2017

EFFECTS OF PERSONAL TECHNOLOGY DEVICES ON INSTRUCTION AND LEARNING IN HIGH SCHOOL BIOLOGY

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A Dissertation
Presented to
the Faculty of the Department of Educational Studies, Leadership and Counseling
of the College of Education and Human Services
Murray State University
Murray, Kentucky

In Partial Fulfillment
of the Requirements for the Degree
of Doctor of Education

by Susan P. Beatty
August 2017

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Acknowledgements

I have many people to acknowledge who have helped me not only in the past three years of my doctoral program, but for many years before it began. I am very grateful for the opportunity Murray State University has given me to earn a doctoral degree, but also for my other degrees as well. I owe a tremendous appreciation to the professors, administrators, and other staff members who have helped me through each of my programs of study by teaching and sharing their knowledge and experience. Because of what I learned and achieved at Murray State, I have been able to teach and impact others to achieve, learn, and grow. In the end, that is what is most important. I especially want to thank Dr. Teresa Clark and Dr. Randal Wilson for their tireless efforts to make the P-20 Doctoral Program all that it is. I also want to thank Dr. Clark along with Dr. Yuejin Xu and Dr. Dusty Reed for their service on my dissertation committee. I appreciate your help and guidance along the way.

The time and energy given to this study would not have been possible without the support of my colleagues at Mayfield Independent School District. Everyone has been kind and generous to help encourage me and provide me with any assistance I needed. I want to thank Mr. Don Hubbard and Mr. Billy Edwards, who gave me great latitude in using our students in my classroom to conduct my research. I want to especially thank Ms. Amy Forsee, who gave of her time and efforts to help me in collecting forms and data. Your kindness and generous spirit are admirable and I am honored to be your colleague.

Finally, I must thank my family and friends who have always been supportive in everything I do. Specifically, I want to thank my parents, Kenneth and Barbara Bucy, who taught me the importance of hard work, but also that getting an education paves the way for more enjoyable work, even if it is still hard. I love you both for all you have done for me and the sacrifices you made so I could receive an education. I must also thank my husband, Russ, and our children, Carley and Camryn, for enduring with me for the past three years and never complaining that I was always studying. Russ, I hope you know that I love you for many reasons, but one reason will always be for your support of my educational pursuits because without you it would have been much harder.

Abstract

The purpose of this study was to explore the use of personal technology devices during classroom instruction as learning tools by high school biology students. The study sought to determine how a classroom environment with a Bring Your Own Device instructional method in place affected student achievement and student perceptions about biology, as well as viewpoints about their devices as tools for learning. Technology in the hands of teenagers today is nearly ubiquitous and often distracting in the traditional classroom. As the literature indicates, different views exist about the efficacy of using personal technology for learning. This study intended to learn more about the benefits and barriers associated with deliberately employing hand-held personal technology devices in a traditional high school classroom setting.

In the data analysis, the results of the pre-test and post-test score data and pre-survey and post-survey score data reveal interesting information regarding the use of personal technology for learning in a high school biology classroom. Overall, the results of this study support the assumption that the presence of a personal technology device as a learning tool in a high school biology class makes no statistically significant difference in student achievement, nor do they significantly influence student perceptions about using their own device to learn or their attitudes about the subject of biology. Regardless of the effectiveness of the method, students participating in this study provided some interesting insights about their experiences using their own technology for educational purposes during a genetics instructional unit. Their responses provided some valuable information about their experiences and informs the researcher about how to improve future research endeavors. The intention of this research is that the results help to inform and complement the body of research about the emergence of personal technology in the lives of students.

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Chapter 1:

In almost every aspect of 21^{st} century society, the digital revolution is plainly evident. Universally abundant and relentlessly conspicuous, technology is demanding change from everyone affected. A wide range of diverse people groups of all ages and from all backgrounds worldwide are experiencing the transformation to a nearly completely digital world. As with shifts in culture that occur in every society over time, changes in how people communicate and use technology require new perspectives to handle those shifts. Some individuals are inspired to advance change through innovation and improved performance in their field of practice. Often, these people are successful, influential leaders because as changes occur around them, they choose to change the way they think during it. They have learned the art of reframing and thus their organizations thrive in today's fast-paced digital environment. (Bolman & Deal, 2014).

Since the first computers became available in the workplace decades ago, like other professionals, educational leaders have sought ways to employ computers in all types of learning environments. Despite noble attempts by forward-thinking teachers, the earliest devices had limited capabilities in what they could do in classrooms to help students learn. The advent of the World Wide Web, the invention of wireless technology, and the teacher/student-friendly software capabilities that now exist have dramatically changed what computer technology can do in classrooms, both for the teacher and student.

The affordability and availability of technology in the form of small, handheld computers like smartphones and tablets, in addition to the software these devices use, have created opportunities to expand what students can learn and how they can learn it. A significant amount of research supports the idea that such opportunities are available and only limited by a person's creativity and ability to innovate. Within the next generation, to keep up with the trends and provide the best learning environment for students, a major shift in classroom design is needed, along with a reframing of the way educators perceive technology in the context of learning. Specifically, mobile technologies have the potential to provide educators with new opportunities and unique advantages to provide rich and diverse learning environments that encourage independence, creativity, and freedom. Technology, particularly in the form of personal technology devices, eliminate the barriers to learning of time and space (Keep & Feltham, 2015).

Context of the Study

A shift in the way people view personal technology is already evident with its increasing prevalence in everyday life. In an October 2015 report by the Pew Research Center, "68% of Americans have smartphones; 45% have tablet computers" and the same data indicate that ownership of less mobile technology, such as desktop computers is decreasing (Anderson, 2015). The way many people communicate, especially young people, has progressed over time from face-to-face conversations and writing letters, to telephone conversation and emails, to text messaging and chat rooms through social media applications. One can only imagine how babies born today will receive and share information when they become high school students or older. As a result of these changes, the increasing infiltration of cell phones, tablets, and other smart technology into school hallways and classrooms has been a difficult distraction for veteran and even some newer teachers to manage. Many teachers experience frustration and view devices as distractions that interrupt the operation of the school.

Reluctant educators, who hold onto the traditional classroom for fear of sacrificing sound pedagogy they were trained to deliver, need not sacrifice rigorous practice to accept the presence of personal technology in the hands of students. In fact, it is important for educators to accept that technology is here to stay and that it will only become more prevalent. To maintain pace with the changes that technological developments are bringing to schools, the challenge is to identify the best and most applicable ways to integrate, regulate, and ultimately utilize personal technology for the benefit of students.

As many of the technology-related theories propose, computers, and especially handheld devices, are simply more engaging now than a textbook. Another challenge of education is to find ways to meet the unique needs of learners so they can in fact, learn. Instead of rejecting technology rather than accepting it because it is foreign or different from how the teacher learned, educational leaders must consider how to best promote literacy in all aspects, including reading and writing, communication and collaboration, and many other skills. If a child can best learn to read using an e-reader instead of a traditional paperback book, is it not worth the change? (Norris & Soloway, 2002).

Purpose of the Study

The purpose of this quasi-experimental quantitative study was to investigate the effectiveness of a Bring Your Own Device instructional method on student achievement through test score comparisons of students in biology classes in a public high school in Mayfield, Kentucky. This study also served to examine the attitudes and perceptions of high school students in the same classes regarding their personal technology devices as learning tools. Teenagers today have a strong affinity for their own technology and many of them bring their devices to school with them every day. The permeation of such devices, especially smartphones, into classrooms has been a difficult distraction for veteran, and even some newer teachers, while they strive to provide learning services to students. The researcher wanted to learn more about the benefits and the barriers associated with using personal hand-held technology devices in a traditional classroom setting and determine whether any additional knowledge about student capabilities and perceptions can be gained by this type of instructional method.

Because many teachers experience frustration and view students' devices as disturbances that interrupt the operation of the school, it is an issue worthy of study. The practical nature of this research area has the potential to provide valuable information about how to help eliminate the aggravation of personal technology in classrooms and instead effectively integrate it with existing pedagogy to enhance instruction and improve student achievement. The intent is that information learned from this study can help teachers and students conquer the perceived barriers that smartphones and tablets bring to the classroom as well as take advantage of the benefits they might be able to provide as tools for learning.

Theoretical Guiding Research

The Influence of Media

Since the introduction of mass media in society in the first half of the 20th century, researchers in technology-related fields have strived to understand the fascinating novelty of new devices and gadgets as they are imagined and invented. Regardless of age, various media forms affect how people behave in their personal environments and interactions with others. The work of Herta Herzog in the 1940's regarding the influence of radio soap operas on their fans led to her Uses and Gratifications Theory. This idea describes what needs are fulfilled, (gratifications) through the operation (use) of some type of media (The Power of Media, 2016). As with radio and television in their early years, this theory is similarly applicable to the excess of digital devices in today's world. While Herzog's work blazed the trail in the study of media and technology in society, the focus of the theory today has shifted to encompass not only the satisfaction and enjoyment technology provides to people, but how people can use technology for more purposeful ends (The Power of Media, 2016). This thinking applies to understanding of how teens and young adults perceive their own technology, why they have these perceptions, and how they do and potentially can use their technology purposefully.

Herzog learned that people use media for several reasons, including enjoyment, escape, and relaxation, but also for social interaction, obtaining information, and learning (The Power of Media, 2016). These findings, when joined with specific learning theories such as E-learning Theory, Learner-Centered Design, John Keller's ARCS Model of Motivational Design, and the 21st Century Skills Initiative, help describe the conceptual framework on which this study is based. Many of these theories overlap in their application to this research and they are all integral to the understanding of it.

Motivation

One of the many reasons that the integration and effective use of personal technology in classrooms is given attention is because of the attraction that young people feel towards their devices. This connection is not broken when they come to school, nor does their motivation decline. Few would argue that for meaningful learning to take place, one of the critical factors is motivation. According to Keller's ARCS Model of Motivational Design, the learning environment must include Attention, or active participation, Relevance, or future usefulness, Confidence, or meaningful success, and Satisfaction, or reward (Francom & Reeves, 2010). Each of these factors is critical in applying any type of personal technology devices in today's classrooms. Students need to be attentive to the subject of the lesson and know that the learning experience has value to them. They also need to know through useful feedback that they can achieve success or growth in their experiences.

A firm understanding of motivational design, as described in the ARCS model, is foundational to this study because it focuses not merely on grabbing the learner's attention through awe and emotion, but seeks to develop within the learner an intrinsic interest. Instead of relying on extrinsic rewards for intended outcomes, using solid motivational tactics that support instructional goals and purposes are most effective because they outlast the entertainment value of shallow engagement attempts. Students may "feel good" about their classroom experience in a room that only entertains, but learning is limited and motivation can even decrease in such contexts (ARCS Model, 2016).

Multimedia Learning

Newer theories that are more specific to using digital devices and other technology-enhanced environments for learning certainly add support to this area of research. E-learning theory, as described by Richard E. Mayer and Roxana Moreno, is concerned with the massive amount of information students receive through multimedia learning situations and how this can lead to "cognitive overload" (Mayer & Moreno, 2003, p. 43). In multimedia learning, electronic technology that engages learners verbally and visually at the same time is paired with effective learning strategies, which require a substantial amount of thinking on the part of the student (Mayer & Moreno, 2003). Multimedia learning has the potential to provide learners opportunities to control their pace of learning with a personalized plan of instruction. However, it is important to consider ways to overcome the mental perplexity that might occur, especially when personal technology devices are added to the mix of expectations that these learning environments place on students (Mayer & Moreno, 2003).

Due to the emergence of the computer over the past few decades, research has increased dramatically in the area of learner-centered design theory proposed by Elliot Soloway and

Cathleen Norris in 2002. Over a decade ago, after proposing the need to embrace computer-based instruction, Soloway and Norris continue today to promote the idea that someone who simply uses a computer has different needs than someone who uses a computer to specifically learn. Much more is known now about how individuals and groups discover information in different types of settings. With the development of readily available software that the average consumer can use successfully now, education must take advantage of its capabilities (Norris & Soloway, 2016) and design classrooms to support its use. Classrooms are filled with diverse types of students and learning groups who can benefit from the scaffolding of learning tasks as they make progress and grow. Classrooms that are designed to be learner-centered, through the introduction of personal technology devices to support the learning process, can increase motivation of students because of the controlled pace, personal touch, and student affinity for the technology.

