli, C. (2001). Self-efficacy beliefs as shapers of children's aspirations and career trajectories. *Child Development, 72*(1), 187-206. doi:10.1111/1467-8624.00273

1175-1184. Retrieved from https://www.uky.edu/~eushe2/Bandura/Bandura1989AP.pdf

Bandura, A. (1989). Human agency in social cognitive theory. *American Psychologist, 44*(9), 1175-1184. Retrieved from https://www.uky.edu/~eushe2/Bandura/Bandura1989AP.pdf

Beier, M. E., Kim, M. H., Saterbak, A., Leautaud, V., Bishnoi, S., & Gilberto, J. M. (2019). The effect of authentic project-based learning on attitudes and career aspirations in STEM. *Journal of Research in Science Teaching, 56*(1), 3-23. doi:10.1002/tea.21465

Bergmann, J., & Sams, A. (2012). *Flip your classroom: Reach every student in every class every day* (First ed.). Eugene, Oregon: International Society for Technology in Education.

Blackwell, C. (2013). Teacher practices with mobile technology integrating tablet computers into the early childhood classroom. *Journal of Education Research*, *7*(4), 231-255.

Blood, E., Johnson, J. W., Ridenour, L., Simmons, K., & Crouch, S. (2011). Using an iPod Touch to Teach Social and Self-Management Skills to an Elementary Student with Emotional/Behavioral Disorders. *Education & Treatment of Children*, *34*(3), 299-321. Retrieved from: http://www.educationandtreatmentofchildren.net/

Botzakis, S. (2015). Visual and digital texts. *Journal of Adolescent & Adult Literacy, 59*(2), 229-231. doi:10.1002/jaal.460

Bruner, J. S. (1961). The process of education. Cambridge, MA: Harvard University Press.

Britner, S. L. and Pajares, F. (2006). Sources of science self-efficacy beliefs of middle school students. J. Res. Sci. Teach., 43: 485-499. doi:10.1002/tea.20131

Browman, K., & Simon, S. (2015). Upper secondary school students' choice and their ideas on how to improve chemistry education. International Journal of Science and Mathematics Education, 13(6), 1255-1278. Doi: 10.1007/s10763-014-9550-0

Cardoza, Y., & Tunks, J. (2014). The Bring Your Own Technology initiative: An examination of Teacher's adoption. *Computers in the Schools, 31*(4), 293-315. doi:10.1080/07380569.2014.967626

Cerasoli, C. P., Nicklin, J. M., & Ford, M. T. (2014). Intrinsic motivation and extrinsic incentives jointly predict performance: A 40-year meta-analysis. *Psychological Bulletin, 140*(4), 980-1008. doi:10.1037/a0035661

ChanMin, K., Seung Won, P., Cozart, J., & Hyewon, L. (2015). From Motivation to Engagement: The Role of Effort Regulation of Virtual High School Students in Mathematics Courses. *Journal of Educational Technology & Society*, *18*(4), 261-272.

Chase, P., Hilliard, J., Geldhof, J., Warren, D., & Lerner, R. (2014). Academic achievement in the high school years: The changing role of school engagement. *Journal of Youth Adolescence*, *43*, 884-896. doi: 10.1007/s10964-013-0085-4

Cheung, A., & Slavin, R. (2013). The effectiveness of educational technology applications for enhancing mathematics achievement in K-12 classrooms: A meta-analysis. *Educational Research Review*, *9*, 88-113. doi:10.1016/j.edurev.2013.01.001.

Chou, C., Block, L., & Jesness, R. (2014). Strategies and Challenges in Ipad Initiative. *International Association for Development of the Information Society*, Paper presented at the International Conference on Mobile Learning 2014 (10th, Madrid, Spain, Feb 28-Mar 2, 2014). Retrieved from https://eric.ed.gov/?id=ED557233

Chase, P. A., Hilliard, L. J., Geldhof, G. J., Warren, D. J. A., & Lerner, R. M. (2014). Academic achievement in the high school years: The changing role of school engagement. *Journal of Youth and Adolescence, 43*(6), 884-896. doi: 10.1007/s10964-013-0085-4

Cobbold, C. (2010). Solving the teacher shortage problem in Ghana: Critical perspectives for understanding the issues. *Journal of Education and Practice*, *6*(9), 71-79. Retrieved from http://files.eric.ed.gov/fulltext/EJ1082464.pdf

Cochran-Smith, M. (2003). Teaching quality matters. Journal of Teacher Education. 54(2), 95-98 Retrieved from http://journals.sagepub.com/home/jte

Cochrane, T., Antonczak, L., Keegan, H., & Narayan, V. (2014). Riding the wave of BYOD: developing a framework for creative pedagogies. *Research in Learning Technology*, *22*(1), 1-14. doi:10.3402/rlt.v22.24637

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.) Hillside, NJ: Lawrence Earlbalm Associates.

Cooley, H. (2004). It all about the fit: The hand, the mobile screen device and tactile vision. *Journal of Visual Culture, 3*(2), 133-155.

Cronbach LJ *(1951).* Coefficient alpha and the internal structure of tests. *Psychometrika. 16 (3):* 297–334. Doi: 10.1007/bf02310555

Decuypere, M. (2019). Researching educational apps: Ecologies, technologies, subjectivities and learning regimes. *Learning, Media and Technology, 44*(4), 414-429. doi:10.1080/17439884.2019.1667824

Delacruz, S. (2014). *Using Nearpod in elementary guided reading groups*. Boston: Springer US.10.1007/s11528-014-0787-9

Delgado, A., Wardlow, L., McKnight, K., & O'Malley, K. (2015). Educational Technology: A Review of the integration, resources, and effectiveness of technology in K-12 classrooms. *Journal of Information Technology Education: Research 14*, 397-416. Retrieved from http://www.jite.org

Denney, S. C., & Daviso, A. W. (2012). Self-determination: A critical component of education. *American Secondary Education, 40*(2), 43-51.