Technology and Career Readiness

While each of these motivational and technologically based theories apply to the topic of study here, a guiding principle that is perhaps not foundational like the other theories, but of great consequence nonetheless for the structure of future educational systems, is the 21st Century Skills Initiative. This is not described as a theory, but instead as a modern movement that seeks to improve what students need to do in school now to be prepared with the knowledge and skills they need as they progress through school and eventually in their workplaces (Framework for 21st Century Learning, 2016). These skills are centered on themes relevant to 21st century life, such as civic, environmental, financial, and health literacies, as well as global awareness. In terms of skills, leadership, initiative, social and productivity skills are very important, but also knowledge in core subjects, critical thinking, communication, and information and media literacy. This framework provides these guidelines to help administrators and teachers design their own curriculum based on the unique post-secondary needs of their students. Aligned with this idea, and importantly so, the precepts behind this movement are strong complements to the emerging P-20 education paradigm that aims to bridge the gap between educational institutions, the workplace, and community (Wilson, n.d.).

As technology research grows in a variety of fields, it is crucial that educational technology develops concurrently through active and robust studies in real-time classroom settings. Investigations about how technology that is available and useful to students to help them learn in specific subject areas and classroom environments is an important element in the advancement of technology in classrooms. This is true not only for educators to improve instructional methods, but to simultaneously help prepare students with more skills to be technologically competent workers when they finish school.

Scope and Bounds of the Study

This study involved 9^{th} and 11^{th} grade high school students in a required first-year biology course. Classes met five days each week for 48-50 minutes each day. Student selection for the study was based on the prevalence of student-owned technology devices that students could use each day in class, the size of the classes involved, and demographics of the classes. Instruction covered one complete unit of study over Mendelian and molecular genetics lasting approximately eight weeks with a pre-test and post-test given to all students to measure achievement. Students in both groups were given a survey before and after the unit to get feedback regarding their opinions about using their devices.

Possible limitations of the study include issues with student access to personal devices on a regular basis, as they are high school students who might not always have their smartphone or tablet available. The classes participating in the study include a convenience sample and the researcher is also the teacher of the classes. Collecting student achievement data from one unit of study in one subject area might make the findings limited and cause difficulty in transferring conclusions to other settings. However, the findings of this study have the potential to provide information useful to a variety of other settings.

Significance of the Study

Research in this area is gaining momentum as educational leaders look for ways to integrate technology into classrooms in an efficient and beneficial way. This study is significant for two reasons: 1) It is imperative that personal technology devices in the hands of students are properly regulated and integrated into instruction. Distractions that they can cause are often the result of improper management and implementation. This study seeks to identify and experiment ways that such devices can be assets in the classroom, not disruptions. 2) Students of today will be workers tomorrow. Employers in the digital age need workers who are prepared with a variety of skills, including the ability to apply and use different types of technology. Students need the experience using a technology tool in a real-life environment and understand that these devices can and should be more than just toys for entertainment. This study is about different ways such devices can be used for learning and how their use might influence student perceptions about their own personal technology.

Definitions of Key Terms

ARCS Model of Motivational Design – A learning environment model, proposed by John Keller, that includes the components of attention, relevance, confidence, and satisfaction which seeks to improve motivation of students to learn (ARCSMODEL.COM).

Blended Learning – A learning model that is a combination of traditional brick and mortar schools and online learning, providing more choice and autonomy to students (Horn & Staker, 2015).

Bring Your Own Device (BYOD) – An instructional method that encourages students to participate in class activities by using their personal technology devices.

Context Specific Competencies – Knowledge and skills associated with a specific, focused field of study.

Digital Divide – In most contexts, this term refers to the gap between those in the population who have access to computer technology, including the Internet, and those who do not. In the context of this study, it means the gap between those who are more technologically competent and those who are not.

Digital Native – Individuals who were born in the digital age and are familiar with computer technology in everyday life (Prensky, 2001).

Digital Immigrant – Individuals who were born before the digital age, but have acquired an interest in technology later in life (Prensky, 2001).

E-learning – Also known as electronic learning, this is a learning method that first introduced computers as a learning tool in the classroom (Kee & Samsudin, 2014).

Generation Z – A generational label for the segment of the population born in the late 1990's to early 2000's. This group is often referred to by other names, such as iGeneration or GenTech (Wiedmer, 2015). They were born after the digital age began so they are also digital natives.

Learner-Centered Design – A learning theory proposed by Soloway and Norris that focuses on the needs of the learner. In this context, it refers to how technology can be used to modify environments to enhance student learning (Norris & Soloway, 2016).

Personal Learning Network – Through technology, an interconnected system of learners that provides educational options to students in a variety of environments and timeframes (Kompen, Monguet, & Brigos, 2015).

Personal technology device – In the context of this study, this refers to laptops, tablets, and smartphones that students possess and customize for their own use.

M-learning – Also known as mobile learning, it evolved from e-learning, when technology devices became smaller and more manageable and transportable, allowing students to have more personalized use of the device (Kee & Samsudin, 2014).

Millennial – A generational label for the segment of the population born between 1982 and early 2000's. In terms of this study, this group is known as the first to be comfortable with technology in most aspects of everyday life (McAlister, 2009).

Multimedia learning – A learning context in which students are engaged through technology verbally and visually at the same time, requiring a relatively complex level of thinking (Mayer & Moreno, 2003).

Network and mobile technologies (NMT) – Technology devices that are handheld or mobile and can connect to public or private Wi-Fi networks (Trentin, 2015).

PDA – Also known as Personal Digital Assistant, a handheld device that can store important information, such as a calendar, for users that can be accessed quickly. Most of today's PDAs can connect to the Internet.

Seamless Learning Space – For this study, this term describes learning as fluid, or an activity that can easily transfer from one setting to another without significant disruption. For example, learning that occurs at school can be continued in the same manner at home through use of personal technology.

Smartphone – Technology device that contains a mobile phone, a media player of audio and video, a camera, a PDA, and computer in one design (Pegrum, Oakley, & Faulkner, 2013).

Tablet – Technology device that has similar capabilities of a computer and smartphone, but consists of a handheld touchscreen, typically without phone capabilities (Pegrum, Oakley, & Faulkner, 2013).

U-learning – Also known as ubiquitous learning, this technology-based learning model allows a student to learn in every possible context of life through a connection with a technology device that is customized to meet the immediate needs of the learner (Kee & Samsudin, 2014).

Web 2.0 – The current stage of development of the World Wide Web that enables greater interactivity between users through social media and other applications.

Summary

Personal technology in the hands of today's students has the potential to positively change the way learning happens in classrooms today. Despite the obvious capacity for distraction, the capabilities that handheld devices possess provide a wide range of learning opportunities for students and teachers. The practical nature of this study has the potential to provide valuable information about how to effectively integrate personal technology using a variety of web applications. This information can help teachers and students overcome barriers that smartphones and tablets bring to the classroom as well as take advantage of the benefits they provide.

Chapter 2: Literature Review

Technology and Education

Educational technology is a wide-ranging and extensive field of study that has grown in scope and complexity in the last several decades. The existence of even the simplest technology has been important in human societies for thousands of years. During their day, the pencil, ink pen, typewriter, and even the overhead projector and desktop computer were appealing innovations that changed the way of life for those who used them and more specifically, for educators and the students they taught. As these new tools developed over time, they made life more enjoyable and work less laborious. That is, by most definitions, the meaning and purpose of technology. A simple definition, according to Webster's online dictionary, is "the use of science in industry, engineering, etc. to invent useful things or to solve problems" (Merriam Webster Online Dictionary). Most people would agree that technological advances in all aspects of life from agriculture, industrial processes, medicine and even education, have made life better for humankind.

Over the past three decades, in the realm of educational technology, particularly in classroom instructional settings, the integration of information and communication technologies (ICTs) has been slowly evolving. The first computer labs arose in the mid-1980's in which classes of students visited and learned to use computers. During the late 1990's, the computer room walls started to come down with the advent of online communication, and schools and other institutions of learning were the primary means of access. Today, since the early 2000's, the classroom has extended past four walls into what is known as "virtual space" allowing for learning to happen virtually anywhere and anytime (Trentin, 2015). Over the years, regardless of the level of technology, its use has been and still is recognized "as essential in all learning environments" (Cristol & Gimbert, 2014, p. 24) by the government and many national institutions. The ever-present nature of today's devices provides limitless learning opportunities for students while simultaneously introducing a variety of instructional challenges for teachers and school leaders.

As beneficial as previous technological advances have been, the tools of today are far different and much more complex than those of previous generations, primarily due to the advancement of computer technology and the plethora of ways it has invaded all sectors of society. In educational institutions of all levels, the integration of the computer into classroom instruction has evolved in only a few decades. From environments in which the number of computers were limited to teacher workstations, to computer labs where classes of students could use them together, to current environments, in which schools can employ a one-to-one ratio, thus providing every student with a computer or device to use, the technological landscape has changed. The advent of the portable laptop computer and even more recently, handheld smartphones and tablets with Web 2.0 tools (Cochrane & Bateman, 2010), allow anyone the decision-making power to access information whenever and however they want it.

Indeed, the effect that the presence of technology is having on school systems today is an issue worthy of investigation. Technology enthusiasts have some interesting arguments in support of it as an integral part of today's instructional practice (Collins & Halverson, 2009) and the notion known as "smart learning" has the potential to change those practices a great amount. As new ways to access learning through technology evolve, many technology experts agree the way schools deliver instruction must change with it if they are to remain relevant and competitive. Technology increases options to students and at the same time can provide personalization and feedback in ways that today's students prefer. An interesting consideration is whether modifying the traditional school through technological advances will meet the demand to give learners access to such alternatives. Various research studies support the idea that when devices like smartphones are used with a focused, well-planned purpose, learning experiences for students can be greatly improved (Tossell, Kortum, Shepherd, Rahmati, & Zhong, 2015), thus allowing traditional schools to remain technologically pertinent.

Teenagers and Personal Technology Devices

The accessibility of mobile devices has resulted in a change in the way people, especially teens, receive and share information (Lenhart, 2015). According to the latest available Pew Research Center statistics, 88% of American teens have or have access to a mobile phone and a majority of those have smartphones. This same survey reveals that 91% of teens have access to some type of mobile device that can access the internet (Lenhart, 2015). Most revealing is that 24% of teens report that they are online “almost constantly” and “94% go online daily or more often” (Lenhart, 2015, p.1). Texting and accessing social media, such as Twitter and Instagram, often replace face-to-face conversation as the means for communication in people ages 13-17. Any parent or educator around teenagers today knows that today’s youth pay more attention to their phones and other tech devices than anything else, and this is becoming more the norm as younger children mature into teenagers (Nielsen & Webb, 2011). Predictions about the future of mobile phones indicate that by the year 2020, they will be the means in which most people access the Internet (Anderson & Rainie, 2008).

The literature describing the relationship between teenagers and technology reveals an increasingly strong association between them. Based on the “ubiquitous availability” (Kee & Samsudin, 2014, p. 107) of portable, handheld devices, namely, the smartphone, rising numbers of young people have access to smartphones and tablets. Smartphones are defined as devices that contain a mobile phone, a media player of audio and video, a camera, a PDA, and computer in one small device (Pegrum, Oakley, & Faulkner, 2013). More frequently, teens are observed using a personal device to perform a number of tasks, such as communicating through social media, as mentioned previously, but also for web searches and gaming. The most recent literature indicates that today's teens prefer text messaging over other forms of communication, even talking face-to-face. As of 2010, 72% of teens were "texters," up from 51% just four years earlier (Nielsen & Webb, 2011). That percentage is sure to grow as prices of these devices decrease and different purchasing options become available to teens and their families.