Ding, L., Er, E., & Orey, M. (2018). An exploratory study of student engagement in gamified online discussions. *Computers & Education, 120*, 213-226. doi:10.1016/j.compedu.2018.02.007

Ditzer, C., Hong, E., & Struder, N. (2016). How tablets are utilized in the classroom. *Journal of Research on Technology in Education 48*(3), 181-193. doi: 10.1080/15391523.2016.1172444

Elstad, E., & Christophersen, K., (2017). Perceptions of digital competency among student teachers: Contributing to the development of student Teachers' Instructional self-efficacy in technology-rich classrooms. doi:10.3390/educsci7010027

Eppard, J., Nasser, O., & Reddy, P. (2016). The next generation of technology: Mobile apps in the English language classroom. *International Journal of Education and Technology 11*(4), 21-27. doi: 10.3991/ijet.v11i04.5293

Fallon, G (2013). Young students using iPads. App design and content influences on their learning pathways. *Computers & Education, 68*, 505-521. Retrieved from https://www.journals.elsevier.com/computers-and-education/

Finn, J. (1993). School engagement & students at risk. Buffalo, NY: U.S. Department of Education, National Center for Education Statistics.

Flower, A., McKenna, J. Muething, C., Bryant, D., & Bryant, B. (2014). Effects of the Good Behavior Game on class wide off-task behavior in a high school basic algebra resource classroom. *Behavior Modification*, *38*(1), 45-68.

Francescucci, A., & Foster, M. (2013). The VIRI (Virtual, Interactive, Real-Time, Instructor-Led) Classroom: The Impact of Blended Synchronous Online Courses on Student Performance, Engagement, and Satisfaction. *Canadian Journal of Higher Education*, *43*(3), 78-91. Retrieved from http://journals.sfu.ca/cjhe/index.php/cjhe

Franco, M. S., & Patel, N. H. (2017). Exploring student engagement in STEM education: An examination of STEM schools, STEM programs, and traditional schools. *Research in the Schools, 24*(1), 10-30.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School Engagement: Potential of the Concept, State of the Evidence. *Review of Educational Research*, *74*(1), 59-109. Retrieved from http://ezproxy.liberty.edu/login?url=https://search-proquest-com.ezproxy.liberty.edu/docview/214138084?accountid=12085

Frick, T., Chadha, R., Watson, C., Wang, Y., & Green, P. (2009). College student perceptions of teaching and learning quality. *Educational Technology Research and Development, 57*(5), 705-720. doi:10.1007/s11423-007-9079-9

Fung, F., Tan, C. Y., & Chen, G. (2018). Student engagement and mathematics achievement: Unraveling main and interactive effects. *Psychology in the Schools*, *55*(7), 815–831. https://doi-org.ezproxy.liberty.edu/10.1002/pits.22139

Gall, M., Gall, J., & Borg, W. (2007). *Educational research: An Introduction* (8th ed.) Boston, MA: Pearson.

Gambari, I. A., Gbodi, B. E., Olakanmi, E. U., & Abalaka, E. N. (2016). Promoting intrinsic and extrinsic motivation among chemistry students using computer-assisted instruction. *Contemporary Educational Technology, 7*(1), 25-46. Retrieved from http://ezproxy.liberty.edu/login?url=https://search-proquest-com.ezproxy.liberty.edu/docview/2135157145?accountid=12085

Glynn, S, Brickmam, P., Armstrong, N., & Taasoobshirazi. (2011). Science Motivation Questionnaire II: Validation with science majors and non-science majors. *Journal of*

Research in Science Teaching, 48, 1159-1176. Retrieved from http://www.coe.uga.edu/smq/

Grabau, L., & Ma, X. (2017). Science engagement and science achievement in the context of science instruction: a multilevel analysis. *International Journal of Science Education* 39(8)., 1045-1068. doi: 10.1080/09500693.2017.1313468

Groccia, J. (2018). What Is Student Engagement? *New Directions for Teaching and Learning.*, *2018*(154), 11–20. https://doi.org/10.1002/tl.20287

Guthrie, R W., & Carlin, A. (2004). Waking the dead: Using interactive technology to engage passive listeners in the classroom. Tenth Americas Conference on Information Systems. New York, 2004. Retrieved from http://aisel.aisnet.org/

Hackshaw, A. (2008). Small studies: Strengths and limitations. *The European Respiratory Journal, 32*(5), 1141-1143. doi:10.1183/09031936.00136408

Harbour, K., Evanovich, C., Sweigart, & Hughes, L. (2015). A brief review of effective teaching practices that maximize student engagement. Preventing School Failure, 59(1), 5-13. doi:10.1080/1045988X.2014.919136

Harper, B., & Milman, N. (2016). One-to-One technology in K-12 classrooms: A review of the literature from 2004 through 2014. *Journal of Research on Technology in Education*, *48*(2), 129-142, doi:10.1080/153915391523.2016.1146564

Harris, J. L., Al-Bataineh, M. T., & Al-Bataineh, A. (2016). One to One Technology and Its Effect on Student Academic Achievement and Motivation. *Contemporary Educational Technology*, *7*(4), 368-381.

Hattie, J., & Timperley, H. (2007). The power of feedback. Review of Educational Research, 77, 81-112. doi: 10.3102/003465430298487. 2007

Haydon, T., Hawkins, R., Denune, H., Kimener, L., & McCoy, D., (2012). A comparison of iPads and worksheets on math skills of high school students with emotional disturbance. *Behavioral Disorders 37*(4), 232-243. Retrieved from http://www.ccbd.net/home?q=node/9#overlay-context=node/2%3Fq%3Dnode/2

Heilbronner, N. (2014). Think instruments, think apps. *Science Scope*, *37*(9), 42-49.

Hesser, T., & Schwartz, P. (2013). Ipads in the science laboratory: Experience in designing and implementing a paperless chemistry laboratory course. *Journal of STEM Education: Innovations and Research*, 14(2), 249-257. Retrieved from http://jstem.org/index.php?journal=JSTEM

Hirsh-Pasek, K., Zosh, J., Golinkoff, R., Gray, J., Robb, M., & Kaufman, J. (2015). *Psychological Science in the Public Internet 16*(1), 3-34. doi:10.1177/1529100615291006155697 21pspi

Hoffman, A.M. (2013). Student’s perceptions of on-task behavior and classroom engagement in a 1:1 iPad school. *English Leadership Quarterly 36*, 9-18. Retrieved from http://www.ncte.org/journals/elq

Jeno, L. M., Grytnes, J., & Vandvik, V. (2017). The effect of a mobile-application tool on biology students' motivation and achievement in species identification: A self-determination theory perspective. *Computers & Education, 107*, 1-12. doi:10.1016/j.compedu.2016.12.011

Johnson, L., Adams, S., Baker, S., Estrada, V., & Freeman, A. (2014). *The NMC Horizon Report: 2014 K-12 Edition*. Austin, TX: The New Media Consortium. Retrieved from http://www.nmc.org/publication/nmc-horizon-report-2014-k-12-edition

Johnson, L., Adams, S. & s, M. (2012) *The NMC Horizon Report: 2012 K-12 Edition*. Austin, TX: The New Media Consortium. Retrieved from http://www.nmc.org/publication/nmc-horizon-report-2014-k-12-edition/

Jonas-Dwyer, D., Clark, C., Celenza, Z., & Siddiqui, (2012). Evaluating apps for learning and teaching. *International Journal of Educational Technology*, 7(1,) 54-57. doi: 10.3991/ijet.v7i1.1901

Jones, B. (2014). Risky business: Students and smartphones. *TechTrends 58*(6) 73-83. Retrieved from http://www.springer.com/education

Jones, S., Crandall, J., Vogler, J., & Robinson, D., (2013). Classroom response systems facilitate student accountability, readiness, and learning. *J. Educational Computing Research 49*(2). 155-171. doi:10.2190/EC.49.2.b

Kastberg, D., Chan, J.Y., and Murray, G. (2016). *Performance of U.S. 15-Year-Old Students in Science, Reading, and Mathematics Literacy in an International Context: First Look at PISA 2015* (NCES 2017-048). U.S. Department of Education. Washington, DC: National Center for Education Statistics. Retrieved [date] from http://nces.ed.gov/ pubsearch.

Kena, G., Hussar, W., McFarland, J., De Brey, C., Musu-Gillette, L., Wang, X., & ... American Institutes for Research, (2016). The condition of education 2016. NCES 2016-144. *National Center for Education Statistics*. Retrieved from https://nces.ed.gov/

Khaddage, F., Lanham, E., & Zhou, W. (2009). A mobile learning model for universities: Re-blending the current learning environment. *International Journal of Interactive Mobile Technologies, 3*(1), 18-23. Retrieved from http://www.online-journals.org/index.php/i-jim

Khaddage, F., Muller, W., & Flintoff, K. (2016). Advancing mobile learning in formal and informal settings via mobile app technology: Where to from here, and how? *Educational Technology & Society, 19*(3). 16-26. Retrieved from http://www.ifets.info/

Kim, C., Park, S. W., Cozart, J., & Lee, H. (2015). From Motivation to Engagement: The Role of Effort Regulation of Virtual High School Students in Mathematics Courses. *Educational Technology & Society*, *18*(4), 261-272. Retrieved from http://www.ifets.info

Kizildag, S., Demirtas-Zorbaz, S., & Zorbaz, O. (2017). School engagement of high school students. *Egitim Ve Bilim, 42*(189), 107-119. doi:10.15390/EB.2017.6740

Koschmann, T., Kelson, A., Feltovich, P., & Barrows, H. (1996). Computer-supported problem-based learning: A principal approach to the use of computers in collaborative learning. Theory and practice of an emerging paradigm (pp.83-124). Hillsdale, NJ: Lawrence Erlbaum

Kucirkova, N., Messer, D. Sheeby, K. & Fernandez, C. (2014) Children's engagement with educational iPad apps: Insights from a Spanish classroom. *Computers & Education, 71*, 175-184. Retrieved from https://www.journals.elsevier.com/computers-and-education/

Langdon, D., McKittrick, G., Beede, G., Khan, B., & Doms, M. (2011). *STEM: Good jobs now and for the future* [ESA Issue Brief]. Washington, D.C.: Department of Commerce. Retrieved from http://www.esa.doc.gov/reports/stem-good-jobs-now-and-future

Lee, H. (2015). Does touch-base interaction in learning with interactive images improve students' learning? *Asia-Pacific Educational Research, 24*(4) 731-735. doi:10.1007/s40299-014-0197

Lei, H., Cui, Y., & Zhou, W. (2018). Relationships between student engagement and academic achievement: A meta-analysis. *Social Behavior and Personality: An International Journal, 46*(3), 517-528. doi:10.2224/sbp.7054

Lewis, M. S., Zhao, J., & Montclare, J. K. (2012). Development and implementation of high school chemistry modules using touch-screen technologies. *Journal of Chemical Education, 89*(8), 1012-1018. doi:10.1021/ed200484n

Luna-Nevarez C., & McGovern, E. (2018). On the use of mobile apps in education: The impact of digital magazines on student learning. *Journal of Educational Technology Systems, 47*(1), 17-31. doi:10.1177/0047239518778514

Lyubartseva, G. (2013). Influence of audience response system technology on student performance in Organic Chemistry lecture class. *Education*, *133*(4). 439-443. Retrieved from http://www.projectinnovation.biz/education.html

Mayo, M. (2009). Video games: A route to large-scale STEM education? *Science*, *New Series, 323*(5910), 79-82. doi: 10.1126/science.1166900

McClean, S., & Crowe, W. (2017). Making room for interactivity: Using the cloud-based audience response system nearpod to enhance engagement in lectures. *FEMS Microbiology Letters, 364*(6) doi:http://dx.doi.org.ezproxy.liberty.edu/10.1093/femsle/fnx052

McDonald, C. (2016). STEM Education: A review of the contribution of the disciplines of science, technology, engineering and mathematics. *Science Education International*, *27*(4), 530-569. Retrieved from http://www.icaseonline.net/seiweb/