Access and availability of technology are important factors to consider, along with the ability of teenagers to pay for it. This is especially true for minority and low-income students. A digital divide has always been an issue for students who had less access to computers and internet at home. While schools have made efforts to help them overcome this, the ubiquity of the mobile device is helping much more. The student who in the past might have been denied access to the Internet because they could not afford a computer has more options through more affordable devices and free WiFi areas (Thomas & Munoz, 2016). As more advanced devices become available to students and everyone becomes more connected to and through the Internet, it becomes even more important to be mindful of how such devices may benefit students in a school setting, where they spend a great amount of their time.

In addition to the charm, affordability, and accessibility of the smartphone, an increasing number of teenagers are drawn to tablet devices and use them for many of the same purposes, such as playing games and browsing the Internet. While similar to laptops in how they function, tablets do not feature calling capabilities like the smartphone. However, they possess touch screens and run from applications, or apps, a specialized form of software like smartphones

(Pegrum et al., 2013). Tablets are larger, making the screens bigger and easier to view than a phone screen, but they are small enough to not be cumbersome. Most tablets have better battery life than other devices, and they are very versatile, some with the capability to fold into a laptop form (Bradley, 2012). The potential for their use is wide-ranging and to some, unimaginable. As students learn more useful ways to use personal devices as learning tools, tablets have the potential to be more attractive to them because they have larger screens with all the other benefits teens use the most, such as text messaging and social media applications.

Generational Learning Shifts

Millennials

The students in today's classrooms have never known life without the internet (McAlister, 2009). The Millennials, described by some as people born between 1982 and 2002, are known as the first generation to be comfortable and confident using computers and "appreciate the multi-sensory engagement that comes from working in a variety of media" (McAlister, 2009, p. 14). They are seemingly always connected to some type of device and because of their tech-savvy abilities, they engage in quite a great amount of multitasking. Many of them are team-minded and prefer working cooperatively in groups, but are also described as confident and achievement-oriented. This could possibly be in part because many family calendars of this generation and today are full of children's activities, which override everything else in the family. Interestingly, theirs is the generation that first coined the term "helicopter parent" (McAlister, 2009, p. 14). The presence of portable technology devices in the hands of the students in this generation has "changed the learning methods and learning strategies of today's teenagers" (Kee & Samsudin, 2014, p. 107) regardless of the opinions of educational leaders and decision-makers. Technology in the hands of the Millennial Generation has permitted them to be the first to be constantly connected regardless of location.

Generation Z

While the Millennials introduced the world to people who are more reliant on technology, the up and coming generation that has evolved after them is known by various names, all of which contain a reference to technology. Sometimes known as iGeneration, Gen Tech, or Net Gen, these "digital natives" (McCaffrey, 2011, Wiedmer, 2015) have been born into a time when the way they learn is molded by the technology in their environment (Wiedmer, 2015). Generation Z students, as they are also often described, have the real-time experience of communicating with people in a completely different space (Wiedmer, 2015). Because of their early experience with mobile and other technologies accessing the World Wide Web and playing video games, their brains are conditioned for fast-moving images and other content (Renfro, 2012). They often dislike traditional classroom settings and have a need for more personalized education and instant feedback (Renfro, 2012).

All of these changes in the ways children interact with the world around them, specifically the role that technology plays in their lives, has led some to perceive an ever-widening gap between how teachers teach and how these students best learn (Wiedmer, 2015). Despite this impression, on the contrary, there are educators in the field of instructional technology with the opinion that today's youth are confident with their devices and can use them effectively in some ways, but even many tech-savvy students are not quite fluent enough at learning in the classroom with them yet (Parsons & Adhikari, 2016). Some researchers predict that the confluence of technology devices in the hands of students, their desire to use them regardless of their competency, and the lack of readiness of teachers to employ them in the classroom is a potential challenge for educators coming very soon.

Changing Educational Systems

The Internet and constant improvements in handheld and other devices, as well as more user-friendly software, provide students and parents with more learning options today. Due to the explosion of technological advancement and the new types of learners (Generation Z) who have grown up during it, to remain relevant, educational institutions have to examine their role in this rapidly changing environment (Collins & Halverson, 2009). Since the first established schools, the assumption has been that these are places where learning occurs. While this is the goal and hopefully the achievement in schools all over the world, now more than ever, students do not have to be in a school building to receive high-level learning opportunities. Using digital tools enables students to create their own learning environment (Johnson, Adams-Becker, Estrada, & Freeman, 2015). Ownership of a small, handheld smart device provides them with access to various types of distance learning and the ability to communicate with others around the world in an instant. They can do all of this without leaving home in a PLE, or personal learning environment, and by joining a PLN, or personal learning network, of other learners (Kompen, Monguet, & Brigos, 2015).

Radical change, though infrequent throughout history, is not new to school leaders. The Industrial Revolution of the 19th century brought with it a need for qualified factory workers with a specific set of skills for those jobs. School system designs were modified to provide a standardized education to a larger number of students simultaneously. This was much different than the way the previous agricultural society provided learning to the next generation of workers, often through apprenticeships (Collins & Halverson, 2009). The design of today's school system with standardized curricula, textbooks, mortar and brick school environments, paper and pencil, and methods of promotion is not much different than that of the 19th century factory model. This fact is eye-opening considering the current revolutionary changes taking place in today's information age. Today's "information revolution" (Collins & Halverson, 2009, p. 4) encourages learners of all ages to pursue learning opportunities that interest them and this learning is not confined to a school building.

In opposition to a standardized, uniform, teacher-controlled industrial model, today's learning technologies have the capacity to provide personalized, unique, student-centered instruction. This instruction, guided by the interests and strengths of the learner, are not limited by time or place. The role of teacher need not be of one who rigidly directs the instructional path, but instead provides guidance and content-related support as students work at a structured, yet individualized pace until they reach the necessary competency level for proficiency. (Collins & Halverson, 2009).

Situated learning, the ideal context for students and teachers, provides an authentic opportunity for students to gain knowledge that is real, relevant, and applicable in everyday circumstances. With the aid of the latest technologies, such as GPS, Bluetooth, cameras, and social media, students have access to learning scenarios that give them experiences like nothing ever before in school. This is especially true in abstract subjects, where it is challenging to provide instruction in a natural setting. For so long, teachers have had to explain concepts out of context and were unable to provide students with intriguing experiences that motivate them to pursue more learning or additional training, which is needed to successfully secure today's jobs (Martin & Ertzberger, 2013). Technology advancements can make situated contexts a reality.

Traditional schools have made efforts to integrate technology into classrooms, but there exist several barriers preventing success of such efforts. Hesitant teachers who are underprepared to use and instruct with the latest technology and students who do not perceive or have enough experience using technology in realistic settings hinder the progress of schools in meeting these demands. Unfortunately, for the most part computers have not successfully integrated into the mainstream of instructional practice in today's classrooms, even though they have become ubiquitous in just about every other aspect of life (Horn & Staker, 2015). The "unique affordances" (Cochrane, Antonczak, Keegan, & Narayan, 2014, p. 3) of the latest technologies are underutilized in the areas where they are needed most: teaching strategies, and assessment of learning. Instead, educators only feel comfortable with replacing old technology with new and this does little to improve learning options for students.

Today, educators have an opportunity to improve instructional practice and enhance assessment of students by taking advantage of the capabilities of smartphones and tablets and the strong affinity that teenage students have for them, (Nielsen & Webb, 2011). Wise educational leaders have foresight and understand that ignoring the prevalence of new technologies or standing around wringing their hands in despair over the frustrations such technology may bring is not good educational practice. Because technology in the lives of students is not going away, and the economic partners who rely on highly educated, tech-savvy students to work for them, it is most sensible to turn distractions into opportunities to teach (Nielsen & Webb, 2011). However, as much as technology is a part of life today, it is important to remember to not allow it to overshadow beneficial pedagogy. Using one's personal technology does not ensure high quality learning.

The establishment of any kind of technology-use strategy in a school or classroom should be predicated on its effectiveness and value to students and teachers. It is promising to some forward-thinking teachers that using technology to enhance instructional methods could provide better tools for students. Opportunities to conduct their own research with access to the most recent information, form connections with others via technology, and share it relatively easily and quickly (McCaffrey, 2011) are just a few ways already being tried in classrooms now and these tasks sound very much like real-life, work-related tasks. What is often most attractive to many educators and students is that using personal technology devices as educational tools open up many opportunities for students to learn in a more individualized, customized way, creating an environment that is centered on students, not teachers (Christensen, Horn, & Johnson, 2011).

Using such devices for research purposes shows a positive effect on students' critical thinking skills (Rambitan, 2015), but there is a need for more study in a variety of different learning environments. Several investigations have looked at mobile learning from different perspectives, and all of them are ultimately concerned with its effectiveness, regardless of the context. To understand this, various studies have sought to show support for the efficacy of using mobile devices and others to demonstrate that they are not worth the effort. Most researchers agree that students, both college and secondary-level especially, are prepared to apply mobile technology into their learning (Rahamat, Shah, Din, Aziz, 2011).

A Technologically Prepared Workforce

According to Kompen, et al., technology is growing exponentially (2009) and so is the amount of knowledge that accompanies it. Estimates in 2009 showed that computer technology power doubles every 18 months and the type of knowledge that workers need to accompany such rapid growth is changing with it. Many types of work have "changed from hands-on to inferential, or from concrete to abstract" (Collins & Halverson, 2009, p. 5) because the tasks required rely on the capabilities of the computer and require a different skill set in the worker. Skills that require the ability to find information, evaluate and analyze it, and communicate it digitally are those that employers need workers to already possess when they hire them. Mobile devices, used regularly for communication inside and outside of traditional classrooms, help prepare students for the "STEM focused global economy" (Cristol & Gimbert, 2014, p. 24).

In 2011, a survey of just over 3000 Seneca College students regarding smartphones and learning was conducted as part of a smartphone research study. Some of the findings reinforce the notion of a strong bond between young people and their phones. Many of today's college students personify their phones, referring to them as "my backup twin," "sidekick," and "close companion" (Lopes, 2011). Interestingly, approximately 80% of those surveyed believe that if their learning information was available to use on their phones, it would help their learning, but 70% have not taken the initiative to use any educational applications on their own (Lopes, 2011). This data reveals that today's college students, as well as future ones, are primed for a greater involvement of smartphone and other mobile technology with instructional practice. This is crucial for preparing them to be technologically prepared for the workforce.

As an educational tool inside and outside the classroom, proponents of mobile devices cite the great need for students to learn the skills of "shared productivity" while using them (Castek and Beach, 2013, p. 555). This refers to the growing demand for 21st century workers to be able to function in teams in a collaborative environment and be able to share information with others, especially in electronic formats. Increasingly more employers indicate that they are looking for several skills related to technology use and communication in new employees. Among these are to "use technology as a tool to research, organize, evaluate, and communicate information" (Nielsen & Webb, 2011, p. 6) as well as "utilize multiple media and technologies and know how to judge their effectiveness a priori as well as assess their impact" (Nielsen & Webb, 2011, p. 7).

What employers look for today in college graduates they hire are those who can work in teams, but also people who are creative and independent enough to work alone when necessary (Cochrane et al, 2014). This capability in a young employee requires a great amount of preparation as a K-12 and post-secondary student in both collaborative settings as a contributing team member and individual. Students need experiences with critical-thinking tasks that require independent and reflective thought. A goal for schools then as they prepare students for the workplace is to provide opportunities for more project-based learning structures in which students can acquire a set of overall workplace skills so they can integrate technology with any subject matter just as they would on the job (Johnson et al., 2015).

In a noteworthy study that makes an intriguing contribution to this body of research, investigators wanted to find out about how students perceive learning math in a different format: conducting real-life, authentic collaborative activities outdoors using mobile phones as data collection tools, just like a team of professional mathematicians might do. Overall, the findings revealed that students liked the activities for several reasons, including the uniqueness of them, the way they were allowed to interact with others, and the application of math in a real-life setting. In the students' survey results, the comments of some of the students reveal the authenticity of this type of instructional activity. The learning that resulted from it included important skills and aptitudes such as collaboration, division of labor, conducting a meaningful discussion, patience and determination to find the right answers, being a part of a group, and leadership (Baya'a & Daher, 2009). The workplace skills these students learned from this experience were facilitated using mobile devices.