McKay, L. & Ravenna, G. (2016). Nearpod and the impact on progress monitoring. *California Council on Teacher Education*, *27*(1) 23-27. Retrieved from http://news.nearpod.com

McNergy, R., & McNergy, J. (2007). Education: The practice and profession of teaching (5th ed.) Boston, MA: Pearson Education, Inc

Mohd Shahali, E. H., Halim, L., Rasul, M. S., Osman, K., & Mohamad Arsad, N. (2019). Students' interest towards STEM: A longitudinal study. *Research in Science & Technological Education, 37*(1), 71-89. doi:10.1080/02635143.2018.1489789

Moreno, R., Meyer, R., Spires, H., & Lester, J. (2001). The case for social agency in computer-based teaching: Do students learn more deeply when they interact with animated pedagogical agents? *Cognition and Instruction, 19*(2), 177-213. Retrieved from http://www.tandfonline.com/toc/hcgi20/current

Morgan, P., Farkas, G., Hillemeier, M., & Maczuga, S. (2015). Science achievement gaps begin very early, persist, and are largely explained by modifiable factors. *Educational Researcher, 45*(1) 18-35. doi:10.3102/0013189X16633182

Morling, B., McAuliffe, M., Cohen, L., & Dilorenzo, T. (2008). Efficacy of personal response systems ("CRC") in large class. *Teaching of Psychology 35*, 45-50. Retrieved from http://journals.sagepub.com/home/top

Nearpod. (2019). *Tech & Learning, 40*(2), 42.

Ng, W., & Fergusson, J. (2019). Technology-enhanced science partnership initiative: Impact on secondary science teachers. *Research in Science Education, 49*(1), 219-242. doi:10.1007/s11165-017-9619-1

Ng, W. (2014). Flipping the Science Classroom: Exploring Merits, Issues, and Pedagogy. *Teaching Science 6*0(3), 16-23. Retrieved from http://asta.edu.au/resources/teachingscience

Nilgun, O., & Metcalf, D. (2011). The current perspectives, theories and practices of mobile learning. *The Turkish Online Journal of Educational Technology, 10*(2) Retrieved from http://ezproxy.liberty.edu/login?url=https://search-proquest-com.ezproxy.liberty.edu/docview/1288354416?accountid=12085

Nord, C., Roey, S., Perkins, R., Lyons, M., Lemanski, N., Brown, J., and Schuknecht, J. (2011). *The Nation's Report Card: America's High School Graduates* (NCES 2011-462). U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office. Retrieved from https://nces.ed.gov/nationsreportcard/pubs/studies/2011462.asp

NSW Department of Education and Communities. (2013). *Bring Your Own Device (BYOD) in Schools: 2013 Literature Review*. Washington, DC: Government Printing Office. Retrieved from https://education.nsw.gov.au/policy-library/related-documents/BYOD_2013_Literature_Review.pdf

Organization for economic cooperation and development (2016). (6th ed.) Oxford University Press.

Partin, T., Robertson, R., Maggin, D., Oliver, R. & Wehby, J. (2010). Using teacher praise and opportunities to respond to promote appropriate student behavior. *Preventing School Failure,* 54, 172-178.

Patall, E. A., Hooper, S., Vasquez, A. C., Pituch, K. A., & Steingut, R. R. (2018). Science class is too hard: Perceived difficulty, disengagement, and the role of teacher autonomy support from a daily diary perspective. *Learning and Instruction, 58*, 220-231. doi:10.1016/j.learninstruc.2018.07.004

Patrick, B. C., Hisley, J., & Kempler, T. (2000). "What's everybody so excited about?": The effects of teacher enthusiasm on student intrinsic motivation and vitality. *The Journal of Experimental Education, 68*(3), 217. Retrieved from http://ezproxy.liberty.edu/login?url=https://search-proquest-com.ezproxy.liberty.edu/docview/217661137?accountid=12085

Pew Research Center (2017). Mobile fact sheet. Retrieved from http://www.pewinternet.org/fact-sheet/mobile/

Piaget, J. (1970). Science of education and the psychology of the child. New York, NY: Orion Press.

President's Council of Advisors on Science and Technology (PCAST), Executive Office of the President (2012). Prepare and Inspire: K-12 Science, Technology, Engineering, and Math (STEM) Education for America's Future. (2010). *The Education Digest, 76*(4), 42.

Pyatt, K., & Sims, R. (2012). Virtual and Physical Experimentation in Inquiry-Based Science Labs: Attitudes, Performance and Access. *Journal of Science Education & Technology*, *21*(1), 133-147. doi:10.1007/s10956-011-9291-6

Radley, K., Dart, E., & O'Handley D. (2016). The Quiet Classroom Game: A class-wide intervention to increase academic engagement and reduce disruptive behavior. *School Psychology Review, 45*(1), 93-108. Retrieved from http://naspjournals.org/loi/spsr?code=naps-site

Reeve, J. (2012). A self-determination theory perspective on student engagement. Handbook of Research on Student Engagement. 149-172. Boston, MA. Springer US

Reeve, J., & Lee, W. (2014). Students' Classroom Engagement Produces Longitudinal Changes in Classroom Motivation. *Journal of Educational Psychology*, *106*(2), 527-540. doi:10.1037/a0034934

Reeves, J., Gunter, G., & Lacey, C. (2017). Mobile learning in pre-kindergarten: Using student feedback to inform practice. *Educational Technology & Society, 20*(1), 37-44. Retrieved from http://www.ifets.info/

Reider, D., Knestis, K., & Malyn-Smith, J. (2016). Workforce education models for K-12 STEM education programs: Reflections on, and implications for, the NSF ITEST program. *Journal of Science Education and Technology, 25*(6), 847-858. doi:10.1007/s10956-016-9632-6

Rovai, A., Baker, J., & Ponton, M. (2013). *Social sciences research design and statistics: A practitioner's guide to research methods and SPSS analysis* (1st ed.). Chesapeake, VA: Watertree Press.

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology, 25*(1), 54-67. doi:10.1006/ceps.1999.1020

Sawilowsky, S. S., & Blair, R. C. (1992). A more realistic look at the robustness and type II error properties of the t test to departures from population normality. *Psychological Bulletin, 111*(2), 352-360. doi:10.1037/0033-2909.111.2.352

Schumm, M. F., & Bogner, F. X. (2016). Measuring adolescent science motivation. *International Journal of Science Education, 38*(3), 434-449. doi:10.1080/09500693.2016.1147659Schumm, M. F., & Bogner, F. X. (2016). The impact of science motivation on cognitive achievement within a 3-lesson unit about renewable energies. *Studies in Educational Evaluation, 50*, 14-21. doi:10.1016/j.stueduc.2016.06.002

Shahrokni, S. A.(2017). Nearpod. *Tesl-Ej*, *20*(4), 1-11. Retrieved from http://tesl-ej.org/wordpress/

Shi, L. (2016). Empirical study on learners' self-efficacy in ESL/EFL context. *College Student Journal, 50*(3), 454.

Simon, R. A., Aulls, M. W., Dedic, H., Hubbard, K., & Hall, N. C. (2015). Exploring student persistence in STEM programs: A motivational model. *Canadian Journal of Education / Revue Canadienne De l'Éducation, 38*(1), 1-27.

Schmid, S., & Bogner, F. X. (2017). How an inquiry-based classroom lesson intervenes in science efficacy, career-orientation and self-determination. *International Journal of Science Education, 39*(17), 2342-2360. doi:10.1080/09500693.2017.1380332

Sharma, A. (2002). Discovering statistics using SPSS for windows ANDY FIELD (2000). *The Turkish Online Journal of Distance Education, 3*(3)

Siemens, G. (2004). Connectivism: A learning theory for the digital age. *International Journal of Instructional Technology and Distance Learning.* Retrieved from http://itdl.org/journal/Jan_05/article01.htm

Silverberg, L., Tierney, J., & Bodek J. (2014). Use of Doceri software for iPad in online delivery of chemistry content. Journal of Chemical Education, 91, 1999-2001. doi: 10.1021/ed4009057

Singh, K., Granville, M., & Dika, S. (2002). Mathematics and Science Achievement: Effects of Motivation, Interest, and Academic Engagement. *Journal of Educational Research*, *95*(6), 323. Retrieved from http://www.tandfonline.com/loi/vjer20

Skinner, E. A., Kindermann, T. A., & Furrer, C. J. (2009). A Motivational Perspective on Engagement and Disaffection: Conceptualization and Assessment of Children's Behavioral and Emotional Participation in Academic Activities in the Classroom. *Educational & Psychological Measurement*, *69*(3), 493-525. doi: 10.1177/0013164408323233

Smith, B., & Madre, J. (2015). Formative assessment with online tools. *The Science Teacher,* 10-11. Retrieved from http://learningcenter.nsta.org/browse_journals.aspx?journal=tst

Smith, P., Trygstad, P., & Banilower, E. (2016). Widening the gap: Unequal distribution of resources for k-12 science instruction. Education Policy Analysis Archives, 24(8). doi:10.14507/epaa.v24.2207

Stephens, M., Warren, L.K., and Harner, A.L. (2015). *Comparative Indicators of Education in the United States and Other G-20 Countries: 2015* (NCES 2016-100). U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office

Stanhope, D. S., & Corn, J. O. (2014). Acquiring teacher commitment to 1:1 initiatives: The role of the technology facilitator. *Journal of Research on Technology in Education*, *46*(3), 252-276. doi:10.1080/15391523.2014.888271

Steinke, L., & Putman, A. (2007). Why should I stay? Factors influencing technology education teachers to stay in teaching positions. Journal of Technology Education 19(1), 71-84. Retrieved from https://www.iteea.org/39193.aspx

Terrion, J. L., & Aceti, V. (2012). Perceptions of the effects of clicker technology on student learning and engagement: a study of freshman Chemistry students. *Research in*

Learning Technology, *20* (1), 1-11. Retrieved from http://www.tandfonline.com/toc/zrlt20/current

Thomas, C., Pinter, E., Carlisle, A., & Goran, L. (2015). Student response systems: Learning and engagement in preservice teacher education. *Journal of Special Education Technology, 30*(4) 223-237. Retrieved from http://www.tamcec.org/publications/jset/

Traxler, J. (2009). Learning in a Mobile Age. *International Journal of Mobile and Blended Learning.*, *1*(1), 1–12. https://doi.org/10.4018/jmbl.2009010101

Truly, D. (2004). Engaging Schools: Fostering High School Students' Motivation to Learn (Book). *Choice: Current Reviews for Academic Libraries*, *42*(2), 344.

Uçar, F., & Sungur, S. (2017) The role of perceived classroom goal structures, self-efficacy, and engagement in student science achievement, Research in Science & Technological Education, 35:2, 149-168, doi: 10.1080/02635143.2017.1278684

Vatanartiran, S., & Karadeniz, S. (2015). A Needs Analysis for Technology Integration Plan: Challenges and Needs of Teachers. *Contemporary Educational Technology*, *6*(3), 206-220.