If schools are preparing students to be tomorrow's workforce, it is sensible to incorporate into instruction the use of the latest technological devices, as well as provide instruction on how to proficiently use various applications on them (Castek & Beach, 2013). One issue that arises at this point include the capabilities of today's teachers to adequately instruct students about the latest technology. Many do not feel comfortable learning it, let alone teaching it to students who they feel are already more proficient than they are (Wiedmer, 2015). Many are in agreement however, that excluding new technologies and discounting their potential to help students is unfair and foolish (Melhuish & Falloon, 2010) simply because teachers feel unprepared to meet the learning needs of new generations of students.

Bridging the Gap

E-learning, M-learning, and U-learning

The efforts of educators to integrate technology is not a new idea. Schools began integrating computers into schools years ago, but the ways they could be useful to help students learn was limited. With the advent of the Internet, or World Wide Web, and the progress made in hardware and software improvements over the last few decades, e-learning, or electronic learning, became more prevalent in educational systems during the mid-1990's (Kee & Samsudin, 2014). While e-learning opened the door for technology to become a useful classroom tool, it was often constrained to a fixed, desktop device and could only be accessed during a certain time and space (Traxler, 2010), thus limiting the potential of its effectiveness in learning. The first purpose for online learning was to offer advanced level courses to individual students who went to small or rural schools who struggled to provide them for many valid reasons, including no one qualified to teach them (Horn & Staker, 2015).

The creation of smartphones and tablets paved the way for a new aspect of technologically-based learning that is known as m-learning, or mobile learning. Dependent on a handheld device that overcomes the limits of certain times and spaces for learning, (Pegrum, et al., 2013) m-learning allows whatever the student or classroom is engaged in to be more personal and more a part of their everyday lives (Kee & Samsudin, 2014). Using mobile technology allows users to share data and communicate in a more natural way that leads to quicker results and more flexible interactions and efficient outcomes (Yahya, Ahmad, & Jalil, 2010). Besides the study referenced earlier that described using mobile devices to teach mathematics, other studies attempt to explain how such technology can be used in other subjects like science (Rambitan, 2015, Castek & Beach, 2013), college-level math (Fister & McCarthy, 2008), and elementary-level literacy (Gallagher, et al., 2015) as well as assisting English language learners, as one study from Malaysia reveals (Rahamat et al., 2011).

Many of these studies indicate that students can learn using tablet PCs and they generally like it, but most of them do not focus on the specific functionalities that devices allow such as in the mathematics study. The main emphasis in using technology is on tablets as teacher demonstration tools or a way for students to share information. However, one study conducted with high school physics students, focused on using specific apps related to the subject being taught. In this investigation, students not only learned about projectile motion and collisions, the apps allowed them to collect accurate data to analyze. The results show that instructional activities using such applications have a moderately positive impact on learning physics concepts (June-Yi, Hsin-Kai, Sung-Pei, Fu-Kwun, & Ying-Shao, 2015). This research suggests the need for more intentional application development in specific content areas if using tablets and other devices are to be useful tools for teachers and students, especially at higher levels. The more relevant the app to the class, the more reasonable it sounds that students will engage more intently in the lesson.

The latest form of instructional technology is known as ubiquitous learning, or u-learning. It goes beyond the capabilities of mobile learning and considers the context of the learner. One definition of u-learning is “a learning paradigm which takes place in a ubiquitous computing environment that enables learning the right thing at the right place and time in the right way” (Yahya, 2010, Proposed definition of u-learning section, para 1). Characterized by many of the same qualities as m-learning like accessibility and immediacy, it adds the context-awareness aspect. With u-learning, there exists a capability for devices within the surrounding environment of the learner to communicate with one another, which allows the learners to be connected to their learning environment. The aspect of u-learning that is of most interest to educators is that learning styles can be more easily accommodated and information that the computer senses that the student might need is sent to their device. (Yahya et al., 2010). The learning that a student can accomplish within a ubiquitous environment is much dependent on the likes, dislikes, and motivation level of the individual student (Kee & Samsudin, 2014).

While there are many perceived benefits to all learning methods using technology in a mobile or ubiquitous format, barriers also exist. As will be discussed later, technology glitches and various distractions related to social media sites are issues to consider. Various studies indicate that when teachers seek to employ m-learning activities and encourage students to use their cell phones and other devices, too many students will choose to use them for other activities when they are supposed to be engaged in an online-enhanced lesson. (Berry & Westfall, 2015).

The novelty and learning curve experienced by teachers attempting to integrate more technology into their instruction might affect the behavior of students, especially if teacher expectations are not clear and enforced. The perceptions that today's students have about their devices typically does not include a view that they can be important assets to their learning. The majority of students believe their devices are solely for personal or social use, not educational use. Berry and Westfall also report in their study that approximately 20% of the students who participated self-reported that they "do not typically check their phone while class is in session" (2015, p. 65). This means that 80% of students are distracted at least one time per class by their phone. Almost one-quarter of those surveyed reported that they check their phones 3-4 times per class period. A change in mindset of students about their own personal technology is needed to overcome this barrier.

Beyond the distractions that can result during class, there is some evidence to suggest that multi-tasking with a cell phone while participating in class can have a negative impact on academic performance. Berry and Westfall collected results that reveal that "students who check their cell phones between seven and eight times per class have a GPA of about a quarter of a point lower than those who report never checking" (2015, p. 66). This negative consequence is certainly one to be considered, especially when planning for the use of cell phones as a learning tool. Since the existence of a cell phone in the hands of students might be a distraction in and of themselves, it is not enough for teachers to permit students to use them as they wish. Student use must be monitored and regulated correctly and effectively by the teacher to help minimize the distractions. This might also require strict consequences for failure of students to cooperate with classroom expectations (Berry & Westfall, 2015).

Blended Learning

Perhaps a more combined approach is better, at least as a starting point for personal technology integration into instruction. Much more literature is emerging about a phenomenon that mixes many traditional school components with an online learning model known as blended learning. This type of "hybrid learning" (Johnson, Adams Becker, Estrada, & Freeman, 2015, p. 16) is gaining popularity and the research to support it is growing. Some of the benefits of this model include credit opportunities outside of the existing curriculum of the school, mainly advanced level courses, and personalized instruction that enables students to progress at a customized pace, but there are many more. One of those additional benefits is teachers can maintain some level of authority and control over how the devices are used, especially if students use them during class. In most blended models, students come to a school building for some class time to receive the face-to-face help they might need from a teacher and live collaboration opportunities with their peers, while at the same time work from home or other site with a technology device at their own pace on individualized lessons (Horn & Staker, 2015). Not all blended learning models are alike and the customization they allow is what makes them attractive. This is especially true for school leaders and classroom teachers who want to break away from the traditional classroom model that is not always effective for millennials and Generation Z students.

Blended learning allows students to come to school to get specialized help in weak content areas, but also work in certain subjects at their own pace using technology. When properly planned and implemented, this learning structure allows students to achieve mastery at their own pace in a more engaged way, and gives teachers freedom to work with smaller groups of students who need the help. Blended learning models are becoming more common in schools in the most advanced countries and could begin having a major influence within the next two years (Johnson et al., 2015). The personalization aspect of blended learning, along with the mastery requirements at the student's own individualized pace, paves the way for competency-based models that further change the way teachers teach and students learn (Johnson et al., 2015).

A variety of different models of blended learning can be created in a school to meet the needs of that school or class of students. One that has shown to provide promising results is the rotation model, where groups of students receive the content in three or four different ways by visiting different stations. Such stations provide students with individual, small-group, and teacher-led instruction using e-books and software on a technology device and the internet (Horn & Staker, 2015). The Alliance College-Ready Public Schools' network of charter schools is one example that has shown results in student achievement and engagement (Art Simon Productions, 2011). Proponents of blending learning models value them for the integrated learning experience along with the added flexibility for students and parents.

Another approach to blended learning in classrooms is the 1:1 approach in which the school provides the same device, either a laptop computer or tablet, to each student for use in and out of the classroom. Despite the financial investment taken on by the school and need for consistent and dependable maintenance on the devices, there are multiple advantages to this model. Students can do some of their work outside of class whenever it is convenient for them and they can communicate with the teacher and other students more readily after school hours. Some research suggests that in higher education settings, the provision of a mobile device increases student engagement with technology as well as enhances the learning experience of students and teachers (Thomson, 2015).

Seamless Learning Spaces

However their learning environment is structured, the majority of students spend more of their time outside of school in informal settings than they do inside a formal school building (Looi et al., 2010). Mobile devices like smartphones and tablets, as well as laptop computers, provide a means for student learning to be more flexible and extend from one environment to the other in a seamless fashion (Pegrum et al., 2013). Learning occurs in many different formats and environments. "Technology-enhanced learning" (Looi et al., 2010, p. 155), allows for learning to be seamless across all different formats in which students find themselves. "Learning takes place through individual learning in private learning spaces, collaborative learning in public learning spaces, and cognitive artifacts created across time and physical or virtual spaces mediated by technology within a context" (Looi et al., 2010, p. 159). Another way to describe seamless learning is to think of learning spaces as hybrid, dynamic, or "always-on" (Trentin, 2015, p. 378).

The idea of a seamless learning space is often easier said than done in an environment that is still learning how to achieve it. Ways are needed to integrate mobile devices into an "ecology of learning" (Pegrum et al., 2013, p. 73) to make the shift to a collaborative model centered more on students and less on teachers (Pegrum et al., 2013). If the learning environment, or ecology of the learning space, can evolve to accept handheld devices as tools, while features, price, and performance of devices improve, students can be incentivized to take more responsibility for their own learning (McCaffrey, 2011). Again, as stated previously, for personal technology devices to be effective instructional tools in a seamless ecology of learning, the overall mindset of students about the capacity of their devices in a range of settings has to evolve with the integration.

A plethora of ways exist in which students can connect their formal and informal learning experiences using their phone or tablet. Not only can they create digital products with their devices, they can modify them, share them with others, and have the potential to collaborate on big projects that were not before possible. This is similar to what they already do in a social context using Instagram or other social media apps. By using the technology that they are already proficient in, learning processes can take place at a cognitive level. In addition, learning can be more easily assessed using technology to determine if students can transfer what they learn to multiple contexts (Looi et al., 2010).

To make fundamental shifts in meeting the learning needs of students using technology, many researchers believe that more pervasive use of one-to-one devices in some classrooms is essential. With school budget limitations, it is impossible for some school districts to provide a digital device to every student. To truly bridge the gap between students' love for using devices and making them a positive aspect of the learning environment, it is expedient in some situations to allow students to bring their own devices to class and use them. Bring Your Own Device policies contribute to students' abilities to continue learning as their physical environment changes, from formal to informal learning spaces (Pegrum et al., 2013).

BYOD (Bring Your Own Device)

The concept known as "Bring Your Own Device" is a relatively new one in K-12 educational settings, but is gaining momentum to integrate more technology into instruction. Bring Your Own Device is not exclusive to school settings, but other organizations allow employees to use them to complete their work (Vasant, 2015). Schools with an established BYOD policy encourage students to bring and use their own personal devices (smartphones, tablets, and laptops) to classes school-wide (Pegrum et al., 2013). Several factors need to be considered in establishing such a policy and the specific details of them are dependent on each school's unique qualities. Just as some school districts provide district-owned laptops or tablets to students to create a one-to-one learning environment and allow them to use them at school and home, and other schools provide access to classroom sets of devices to be used in the school only, districts that opt for a BYOD policy have to be thoughtful and intentional in developing it in order for it to be effective.

BYOD is much more complex than just encouraging students to bring their personal devices and letting them use them in class. In fact, if that is what is done, the genuine intent of integrating technology into instruction is completely lost. For instructional technology to be effective, it must be incorporated deliberately; the concept of "agency" must come into play. A student's role or relevance in this particular context is very important. In the traditional classroom setting, the teacher has the most agency, but in the ideal BYOD classroom, they share it with students, who have "a suitable skill set for making optimum use of digital tools, thinking critically and processing and applying the information to create new knowledge" (Parsons & Adhikari, 2016, p. 71). In addition to learning in the classroom, a long-term goal of BYOD is that "the more students use their own device for learning, the more they will potentially use it for their learning outside of the classroom" (Vasant, 2015, p. 65) thus increasing student agency and accountability in their own learning.