Virginia Employment Commission (2017). Virginia Community Profile: Charlotte County. Retrieved from http://www.virginialmi.com

Virginia Department of Education (2015). Virginia Standards of Learning Assessments: Technical Report 2014-2015 Administration Cycle. Retrieved from www.doe.virginia.gov

Wagner, T. (2008). *The Global Achievement Gap*. Basic Books: New York, NY

Walker, G. (2012). A review of technologies for sensing contact location on the surface of a display. *Journal of the Society for Information display*. *20*(8): 413-440. doi:10.1002/jsid.100

Wang, Y., Chung, C., & Yang, L. (2014). Using clickers to enhance student learning in mathematics. *7*(10) doi:10.5539/ies.v7n10p1

Warner, R.M., (2013). *Applied Statistics: From bivariate through multivariate techniques (2nd ed.)*. SAGE Publishing: Thousand Oaks, CA

Young, A. M., Wendel, P. J., Esson, J. M., & Plank, K. M. (2018). Motivational decline and recovery in higher education STEM courses. *International Journal of Science Education, 40*(9), 1016-1033. doi:10.1080/09500693.2018.1460773

Zaccone, M. C., & Pedrini, M. (2019). The effects of intrinsic and extrinsic motivation on students learning effectiveness. exploring the moderating role of gender. *International Journal of Educational Management, 33*(6), 1381-1394. doi:10.1108/IJEM-03-2019-0099

Zhang, M., Trussell, R., Gallegos, B., & Asam, R. (2015). Using math apps for improving student learning: An exploratory study in an inclusive fourth grade classroom. *TechTrends 59*(2): 32-39. Retrieved from https://link.springer.com/journal/11528

Zijuan, S., Gaofeng, L., & Le, H. (2017). Mobile-assisted Language Learning Using WeChat Instant Messaging. *International Journal of Emerging Technologies In Learning*, *12*(2), 16-26. doi:10.3991/ijet.v12i02.6681

APPENDICES

APPENDIX A

LIBERTY UNIVERSITY
INSTITUTIONAL REVIEW BOARD

October 10, 2018

Jan Hirtz
IRB Approval 3473.101018: Does the Interactive Push-Presentation System Nearpod Affect Student Engagement and Academic Achievement in High School Anatomy?

Dear Jan Hirtz,

We are pleased to inform you that your study has been approved by the Liberty University IRB. This approval is extended to you for one year from the date provided above with your protocol number. If data collection proceeds past one year or if you make changes in the methodology as it pertains to human subjects, you must submit an appropriate update form to the IRB. The forms for these cases were attached to your approval email.

Your study falls under the expedited review category (45 CFR 46.110), which is applicable to specific, minimal risk studies and minor changes to approved studies for the following reason(s):

> Your study involves surveying or interviewing minors, or it involves observing the public behavior of minors, and you will participate in the activities being observed.

Thank you for your cooperation with the IRB, and we wish you well with your research project.

Sincerely,

G. Michele Baker, MA, CIP
Administrative Chair of Institutional Research
The Graduate School

LIBERTY
UNIVERSITY.
Liberty University | Training Champions for Christ since 1971

Appendix B
Permission to Conduct Research Study Letter

June 25, 2018

Dr. Leonard, Superintendent
Charlotte County Public Schools
250 LeGrande Ave, Suite E
Charlotte Court House, VA 23923

Dear Dr. Leonard:

As a graduate student at Liberty University in the School of Education, I am required to conduct research as a requirement for an Educational Doctorate (Ed.D.) degree in Curriculum and Instruction. The title of my research is Does the Interactive Push-presentation Application Nearpod Effect Student Engagement and Academic Achievement in Anatomy. The purpose of my research is to add to the body of literature on using app technologies in K-12 STEM classrooms, specifically science classrooms. The study will use a Unit test, made up of released SOL questions, to quantify achievement and the Science Motivation Questionnaire (CMQ_II) to gauge engagement.

I am writing to ask your permission to conduct this research in the two Anatomy classrooms at Randolph Henry High School during the fourth week of the fall semester. I would ask students and their guardians for permission to use the data collected for analysis and reporting. All data will be de-identified and reported with no specific student information attached. The letter attached would be used to solicit volunteers for the study. The letters would be given out during open-house as well as the first day of class for that semester.

Thank you in advance for considering my request. If you select to grant your permission, please provide a signed statement on approved letterhead indicating your approval.

Sincerely,

Jan A. Hirtz
Liberty University Doctoral Candidate
Email: jhirtz2@liberty.edu
Phone: (434) 660-8206

APPENDIX C

Charlotte County Public Schools

NANCY H. LEONARD, SUPERINTENDENT
P.O. BOX 790 • 250 LEGRANDE AVENUE
CHARLOTTE COURT HOUSE, VIRGINIA 23923
434/542-5151 FAX 434/542-4261

June 26, 2018

Mrs. Jan Hirtz
6967 Rolling Hill Road
Red House, VA 23963

Dear Mrs. Hirtz:

Please allow this letter to serve as official notification that permission is granted to conduct research at Randolph-Henry High School as outlined below in an excerpt from your request letter.

> *As a graduate student at Liberty University in the School of Education, I am required to conduct research as a requirement for an Educational Doctorate (Ed.D.) degree in Curriculum and Instruction. The title of my research is Does the Interactive Push-presentation Application Nearpod Effect Student Engagement and Academic Achievement in Anatomy. The purpose of my research is to add to the body of literature on using app technologies in K-12 STEM classrooms, specifically science classrooms. The study will use a Unit test, made up of released SOL questions, to quantify achievement and the Science Motivation Questionnaire (CMQ_II) to gauge engagement.*
>
> *I am writing to ask your permission to conduct this research in the two Anatomy classrooms at Randolph Henry High School during the fourth and fifth week of the fall semester. I would ask students and their guardians for permission to use the data collected for analysis and reporting (see Informed Consent). All data will be de-identified and reported with no specific student information attached. The letter attached would be used to solicit volunteers for the study. The letters would be given out during the first day of class for that semester.*

I wish you much success in your research!

[redacted]

COPY: S. Critzer, R-H Principal

Appendix D

Informed Consent Form October 15, 2018

CONSENT FORM

Does the Interactive Push-presentation Application Nearpod Effect Student Engagement and Academic Achievement in High School Anatomy?

Jan A. Hirtz
Liberty University
School of Education

Jan Hirtz, the chemistry teacher at Randolph Henry High School, is a doctoral candidate at Liberty University and is conducting a study to gauge effectiveness of iPad application integration in her classroom. Although the instructional techniques have been used successfully in her classroom last year, she would like to collect and analyze data associated with this educational technology. The data collected and analyzed would have no identifying student information associated with it. Please read this form and ask any questions you may have before giving permission for your data collected this semester can be used in the study.