Benefits and limitations exist for any type of technology policy, but BYOD is an option that might be worth considering. Some schools are hesitant to adopt a BYOD policy because it requires a great deal of regulation and supervision and much of this responsibility is delegated to teachers, many of whom are hesitant in using mobile devices in the first place (Lam & Tong, 2012). The physical space of classrooms is an important consideration as well because they need to be redesigned in a way that makes seating and access to power more comfortable for the students and teachers (Vasant, 2015). Planning is an important part of any new instructional model and these issues are certainly worth considering.

While there is a great deal to consider in setting BYOD policies, there are many affordances for the education of students that should be equally considered. For several of the reasons already described previously, mobile devices in the hands of students provide them access and opportunity to a much larger range of learning experiences. They can use them in the classroom or at home. They can collaborate with classmates via the device or communicate with people all over the world to acquire information that they never would have otherwise (Melhuish & Falloon, 2010), and they can learn specific content in real-world settings (June-Yi et al., 2015). BYOD is a way to make “digital tools available as an integral part of education rather than just episodic interaction in a computer lab” (Parsons & Adhikari, 2016, p. 66).

Researchers are beginning to learn information about the perceptions of teachers, students, and parents regarding student technology use in classrooms. In a two-year-long 2016 New Zealand study, results indicate mixed results in attitudes in all stakeholder groups. Some teachers embrace the new innovative way to teach, while others are frustrated with the changes that accompany it (Parsons & Adhikari, 2016). One interesting finding in this particular study is that teachers report that even if students who are supposedly “digital natives” are given more agency, they still struggle with the autonomy and need support from the teacher using the device as a learning tool. Whether this is due to the novelty of students’ having more freedom to create their own learning and it is a struggle for them, or that they are not as technologically proficient as teachers expect, it is something to consider in the context of technology integration (Parsons & Adhikari, 2016).

The findings of this study also suggest a classroom "culture in transition," (Parsons & Adhikari, 2016, p. 75) meaning that students, as well as teachers, are slowly adjusting the way they perceive how classroom instruction is most effective and comfortable. While today's students are strongly attached to their devices, most of them have early school experiences without them. Integrating technology into how students participate in their learning can cause anxiety for them too, not just the teachers. As the technology culture slowly evolves to be more accepting of personal devices and educators learn new ways to use them to align teaching to student learning styles with the technology, the apprehension for teachers, students, and parents will hopefully decrease (Parsons & Adhikari, 2016).

In terms of academic achievement of students and BYOD in K-12 schools specifically, one study compared standardized assessment score data of 8th and 10th grade students in varied classroom environments. The results showed that students whose teachers who by choice consistently employed mobile learning devices had positive test scores in almost all areas tested, even within subgroups (Cristol & Gimbert, 2014). The size of the student population was a limitation however, and it was difficult to control for technology use in different classrooms. Even so, it contributes some support to the supposition that device use is positively related to student growth. The results also lead to the question regarding empowerment of students as agents in their own learning (Parsons & Adkihari, 2016). How much do the students themselves direct their own learning when they are using their personal device as opposed to how much the teacher directs them?

Lastly, in consideration of BYOD policies and their effectiveness, it is important to think about student perceptions amid all the methodology and assessment discussions. Several studies have indicated success or failure in the achievement of students while using all forms of technology over the years, as referenced in this review, but little has been done to understand how students perceive their own devices as learning tools. It is well established that teens have an uncanny attachment to technology in social and even solitary situations, but whether it is possible that students can learn to see their devices as a beneficial tool for both formal and informal learning is intriguing and worthy of study. To help understand this further, it is important to consider the benefits and drawbacks of BYOD policies.

Major benefits

Motivation.

With all the interest and excitement about the integration of technology into instruction, specifically personal handheld technology, it is important to consider whether using their own devices as a learning tool would motivate students through their educational experience. An April 2015 survey of smartphone owners of all ages revealed some important considerations about how people rely on their phones. Of the American adults surveyed who own a smartphone, 7% are completely dependent on them for Internet access and when this is broken down into young adults, the percentage increases to 15% (Anderson, 2015). The same trends apply to those in lower-income brackets and minorities. In addition, this same survey indicates that most adults use their phones for text messaging, talking, and emailing. 75% of these reported using them for social media (Anderson, 2015). While a few report using their devices for acquiring news from time to time and to do personal research, very little is known about whether even adults can perceive their phones as anything other than a social tool or convenience item.

In today's world, education cannot possibly disregard or discount technology as significant because as it develops, learning and communication also change (Rambitan, 2015).

The findings of one study about the usefulness of text messaging as an instructional tool indicate that text messaging can be viewed as an asset to learning because it can alter perceptions of students about their learning environment and improve their motivation (Swartzwelder, 2014). What is interesting about this same study is that they found no statistical differences in pre and post grades of classes that used text messaging compared to those classes that did not, only differences in engagement and interaction. This result begs the question: Is the motivational incentive caused by the presence of a device a good enough reason to incorporate them or should achievement results also be a necessary outcome?

Engagement and Collaboration.

According to some writers, students and teachers alike report that when teaching is conducted in a way that appeals to the learner, it produces better results (Rocca, 2009). One study about student opinions about using phones in class indicate that the more they are used, the more students become involved in the class (Tessier, 2013). This is often the key to improved interactions between students and teachers and overall engagement in the learning process. Focus and commitment are certainly important to learn and using mobile devices encourages more independent, exploratory learning. Students are required to be active participants. Instead of the teacher feeding the information to them, it puts the work of learning on the shoulders of the learner and improves engagement. This increases the accountability for the students in their own success, which is a necessity when they someday enter the world of work (McCaffrey, 2011).

The issue of content delivery is one at the heart of any alternative style of teaching, whether technology is embedded in it or not. For students to be engaged in their own learning and take a strong interest in something they want to learn about, they must be inspired in some way. Creative pedagogies that include technology seek to involve students in the learning design and stimulate imagination and inventiveness, which are 21st century skills that today's human resource directors are looking for in potential employees in all kinds of organizations. Technologies that intend to support new methods of instruction cannot be just replacements for old practices; they must provide innovative and novel ways to instruct, assess, and provide meaningful feedback. The ultimate goal in this scenario is for students to become so inspired that they begin deciding what they want to learn, a term referred to as heutagogy (Cochrane et al, 2014). Research in this subject indicates that the current timeline of technology development in terms of Internet connectivity capabilities and the advancement of devices makes the potential for such learning opportunities very possible, especially in higher education (Cochrane et al, 2014).

Most of the jobs today's students need preparation for require interactions with others (Sawmiller, 2010). The ability to take ownership of their own situations and work successfully on a team improves their likelihood of success, regardless of the profession. Students who can work well in collaborative teams in the classroom setting and use technology to analyze and share information, are at an advantage when they someday must work on a team in a work setting. Technology proficiency in natural contexts as a student does more to ensure a smoother and more efficient communication style later. A great example of a school that uses technology to promote engagement and collaboration is Summit Public Schools (Horn & Staker, 2015). Built into their daily schedule are personalized time and project time in which students spend blocks of the day working through learning tasks individually on a computer and other blocks working with other students and a teacher on a project for skill building. This blended learning model has not only increased student achievement and placed Summit ahead of its peers on state assessments, but it provides students' opportunities to apply real-life skills in a collaborative setting in a more authentic environment (Horn & Staker, 2015).

Enhanced Formative Assessment.

One of the problems with universal schooling is that the feedback teachers can provide to students about their learning is not as productive or valuable as it is when learning is one-to-one. In the earlier apprenticeship learning environments of decades ago when a student learned directly from an expert in a particular trade, learning was personalized and focused. Conversely, teachers today with large groups of students have not had the means nor the time to give each individual student the attention and meaningful feedback about progress that each one is making. Often the feedback given is sparse and not timely to make a difference in a child's performance. Interactive learning technologies in which students and teachers employ smart devices can help provide immediate feedback to students in amazing ways. Teachers and students send each other questions and answers electronically in a way that informs both the teacher and student whether the students' responses are correct. Students can not only see their mistakes immediately and correct misconceptions, they can sometimes see other students' mistakes, learn from them, and can avoid them later (Kennedy & Robson, 2015).

Familiarity and Cost-Effectiveness.

In addition to the engagement that student devices add to the learning environment, students are already familiar with their own devices and little, if any, instruction about using the device might be necessary. They are usually knowledgeable about how to use their smartphone or tablet and they know what applications are on them. Students use this device at home or on-the-go and it has become natural and comfortable to them. This familiarity "fosters an important link between formal and informal learning" (Skillen, 2013). This link is key to teaching students that their personal device can be a valuable tool to help them learn in all contexts of life: at home, at school and even in social settings.

As schools struggle to find funding to pay for one-to-one device initiatives, Bring Your Own Device policies eliminate the need for schools to pay for large numbers of computers and other devices. Besides the cost of machines that are difficult to keep current, often it is problematic for schools to stay current on systems and software. The time it takes for school districts to connect and supply schools with adequate devices and the supplementary parts they need, they are nearly out-of-date (Skillen, 2013). Student-owned smartphones and tablets are usually newer than the devices of schools and students know how to update the software and applications. Universities and school districts rarely have the most current and popular technologies as compared to what students possess on their own personal devices (Trentin, 2015). BYOD is relatively easy to implement and requires little on-site training for students. For these reasons, it is cost-effective and less demanding on school budgets.

Another advantage is that many of the phone and tablet applications, even the learning apps, are free or relatively inexpensive. A plethora of skills can be taught and learned, including collaboration, using some very effective applications. Students have some degree of choice about the apps they use for particular learning tasks and this eliminates the glitches that frequently happen when they are required to use the school's version of a software application. BYOD settings encourage learning in all different contexts with a large degree of freedom to give individual students opportunities to show competency in unique ways (Skillen, 2013), thus supporting a more student-centered environment.

Context-Specific Competencies.

Besides the universal collaborative skills that all employers expect their workers to possess upon being hired, content specific competencies exist that can be gained through using technology if students are given the opportunity to work in realistic, natural settings. Technological advances can now provide teachers ways to teach writing as well as problem-solving skills in different ways, plus providing students with instant feedback. Graphics, models, and even original creations can be used and manipulated by students to aid in understanding phenomena just as they would in a real-life workplace context (Looi et al., 2010). One example of this is to teach students through blogging. Blogs require students to be competent with technology, but also be able to express their ideas through writing, and share their work with others (Sawmiller, 2010).

The ability to experience accurate scenarios that they might experience as a professional on the job is a tremendous motivator for students and great way to increase overall satisfaction with learning experiences (Lam & Tong, 2012). "Students no longer need to engage with information and discussion at the expense of real life, but can do so as part of real life as they move about the world" (Traxler, 2010, p. 3). These sharing opportunities create value in others' points-of-view (Castek & Beach, 2013) thus instilling a respect for diversity that students are sure to encounter in their future careers.

The results of one interesting study illustrates the idea of context specificity involving student use of mobile technology in an art class, as well as the influence of mobile device use. The researchers of this study wanted to learn whether students who learned the content of the class through a "here and now mobile learning" (Martin & Ertzberger, 2013, p. 77) showed more retention of the information than those who learned in the traditional classroom setting. This is appealing because many experts believe that art, like some other subjects, is best learned in real contexts, whether students are learning-by-doing or visiting a venue with authentic experiences, such as an art museum. In this study, different groups of students were presented a series of paintings and the history behind them using a different form of technology and given a pre-test, post-test and attitude survey. Some groups read about the art on a computer after they viewed it in another room and other groups used devices that allowed them to read it simultaneously as they viewed it.

Mobile devices, in this particular study, gave the teacher the option of assigning the learning task to students outside of the traditional classroom. Students experienced the learning anytime and anywhere, in more informal settings like the museum, which is the premise behind this idea of here-and-now mobile learning. The results provide some interesting considerations. Students who used the computer in the classroom scored higher on the post-test than the students who used the mobile devices as they viewed the paintings, which is not what the researchers expected. The mobile device users, who used iPads and iPods, reported they were excited about the learning task and liked using the devices; however, the researchers concluded that they were more distracted by the device than the simple computer users. In addition to distraction, the iPad/iPod users were processing information both visually and verbally at the same time, which many experts believe decreases retention abilities (Martin & Ertzberger, 2013). While students enjoyed the task, the consideration that remains is when and where technology is most appropriate and effective. Certainly there are benefits, but drawbacks also exist.

Major Drawbacks

Like the literature that contains applicable information about the benefits of mobile learning and other associated technology integration efforts, there remain other researchers concerned with the drawbacks of it. These are worthy of attention to make the best decisions for student success, regardless of the level of technological investment. This will help to ensure a seamless transition from a traditional low-tech environment to a tech-embedded climate.

Technical Issues and Standardization.

If school districts and other educational institutions are committed to technology integration, they must be willing to make the investments necessary to ensure that hardware and software remain current and usable, the networks are maintained, and there is a competent IT staff available for support (Pegrum et al., 2013). Ignoring issues such as these have not only exacerbated the resistance that teachers and even students have in using technology on a day-to-day basis, but do not live up to the commitment required to make technology tools successful. Some technical issues can be avoided by employing a BYOD policy because the school does not maintain personal devices of students, but it is important for the networks provided for students and teachers can support the activities that they participate in while using them.

Along with maintaining the network, some qualitative study evidence suggests that teachers are more likely to embrace and actively use specific software and other instructional technology if they have a part in selecting it. Like many other things in school districts, the paperwork and long wait times that result when purchasing anything with school money prevents things from happening in a timely manner. Procurement and waiting for installation by the only approved person to install software programs is cumbersome and deters teachers from pursuing it. A sense of ownership and responsibility accompanies the investment process when teachers are enabled to control their own practice. School leaders are wise to give their teachers more freedom to make decisions about technology if they truly want them to use it (Yu, 2013).

In terms of standardization, in a perfect situation, every student would have an adequate device with plenty of battery life, memory, and data to use whenever they need it. Unfortunately, there are variables that cannot be controlled by teachers and even students related to the performance of their devices because of financial issues and even lack of responsibility on the part of students in caring for their devices and keeping them functional. As the classroom cultures change in terms of what students are expected to do with their devices, perhaps they and their parents will make more conscious efforts to provide adequate technology for consistent, purposeful use, and students will choose to take better care of their devices.

E-safety.

Along with a dedication to adequate resources, concerns about electronic safety and ethical considerations must be addressed as well. Certainly, if a BYOD policy is established, an acceptable use agreement needs to be in place to make sure the expectations of proper student use of the organization's network is communicated and understood even if students are using their own device (Traxler, 2010). A 2015 study of Belgian primary school children indicated that online risk awareness intervention efforts have an impact on students' behavior while online. Those who received access to instruction regarding the possible dangers of online activity showed less risky behavior even four months after the intervention (Schilder, Brusselaers, & Bogaerts, 2015). This study indicates that efforts to educate in early grades have the potential to mitigate online behavior issues that usually occur during adolescence.

It is critical that measures are in place to protect students from outside sources on the Internet that could be harmful to them. Not only should the highest levels of leadership show concern and awareness of this issue, but teachers should be cognizant of the maturity level of their students and make decisions about the type of use that is appropriate. Primary age might not be the best age to begin online activities, but as the Belgian study shows, education about how to use the Internet can begin in lower grades to prepare them for it later. Most of the time, even in higher grades, guided use with close monitoring is a good starting point (Lam & Tong, 2012) and after careful consideration in the proper context, restrictions can be lessened.

Appropriate Applications.

Finally, a drawback that exists that helped shape the purpose and thinking behind this research study is the "prevailing assumption that technology which works outside of school, will work just as well in school, and that it is up to educational practitioners and researchers to determine ways of achieving this" (Melhuish & Falloon, 2010, p. 2). The integration of technology into every learning environment without regard to context is a major concern of some researchers. Just as every student has a distinctiveness about them, including the ways in which they best learn, every classroom-student-teacher combination is also unique.

In considering how to properly integrate technology into today's learning environments, the question should always be asked as to whether it is appropriate at all. Assuming that just the mere presence of mobile devices or any other technology in a classroom will improve learning is naïve and tenuous (Melhuish & Falloon, 2010). Some researchers in cognitive theory propose that multitasking during class is something that inhibits learning by students. Their brains cannot handle large amounts of different cognitive demands at the same time, but in sequential order (Clayson & Haley, 2013). This aligns with the before-mentioned work of Mayer & Moreno regarding multimedia learning and leads to questions about whether cell phones and other devices are always appropriate in every classroom setting. Sometimes, knowing when not to employ technology and its associated applications is just as important as knowing when to apply them (Mishra, et al., 2009).

Digital Literacy.

As has already been described, learners in schools today are members of a generation that have experienced technology in every aspect of life. They are immune to the fast-paced world of computer technology and are unaware of how much of their everyday lives are influenced by it. They have always lived when computers and other devices are commonplace and a normal part of life. However, this does not necessarily mean that all students are digitally literate, or have the technological awareness required to engage in smart learning in a productive way. Today, more than ever, students need to "understand the fundamental concepts of technology operations, demonstrate the ability to choose, use, and troubleshoot current technologies" (International Society for Technology in Education [ISTE], 2017).

Each person's experience will dictate their level of competency so it cannot be assumed that all Millennials or Generation Z students will be tech-savvy and be able or even prefer to learn using a smartphone or tablet. Simply owning a smartphone does not mean a person can adequately and effectively use the device or make thorough use of the many capabilities they possess today. Using a device as a game player or even to communicate through social media does not ensure that a student can employ the creativity or critical thinking skills and other higher-level thinking that is often required to learn with it. Educators at all levels must adopt the mindset that students need to be able to "recognize the rights, responsibilities and opportunities of living, learning and working in an interconnected digital world" (ISTE, 2017). Gaming and social media alone do not provide opportunities to grow into capable and responsible digital citizens.

Along with lack of digital learning skills, many students do not possess the mindset required to work independently in a virtual or technologically enhanced setting. Without the right outlook, they can become frustrated and develop a negative view of smart learning. Part of being digitally literate is being able to use the technology device as a learning resource, especially when other support might not be readily available. An unwise assumption is that all students will initially embrace smart learning and want to learn using their device as a tool. To improve digital literacy and engagement with devices, students need skills in using them to gain confidence and positive attitudes about them (Webster, 2015).

A New Paradigm for Teachers

Challenges

Well-established by observation and the most current statistics, today's upcoming teenagers are members of a population with strong associations with technology, even to the frustration of those in earlier generations who remember a time without the prevalence of it in everyday life (Renfro, 2012). Many of today's seasoned teachers grew up during a time when mobile devices were not even invented, much less available. The introduction of the smartphone to the public was an event that everyone experienced almost simultaneously. Because of their sensational attributes and dynamic features, they not only attracted the traditional 13.5% of the general population known as "early adopters" (Sinek, 2009, p. 116) they were extremely appealing to the younger generations. Not only is Generation Z so technologically consumed because of the ubiquitous nature of various devices, they were the first to be mesmerized by them and learned how to use them at a rapid rate, leaving many adults lagging behind.

Just as a lack in knowledge about technology is a challenge for today's teachers, it is even more challenging to safely allow the presence of technology in today's environment to diffuse into traditional classrooms and simultaneously maintain "sound pedagogical foundations necessary for long-term retention and learning" (McAlister, 2009, p. 14). This requires teachers to not only learn how to use the technology themselves, but to include it in their teaching in a way that preserves the content and equips students with knowledge and skills unrelated to technology. Two different skills are necessary to use and effectively implement technology into instruction. Unfortunately, too frequently the only on-the-job training current teachers receive is the basic operational skills of the devices, not how to use them as teaching tools (Johnson et al., 2015). This is a tremendously important consideration because if teachers do not have the training nor the time to adequately plan to get comfortable with it, it is unlikely that any technology instruction will be effective, regardless of their efforts.

Acceptance of the latest educational technology is a difficult sell, especially to experienced educators. Even competent individuals who are unfamiliar with a classroom setting in which technology is embedded are unlikely to even touch it, much less embrace it. (Hammonds, Matherson, Wilson & Wright, 2013). Many teachers, both older and younger, feel ill-prepared by their preservice training to use and integrate technology (Johnson et al., 2015). What is important is for teachers to become at ease with using devices and learn to appreciate the value of them. If they see new technology as "one more thing required of them" (Hammonds et al., 2013, p. 36) true acceptance is hard to achieve.

Probably the most well-known and vocalized challenge that teachers experience with device use in class is the way students behave with them. It would be nice to have classroom environments in which every student meets all expectations every day, but that is far from realistic. Rules and expectations that teachers have for students have always been tried and tested and using personal devices during a class, especially for unrelated activities, is just another one to address. In one study at the college level, 85.1% of students and 84.2% of faculty reported that cell phones used by students during classes were distractions (Burns & Lohenry, 2010). Another study reports that as much as 75% of students use cell phones in class for social purposes (Gurrie & Johnson, 2011), but these were classes in which the teacher did not address expectations about technology use. The teacher expected students to refrain from use without establishing guidelines. Most researchers recommend that teachers, even at the university level, should have policies regarding cell phone etiquette, regardless of the level of use in instruction. They should communicate it clearly and enforce it for everyone (Burns & Lohenry, 2010).

Most researchers agree that what must happen is a change in thinking that some educators are fearful to accept and often resist. For classrooms to become preparatory sites for 21st century skill building, the change in mindset must start with the teacher. This is often difficult for many older educators, who were trained in a very different way. What is important for teachers and administrators to realize is that the skills they have taught in the past may be obsolete and new skills are required for tomorrow's workforce (Wiedmer, 2015). For Generation Z and those who follow them to be prepared with the skills they need, teachers have to learn to teach in a way that challenges students with learning opportunities that involve active learning, collaboration, and at times, the integration of technology.

Pedagogical Aspects

With the considerable potential of personal technology to modify current learning environments into spaces that support 21st century students, it is very important to implement them with a highly supportive instructional plan that fosters "real didactic innovation" (Trentin, 2015, p. 378) to enrich and improve the process of learning, not hinder it. Due to the skepticism that some educators have about the efficacy of uncertain and innovative integration, the significance of a methodologically sound, results-driven course of action is undeniably essential. Too often, the network and mobile technologies, or NMTs, are not truly used for teaching purposes, but as support services for teachers or students. Until NMTs have a specifically agreed-upon and approved purpose, with a more exact subtext to provide learning assistance for students in a way that teachers can understand, the acceptance of them in classrooms will continue to be contested (Trentin, 2015).

The opposition of traditional teachers, and even preservice teachers in university classrooms now to NMTs, is the result of poor integration of them into the educational aspect of life. Instructional technology researchers now seek to find out not only how to use technology effectively, but also why it should be used (Trentin, 2015). As has been stated previously, when smartphones and tablets started becoming more available to people of all ages, they became visible everywhere people assemble, which included schools. No one in schools predicted, or reasonably could have, the influence that these devices in the hands of students would have on the way they behave with them, and specifically, the way they learn or expect to learn. However, this is no excuse to ignore the issue school leaders currently face. Proper integration of technology, particularly personal technology, based on identified educational needs of students, thorough planning of meaningful activities based on those needs, and adequate training for teachers is key to a successful transition (Trentin, 2015).

How does such an integration happen? Since the early days of learning style inventories based on David Kolb's theory of experiential learning (McLeod, 2013) or Howard Gardner's Multiple Intelligences (Smith, 2002, 2008), tests have been administered to students for decades with the intent of gaining information about how they best learn so that instruction could be modified to meet their needs. Just as some students are visual learners, others auditory or kinesthetic learners, perhaps there is a need to seriously consider that many students today can best learn using their technology device. Lack of understanding on the part of adults does not negate or dismiss the possibility that “revolutionizing teaching/learning processes” (Trentin, 2015, p. 380) by using technology can make learning more personal, productive, and participatory.