Background Information:

The purpose of the study is to gauge the effect of an application called Nearpod on student achievement and engagement. All students will be given the same instruction but some will input their answers interactively into the iPad using this application. The information is then sent electronically to the teacher's computer. It is intended to allow a teacher a quick assessment of individual students understanding of the concept being taught. It is the hope that this increase in communication can better individualize instruction in a classroom and give the teacher the ability to give immediate feedback and correction to students. This study will determine whether this interactive application helps students engage and increase their achievement in Anatomy.

Procedures:

If you agree to participate in the study, your student's data on engagement and academic achievement will be used to analyze the effects of the mobile application. Approximately half of the students this semester will be using the application to interact with lecture and the other half will not. The lecture, instruction, and in class activities will be the same for all students. The study will last between two and three weeks and regular understanding checks will be given. The students will also be asked to take a survey before and after the study to gauge their engagement in science.

Risks and Benefits of Study:

No risks are associated with giving permission for student's data to be used in the study. The benefits to allow the data to be used in this study help teachers and administration learn how students best learn.

Compensation:

No one will be compensated for participating.

Confidentiality:

The data associated with this study will not be linked by name, race, sex, or any other information that might make it possible to identify the identity of a student. Research records will only be accessible by me. Anything published will be anonymous to the students and the school district. The data will be password protected and stored on an external hard drive accessible only to me, the researcher.

Voluntary Nature of Study:

Participation is voluntary. If you do not want your student's scores to be used in this study, your student's instruction and relationship with me will not be impacted. If you agree to let me use your student's scores as data for analysis, you are free to withdraw at any time.

Contacts and Questions:

The researcher conducting this study is Jan A. Hirtz. To contact me please email or call at jhirtz2@liberty.edu or (434) 660-8206.
If you have any concerns or questions you are encouraged to contact the Instructional Review Board at irb@liberty.edu
Please notify me if you would like a copy of this letter for your records.
Statement of Consent:
I have read and understood the above information. I consent to have my student's data used in this study.
Signature of minor: ________________ Date __________
Signature of Parent or guardian _______________ Date __________
Signature of Researcher _________________ Date ___________

APPENDIX E

Lesson Plans for Research Study		
	Nearpod Classroom	Non-Nearpod Classroom
Day 1: 90 min	Warm up review from previous material (5 min) Teacher will discuss the procedures and expectations of study. Will discuss timeline and logistics of (i.e. completion of flipped lessons, deadlines, log in information for gaining access to multimedia lecture and Nearpod. (50 min) Practice using online Nearpod to interact with Lecture (20 min) Question and answer session (15 min) Weekly HW sheet handed out, due Friday.	Warm up review from previous material (5 min) Teacher will discuss the procedures and expectations of study. Will discuss timeline and logistics of (i.e. completion of flipped lessons, deadlines, log in information for gaining access to multimedia lecture and Nearpod. (50 min) Question and answer session (15 min) Weekly HW sheet handed out, due Friday. In Class time to work on HW (20 min)
Day 2: 63 min	Warm up review from previous material (5 min) Lesson (Ch 6.1) with practice on their own with Nearpod and answers reviewed on Nearpod. (50 min). Exit slip question on paper to turn in and discuss (8 min)	Warm up review from previous material (5 min) Lesson (Ch 6.1) with practice on paper. Answers reviewed by teacher (50 min) Exit slip question on paper to turn in and discuss (8 min)
Day 3: 90 min	Warm up review from previous material (5 min) Skeletal System lab 1 (85 min) Exit slip question on paper to turn in and discuss.	Warm up review from previous material (5 min) Skeletal System lab 1 (85 min) Exit slip question on paper to turn in and discuss.

	HW: Lab write up with practice problems	HW: Lab write up with practice problems
Day 4: 63 min	Warm up review from previous material (5 min) Lesson (Ch 6.2) with practice on their own with Nearpod and answers reviewed on Nearpod. (50 min). Exit slip question on paper to turn in and discuss (8 min)	Warm up review from previous material (5 min) Lesson (Ch 6.2) with practice on paper. Answers reviewed on multimedia video. (50 min) Exit slip question on paper to turn in and discuss (8 min)
Day 5: 90 min	Warm up review from previous material (5 min) Go over weekly HW sheet (20 min) Review for quiz on Ch 6 1:2 using Nearpod (20 min) Quiz on Ch 6. 1-2	Warm up review from previous material (5 min) Go over weekly HW sheet (20 min) Review for quiz on Ch 6: 1.2 by teacher (20 min) Quiz on Ch 6. 1-2
Day 6: 90 min	Warm up review from previous material (5 min) Go over quiz Ch 6. 1.2 Lesson (Ch 6. 3) with practice on their own with Nearpod and answers reviewed on Nearpod. (50 min). Exit slip question on paper to turn in and discuss (8 min)	Warm up review from previous material (5 min) Go over quiz Ch 6. 1.2 Lesson (Ch 6.3) with practice on paper. Answers reviewed by teacher. (50 min) Exit slip question on paper to turn in and discuss (8 min)
Day 7: 63 min	Warm up review from previous material (5 min) Skeletal System Food Project (55 min) Exit slip question on paper to turn in and discuss.	Warm up review from previous material (5 min) Skeletal System Food Project (55 min) Exit slip question on paper to turn in and discuss.

	HW: Lab write up with practice problems	HW: Lab write up with practice problems
Day 8: 90 min	Warm up review from previous material (5 min) Video on Skeletal System (20 min) Lesson (Ch. 6. 4) with practice on their own with Nearpod and answers reviewed on Nearpod. (50 min). Exit slip question on paper to turn in and discuss (8 min)	Warm up review from previous material (5 min) Video on Skeletal System (20 min) Lesson (Ch 6. 4) with practice on paper. Answers reviewed by teacher (50 min). Exit slip question on paper to turn in and discuss (8 min)
Day 9: 63 min	Warm up review from previous material (5 min) Lesson (Ch 6. 4) with practice on their own with Nearpod and answers reviewed on Nearpod. (50 min). Exit slip question on paper to turn in and discuss (8 min)	Warm up review from previous material (5 min) Lesson (Ch 6 4.) with practice on paper. Answers reviewed by teacher. (50 min). Exit slip question on paper to turn in and discuss (8 min)
Day 10: 90 min	Warm up review from previous material (5 min) Go over weekly HW sheet (20 min) Review for Test on Ch 6 1-4 using Nearpod (30 min) Quiz on Ch 6 1-4	Warm up review from previous material (5 min) Go over weekly HW sheet (20 min) Review for Test on Ch 6 1-4 by teacher (30 min) Quiz on Ch 6 1-4
Day 11: 90 min	Warm up review from previous material (5 min) Go over quiz questions (30 min)	Warm up review from previous material (5 min) Go over quiz questions (30 min)

	Lesson (Ch 6. 5) with practice on their own with Nearpod and answers reviewed on Nearpod. (40 min). Exit slip question on paper to turn in and discuss (8 min)	Lesson (Ch 6. 5) with practice on paper. Answers reviewed by teacher. (40 min). Exit slip question on paper to turn in and discuss (8 min)
Day 12: 63 min	Warm up review from previous material (5 min) Flipped lesson (Ch 6. 6) with practice on their own with Nearpod and answers reviewed on Nearpod. (40 min). Exit slip question on paper to turn in and discuss (8 min)	Warm up review from previous material (5 min) Flipped lesson (Ch 6. 6) with practice on paper. Answers reviewed by teacher (40 min). Exit slip question on paper to turn in and discuss (8 min)
Day 13: 90 min	Warm up review from previous material (5 min) Lab on Leg Bones Exit slip question on paper to turn in and discuss. HW: Lab write up with practice problems	Warm up review from previous material (5 min) Lab on Leg Bones Exit slip question on paper to turn in and discuss. HW: Lab write up with practice problems
Day 14: 63 min	Warm up review from previous material (5 min) Flipped lesson (Ch 6. 7) with practice on their own with Nearpod and answers reviewed on Nearpod. (40 min). Exit slip question on paper to turn in and discuss (8 min)	Warm up review from previous material (5 min) Flipped lesson (Ch 6. 7) with practice on paper. Answers reviewed by teacher (40 min). Exit slip question on paper to turn in and discuss (8 min)

Day 15: 90 min	Post-tests SMQ II	Post-tests SMQ II

APPENDIX F

Science Motivation Questionnaire (SMQ-II)

Instrument removed to comply with copyright

APPENDIX G
Permission to Use Science Motivation Questionnaire II
The SMQ-II that assesses components of students' motivation to learn chemistry in college and high school.

Permissions and directions below are copied from https://coe.uga.edu/outreach/programs/science-motivation:

Permissions and Directions: Science educators who wish to use the Science Motivation Questionnaire II© 2011 Shawn M. Glynn for research and teaching have permission to do so if they cite the Glynn et al. (2011) reference below and comply with the fair use of this copyrighted and registered questionnaire. This permission extends to discipline-specific SMQ-II versions such as the Biology Motivation Questionnaire II (BMQ-II), Chemistry Motivation Questionnaire II (CMQ-II), and Physics Motivation Questionnaire II (PMQ-II) in which the words biology, chemistry, and physics are respectively substituted for the word science. In any use of the SMQ-II, its versions, and translations to other languages, permission is contingent upon citing the Glynn et al. (2011) reference, which provides information on the SMQ-II administration, components (scales), scoring, reliability, and validity.

APPENDIX I

SMQ II item number	Factor loading: Total	Boys	Girls	Lower secondary	Upper secondary	Statement
Factor: grade motivation						
24	0.78	0.79	0.79	0.76	0.77	Scoring high on science tests and labs matters to me
4	0.76	0.69	0.84	0.68	0.80	Getting a good science grade is important to me
8	0.75	0.78	0.71	0.79	0.72	It is important that I get an ‘‘A’’ in chemistry
20	0.67	0.66	0.70	0.58	0.71	I think about the grade I will get in science
2	0.57	0.52	0.60	0.53	0.60	I like to do better than other students on science tests
Factor: self-efficacy						
15	0.80	0.82	0.78	0.75	0.84	I believe I can master science knowledge and skills
9	0.79	0.77	0.81	0.72	0.83	I am confident I will do well on science tests
18	0.70	0.77	0.60	0.66	0.73	I believe I can earn a grade of ‘‘A’’ in science
14	0.64	0.60	0.70	0.61	0.66	I am confident I will do well on science labs and projects
21	0.56	0.62	0.51	0.49	0.62	I am sure I can understand science
Factor: self-determination						
22	0.74	0.75	0.72	0.69	0.78	I study hard to learn science
11	0.70	0.70	0.69	0.70	0.71	I spend a lot of time learning science
16	0.60	0.60	0.60	0.66	0.56	I prepare well for science tests
5	0.60	0.63	0.52	0.50	0.66	I put enough effort into learning science
6	0.56	0.58	0.49	0.52	0.59	I use strategies to learn science well
Factor: career motivation						

SMQ II item number	Factor loading					Statement
	Total	**Boys**	**Girls**	**Lower secondary**	**Upper secondary**	
13	0.78	0.79	0.75	0.66	0.86	Understanding science will benefit me in my career
23	0.78	0.79	0.76	0.79	0.80	My career will involve science
25	0.73	0.73	0.75	0.73	0.77	I will use science problem-solving skills in my career
7	0.72	0.67	0.72	0.50	0.83	Learning science will help me get a good job
10	0.69	0.66	0.76	0.58	0.74	Knowing science will give me a career advantage
Factor: intrinsic motivation						
19	0.80	0.78	0.81	0.75	0.84	I enjoy learning science
12	0.71	0.69	0.72	0.67	0.74	Learning science makes my life more meaningful
17	0.67	0.71	0.61	0.58	0.73	I am curious about discoveries in chemistry
3	0.66	0.65	0.65	0.55	0.75	Learning science is interesting
1	0.48	0.55	0.36	**0.34**	0.59	The science I learn is relevant