All too often, sincere and admirable attempts have been made to introduce technology into teaching, but received a “patchy return of investment,” (Trentin, 2015, p. 381). This is because the steps for proper execution were taken in the reverse direction. The technology was presented without acceptance from the teachers who were expected to facilitate it, and they were not provided sufficient training. Thus, the technology that had great potential for helping students learn, did not get used and its benefits not realized (Trentin, 2015). To overcome this problem, Trentin suggests the “learning-by-doing pedagogy” (2015) first proposed by John Dewey in 1916, that describes how students understand best when they share control and responsibility in their learning. Using this theory as a basis, there is a need to teach students how to use their devices as learning instruments instead of entertainment systems, as discussed previously. To do this, students need authentic experiences with their own technology (Skillen, 2013) and teachers need professional development and resources (Trentin, 2015).

Preservice Teachers

With the prediction that approximately 1.6 million public school teachers are expected to retire within the next ten years (U.S. Department of Education), an important consideration is how those who will replace them are effectively trained. For teachers of the future to be able to meet the demands of an increasingly high-tech environment, they deserve to receive preservice training that adequately prepares them for this challenge. A 2013 study of preservice teachers’ perceptions about cell phones in the classroom has some interesting findings. Seventy-two percent of the participants were identified as digital natives because they ranged in age from 18 to 31 and the other 28% were older than 31 and considered to be digital immigrants. Immigrants are described as people who knew and experienced a time in life without digital devices, like many of today's current teachers. More than half (52.2%) of the preservice teachers surveyed indicated that they were not certain whether they supported using cell phones as an instructional tool. Only 25% of the responders reported that they supported using devices, with 22.8% against using them. While more digital immigrants indicated an opinion against using cell phones, still 18.2% of the non-supporters were digital natives (Thomas & O'Bannon, 2013).

Regardless of the reporting of the preservice teachers' attitudes about device use in class, what is more relevant is that "96% of the preservice teachers lacked instructional modeling of cell phone use in their K-12 and postsecondary education experiences" (Thomas & O'Bannon, 2013, p. 16). For future teachers to be prepared with appropriate technology skills to meet the needs of this generation of students and those that follow, they need instruction themselves as they train to become teachers. Skills in using the technology devices themselves alone is not sufficient. Preservice teachers need to learn to use the technology, but also simultaneously understand and appreciate the important place of technology as a pedagogical support to their instruction. This study implies that while digital natives might be keener in the use of technology, their perceptions differ little regarding the effectiveness of technology devices as instructional tools than that of those who are less adept (Thomas & O'Bannon, 2013).

A similar study of teachers attending a professional development conference focused on a "vision of learning for the future through the use of technology and hands-on experiences with experts for the purpose of learning effective methods for integrating technology" (Thomas, O'Bannon, & Bolton, 2013, p. 301). Predictable results in perceptions of this particular population were presented in this research. 70.5% of those surveyed supported use of cell phones in the classroom. However, most of their experience using it was personal, not instructional, and involved their own use in communicating with colleagues and parents through email or using the tools on the device, such as the calendar feature. Only 7.7% reported using them with students to assign learning tasks. The fact that many of them reported that their school technology policies prohibit student use of handheld devices is a good reason even this group, who typically have little resistance to new innovations, did not use it either (Thomas et al., 2013).

A Community of Practice

Teachers should not be expected to acquire these new skills on their own, but instead they need and deserve valuable support as they attempt to make great strides in modifying their learning environments for the benefit of their students. Learning the technology itself is not enough; they should be able to couple it with sound teaching at the same time (Mishra, 2009). This requires meaningful and personalized professional development opportunities that provide them with the positive self-efficacy that they need. Too often, professional development is vaguely generic and does not meet the needs that teachers see as an area in which they need improvement. Workshops and instructional opportunities for teachers should be targeted and contextualized. (Pegrum et al., 2013). They deserve time to experiment and try new ways of doing their work in their own classrooms, perhaps even with their students. This would provide a great example to students about the value of a growth mindset, especially if they observe their teacher failing at an attempt at technology but trying again over and over to learn it (Dweck, 2014).

The most valuable way to integrate technology into existing instructional environments is to encourage a “professional development community of practice” (Pegrum et al., 2013) that encourages teachers to be bold enough to try something new in their methods and involve students in solving any technology problems that arise. This encourages risk-taking, which is a necessary quality of a good leader, and reinforces the belief that it is okay to experience failure, make mistakes, and learn from them. Learning the skills necessary to see the best results takes time to learn and plan as well as time to realign thinking (Cochrane & Bateman, 2010). Training in knowing what technological strategies should be employed in the right setting is something that teachers need (Trentin, 2015) as well as how to use them properly. Proficiency at technology use themselves is the best way for teachers to promote proper etiquette and good practice, thus reducing the likelihood for improper use or distracting behavior (Lam & Tong, 2012).

At the same time, educators must remember that technology integration is not a fix-all for every student achievement issue. Applying technology using tried and true teaching methods will ensure improvement in student success (Sawmiller, 2010). What is necessary is to make certain that "an adequate pedagogical scheme" (Trentin, 2015, p. 378) dictates any blended learning or BYOD arrangement in schools. Simply encouraging technology use without proper guidance or facilitation does not promote personal devices as learning tools and requiring every teacher to integrate technology translates into "hoops" for them to jump through to meet a needless requirement (Thomson, 2015). Before a single smart device is even implemented as an instructional tool, it is important for teachers and school leaders to consider the need for it. The 4E Framework, whose basis in terms of smart technology is "to establish a rationale and ownership model where it is needed" (Thomson, 2015, p. 87), is a rationale that considers whether the devices enable, enhance, enrich, and empower students, teachers, and the overall learning experience in a positive way.

As it is important to make learning experiences realistic for students, it is also critical that teachers learn to accept the notion that investing time learning how to use the newest technology for teaching is worth it in improved efficiency in the short term and measured productivity in the long term (Mishra, Koehler, & Kereluik, 2009). Educational technology is moving in exciting new directions and a great approach that ensures efficiency and productivity is to partner the three components of pedagogy, content, and technology skill with an equal emphasis on each one. The TPACK framework, or Technological Pedagogical Content Knowledge framework addresses this partnership because it helps teachers determine what technology is best suited for their content and environment and helps them learn to apply it (Mishra, et al., 2009). Instead of telling teachers what to do and possibly undermining their individual strengths and professional competency, this framework focuses on teacher decision-making and discretion.

Such issues are difficult to consider because technology developments are ever-changing and in constant motion. Technological capabilities often change more rapidly than the ability to properly investigate whether they are working or not (Fisher & Cox, 2008). This is often a frustration that is difficult to manage because the speed of technology development is out of the control of those who rely on it. This is another great reason to view technology integration in instruction as a learning process for the teacher as well as the student. Trying one way and then trying something new until the desired outcome is achieved is the very definition of "practice."

Future Implications

"For the young, the fact that cell phones are powerful, inexpensive computers optimized for communication; full of useful add-ons such as texting, cameras, GPS, and Internet browsers… and most important, always in their pockets clearly makes them, when used effectively, a tremendous tool for learning (Nielsen & Webb, 2011, p. xi). The body of research surrounding this issue supports the need to embrace technology in the hands of students. This is not only important because they enjoy using them, but there is evidence that they can be useful in helping some students learn better and be more prepared adults ready for work. Authentic learning experiences are still too infrequent in schools today and such experiences provide vocational environments for students to develop lifelong skills that prepare them for future careers (Johnson et al., 2015).

Current statistics reveal that 65% of today's students will need skills for jobs that today do not exist (Renfro, 2012). This is a staggering thought after reviewing the technology issues that need to be considered in bridging the gap between what is currently taught and what needs to be taught. Every year, more educators are realizing that with changing technology in all sectors of society, what students need to learn is changing with it (Sawmiller, 2010). They also see that traditional methods might not be the best way to teach everything students need (Johnson et al., 2015). What is needed to overcome this challenge is to make efforts to provide students with more real-life contextualized learning activities and experiences, allowing them to become comfortable using their personal technology in both formal and informal learning environments (Looi et al., 2010). With teacher attitudes changing, the integration of cell phones into classrooms can provide more Internet access to students who are increasingly using them over computers, due to their lesser cost and increased functionality (Thomas et al., 2013). BYOD initiatives specifically seek to meet such challenges by broadening learning beyond the walls of the school (Parsons & Adhikari, 2016).

In this analysis, several research studies regarding the integration of mobile devices in instruction have been described. Some evidence suggests that mobile devices improve student achievement, although it is limited to certain learning settings and is unclear whether these results transfer to multiple contexts. What most educational technology experts agree on though is that the technologies alone are not what lead to improved outcomes. Trying new ways to use them to improve instructional practices makes the difference.

One of the aims of this study is to investigate different uses of technology and how it changes student perceptions. As school leaders continue to consider ways to take advantage of the benefits of mobile phones in the classroom and negate the barriers, what students think about it should be considered too. They, along with the teacher, will be intimately involved in using the technology to learn and what they think about it can have an impact on the success of its implementation. As students of today are very fond and closely attached to their devices, an important question is whether they can see them in any other way, especially in the context of learning. Thomas and Munoz revealed in their 2016 study that students report that they see some benefits to mobile phone use and most reported that they already use many basic features of their phones for classwork, such as the calculator and calendar. However, they also reported that they can see the distractions of phones to be a problem in the classroom. The task of teachers who are committed to this task, and a promising area of research, is to find the best ways to eliminate the distractions of personal technology while integrating it as instructional tool that helps students learn (Thomas & Munoz, 2016).

Interestingly, little research shows an in-depth understanding of whether the mindset of teenagers regarding their technology is aligned with using them as effective learning tools (Kee & Samsudin, 2014). Is it possible for teens to view their devices as apparatuses for learning? If so, do devices aid in promoting learning a specific subject? As it is important to consider if personal technology is effective in different classroom settings, what is additionally worthy of reflection is what can and should be done to prepare students to see them as helpful instructional tools instead of just toys for entertainment.

Chapter 3: Methodology

Research Design

Course Design and Content

For an eight-week biology unit on genetics, a Bring Your Own Device (BYOD) instructional method was implemented in two sections of a high school biology course, taught by the researcher. The general design of the study involved integrating the BYOD instructional method in two sections (the experimental group) and not integrating it in two other comparable sections (the control group). The content of this specific course was based on the ACT Quality Core Course Outline for biology as required by the Kentucky Department of Education (KDE) for Kentucky school districts to teach in biology courses. A credit in biology is a course requirement for all Mayfield High School graduates and in addition, each student enrolled in biology is required by KDE to take the ACT Quality Core End-of-Course Test in biology. The researcher has 17 years of classroom teaching experience, with 13 years as a high school biology teacher, qualifying her by state requirements to teach the course.

During the study, the Quality Core Biology curriculum was followed and taught to students by the teacher in all four classes. Any prior knowledge of the biology content that the students had was the result of what instruction they received in prior science classes, such as in middle school, or any outside learning they received from home or another source. The students had not already taken a science class in high school that included content from this unit, so much of the material was new to them. The intent of the design was that the only difference in the instruction given to the students in these classes was the presence or absence of the BYOD instructional method.

Instructional Technology in BYOD Classes

Students in the BYOD group were expected to access information using their devices, use websites as directed, and communicate with the teacher and each other as required by certain assignments. They received very few handouts and other paper-and-pencil tasks during the unit. Smartphones, iPads, and laptops were used to deliver content and send and receive communication with the teacher, whenever appropriate.

Specifically, the teacher engaged with the students through a variety of different technology applications. An online Google Classroom was created for each of the device group classes as a way for the students to receive assignments from the teacher, as well as messages and other questions from the teacher. The students were encouraged to communicate with the teacher and each other through Google Classroom as well, especially outside of class. Within Classroom, the teacher used other Google applications, such as Docs, Slides, and Forms. Each time an assignment was given, the instructions were written in a Google Doc and posted to Classroom for students to open, read, and save or print as they needed. The teacher created slideshows about the genetics content using Google Slides and posted each of these to the Classroom site as well. Students could access them to read ahead, follow along during class, or look at them later while studying.

The teacher especially favored using Google Forms, mainly due to the ease of using these for formative assessments. Very simply, the teacher could create a form of questions she wanted to assess from previous lessons before moving on through the content. Once created, the assessment could be scheduled to post to Classroom whenever she wanted the students to open it. Within the established deadline, students had to answer the questions, and submit them. The teacher received instant information about what students knew and she could send them feedback quickly to clear up misconceptions they had about the content.

Along with Google Slides, the teacher converted the Google slideshows to Nearpod, a website that allowed her to create interactive lectures, so students could directly follow along using their devices. Nearpod is a site that is very teacher-friendly and allows them to incorporate existing content into a new lecture. What is unique about this application is the interactivity of it allows students to directly connect their device with the lecture and increase their engagement in the lesson. Students can submit answers to quick polls or questions, they can write in short answer responses, and even provide drawings, as appropriate. The teacher discovered that in biology, the drawing feature was especially effective because it provided students who struggled with vocabulary to demonstrate what they knew about structures and functions. This helped the teacher know what vocabulary terms and concepts needed extra reinforcement.

After a certain amount of content was presented, the teacher directed students to supplemental resources, especially those in the CK-12 Foundation website. The resources found at this site include videos, practice quizzes, and current content-related articles for students to provide extra support to them about specific aspects of the content. The teacher tried to be selective about which activities she assigned because she wanted to make sure the activities were relevant and meaningful and worth the time required for students to interact with them. The teacher could monitor student progress on this site because she could create an online class within the site and provide students a username and password. The progress they made working through the assignments was recorded for the teacher to evaluate. Evidence from the teacher reports showed that most students took advantage of the supplemental resources from CK-12, however, the teacher cannot ascertain whether they actively engaged in the activities or just visited the site and scrolled over them. Students were also encouraged to use other support websites as needed, including Quizlet and Braingenie. Some students took advantage of these options when they finished their assignments early. Appendix A contains more specific information about how the teacher integrated technology applications with the genetics content.

Control and Experimental Groups

The four biology classes involved in the study contained 15 to 22 students in each of them. Two sections were classified as pre-Advanced Placement (AP) for students on the AP curriculum track in science, and two were classified as introductory for students on the traditional curriculum track. AP track students in the advanced classes were a blend of freshmen and juniors. Freshmen were placed in this track on the basis of high math test scores in the previous grade and those who remain successful in these courses continue the Advanced Placement science sequence of biology, chemistry, and physics as they continue high school. These freshmen made up about one third of the students in the two advanced sections. The other two-thirds were juniors who joined the AP track late and might possibly pursue Advanced Placement biology, chemistry, or physics as a senior upon completion of this course. Most of the traditional students were juniors who were completing their final science requirement for graduation, with no intention of taking another science course.

Control Group.

The researcher selected the classes intentionally, two advanced and two traditional, to participate in this study. Using one class of each level, either learning with or without a BYOD policy in place, was valuable because classes of students at the same level of achievement could be compared. One of each of the traditional and pre-AP sections served as the control group. Students in the control group received instruction as the teacher normally provided without a

BYOD instructional method in effect. This means that the mode of instruction might have had some technological support, but mainly in the form of technology used by the teacher to assist in presenting material on the Smartboard or showing videos to the class as a group. This use of technology was not considered part of a BYOD method in which students had continuous access to their phones or tablets. In the control group, students were expected to keep their phones on silent, hidden, or face down on top of their tables, as they did all year.

Experimental Group.

Likewise, one of the traditional sections and one of the pre-AP sections served as the experimental group. In this group, students received information about the newly instituted Bring Your Own Device (BYOD) instructional method in effect for the unit of study. Specific parameters of what type of use was acceptable and not acceptable was clearly explained and all students in these groups were required to have a Mayfield Independent School District Student User Agreement Form on file. Students were expected to use their devices as much as possible to complete assignments and other tasks, following the BYOD guidelines as instructed by the teacher.

Description of the Population

Participants and Sampling Procedures.

This study used a a convenience sample because the students were the researcher's own students currently enrolled in a biology class. However, specific sections taught by the researcher were intentionally selected based not only on the course level, but also on the demographics of each section and student-reported availability of personal technology devices to use in the study. Of the 79 eligible students in four classes selected to participate in the study, 24 of the students and their parents provided consent to use their test and survey scores in the data analysis and provided complete data, resulting in an overall 32% response rate. In terms of each group, the control group had 12 of 33 students consent and provide complete data, a 36% response rate, while the experimental group had 12 of 37 students consent and provide complete data, a 32% response rate. The characteristics of the potential participants in the control and experimental groups collectively are shown below in Table 1.

Table 1. Characteristics of Potential Participants Overall

Characteristic				
Grade	**9th**	**11th**		
	18	60		
Gender	**Male**	**Female**		
	42	37		
Race/Ethnicity	**White**	**Black**	**Hispanic**	**Two or more races**
	37	14	19	9
Free Lunch Status	**Full Pay**	**Free**		
	19	60		
Course Enrollment	**Traditional**	**pre-AP**		
	39	40		

Tables 2 and 3 show the characteristics of the students in the experimental group and control group respectively, who provided consent for their data to be analyzed in the study.

Table 2. Characteristics of Students in the Experimental Group

Characteristic				
Grade	**9th**	**11th**		
	4	8		
Gender	**Male**	**Female**		
	7	5		
Race/Ethnicity	**White**	**Black**	**Hispanic**	**Two or more races**
	9	2	1	0
Free Lunch Status	**Full Pay**	**Free**		
	5	7		
Course Enrollment	**Traditional**	**pre-AP**		
	4	8		

Table 3. Characteristics of Students in the Control Group

Characteristic				
Grade	**9th**	**11th**		
	2	10		
Gender	**Male**	**Female**		
	5	7		
Race/Ethnicity	**White**	**Black**	**Hispanic**	**Two or more races**
	5	5	2	0
Free Lunch Status	**Full Pay**	**Free**		
	2	10		
Course Enrollment	**Traditional**	**pre-AP**		
	4	8		

Participation, Confidentiality, and Anonymity.

Participation in the study was completely voluntary for all students in the selected classes. Students and their parents were asked for consent for their pre and post-test scores and pre and post-survey results to be considered in data analysis by completing a Parent Consent Form (Appendix B) and a Student Assent Form (Appendix C). Prior to consent, everyone was provided the guidelines of the BYOD instructional method and these were explained thoroughly. Included in the description was an invitation to opt-out at any time. Students and parents who provided consent initially could choose to revoke consent later. This was explained and included in the assent and consent documents provided to students and parents respectively.

To ensure anonymity, a neutral colleague conducted the explanation of the BYOD guidelines and study information to students in the absence of the researcher. Ms. Amy Forsee, School Technology Coordinator for Mayfield High School, completed confidentiality training as required by IRB instructions and assisted the researcher with consent documents and administration of testing instruments. During one class period prior to the start of the instructional unit, she distributed student assent and parent consent forms to students. She explained to students the protocol for completing the forms and returning them to her. By returning the assent and consent forms, students and parents agreed to allow the researcher to evaluate assessment data and survey results of that student as part of the study. Copies of these signed forms were kept in a locked file box in a secure location by Ms. Forsee for the duration of the data collection period. The researcher was unaware of which students had given consent and which had not until the data collection was completed and student grades were assigned and recorded in the school office.

After completion of data analysis and reporting of results began, all the students' names were removed from all documents, with the only identifiable information was which group they were in (experimental or control), gender, and other demographic information necessary for comparison. Likewise, all surveys were treated in the same manner to eliminate any identifying information. Students' grades were submitted to the office prior to the researcher knowing which students and parents had given consent.

Risk

A minimal amount of risk was involved in this investigation. Every student continued to receive instruction guided by ACT Quality Core Standards, regardless of method. Both groups were taught the same content, but in different formats, one with devices, and one without devices. The teacher had utilized these standards since the Kentucky Department of Education adopted them for the 2011-2012 school year when Kentucky high schools were required to abide by them, so she had a high level of knowledge of the content contained within the standards for the biology course. Because the teacher remained unaware of which students provided consent until after student grades were submitted to the administration, students did not have to fear that consent or lack of consent could influence their grade in the course.

The only anticipated risk associated with this study was that the quality of instruction associated with this specific instructional unit might be questionable. If the BYOD implementation failed to show positive impact on learning or even caused disruptions to learning, it could be argued that students in the experimental group did not receive the content in the unit of study as adequately as the control group. On the other hand, if the BYOD implementation was successful, it could be argued that the control group was denied the benefit of that advantage. Because this was a foreseeable potential consequence, the teacher decided to limit the time of this study to one unit, so any negative impacts would not be as substantial. However, if results showed that the BYOD methods indicated a positive impact on learning, the researcher reserved the option to possibly expand the methods to include students in the control group and other students in her classes not associated with the study.

Potential Limitations

Even though most students own a personal technology device of some kind, a few students did not have one for one reason or another. Students in the experimental group who did not possess their own device or had one but could not use it were provided a device owned by the school to use in class. While this was a drawback of the purpose of the study involving student-owned devices, it was important to the teacher for every student to have equal access to the instructional delivery. Even though the devices were not personally theirs, students could still get the experience of learning with a technology device.

Another potential limitation in this study was the possibility of inclement weather or excessive absenteeism due to illness during the instruction of the unit. Fortunately, the mild winter provided a smooth period of eight weeks without any school cancellations due to snow.

Uncontrollable absences of sick students occurred in a few of the classes, but these were unavoidable, regardless of any attempts to control for it.

Lastly, and probably the most significant limitation was the fact that the researcher was also the teacher of the classes. Another teacher's classroom would have been a preferable location to conduct a study like this, however the researcher's interest in this study was directly related to her experiences as a classroom teacher and it was important for her to gain the experience herself. As stated earlier, every effort was made to remove all bias and maintain confidentiality and ensure the integrity of content delivery as well as assignment of students' grades.

Research Hypotheses

After considering the literature regarding this issue and the intent of the study, the researcher developed the following hypotheses to test:

H1: A Bring Your Own Device instructional method in a high school biology class will have no effect on student achievement.

H2: A Bring Your Own Device instructional method will have no effect on attitudes regarding devices as learning tools in a high school biology class.

H3: A Bring Your Own Device instructional method will have no effect on student attitudes about biology in a high school class.

These hypotheses will be tested using content-related assessments and attitude surveys.

Description of Research Instrumentation

Pre- and Post-tests

The week before beginning the instructional unit, Ms. Forsee administered a paper and pencil pre-test (Appendix D) to students in both the control and experimental groups. At the end of the unit, she came and administered a paper and pencil post-test (Appendix E) to the students. The pre- and post-tests were developed by the researcher and measured knowledge of the ACT Quality Core content included in the unit. The source for questions on the pre- and post-tests came from the ACT Quality Core Test Bank. Specific questions were selected based on the ACT Quality Core Standards covered during the unit.

The questions on each test were not identical, but the items chosen were based on the same standards, at the same levels of difficulty as documented in the test bank. Specifically, the assessments consisted of 13 multiple-choice questions and two constructed response questions, comparable to the design of the ACT Quality Core End-of-Course Assessment given at the end of the school year. After the unit of study, all four classes that made up the control and experimental groups were given a post-test by Ms. Forsee to measure achievement for comparison to the pre-test scores.

Pre- and Post-surveys

In addition to the pre-test at the beginning of the unit, Ms. Forsee administered a pre-survey (Appendix F) to evaluate students' current attitudes about using their personal devices as learning tools, as well as their perceptions about biology. Questions included such topics as time they spend with technology, what kinds of activities they do with their phones/tablets, and overall perceptions about learning and technology. Also, Ms. Forsee gave students of all four classes a post-survey (Appendix F) at the completion of the unit to assess any changes in their attitudes about using personal devices as an instructional tool. These questions were nearly identical to the pre-survey questions, but appropriately written for the post-unit experience.

The researcher created both versions of the survey. She wanted to learn whether the presence of the devices during the 8-week unit changed students' perceptions from the original attitudes as reported on their pre-surveys. The intent was that this data would provide evidence about whether a BYOD learning strategy was instructionally supportive, but also the researcher wanted to learn whether employing student devices in a new and different context altered students' views about their technology. Specifically, the intent was whether students were capable of viewing their devices as useful to help them learn, not just forms of entertainment. In addition, the researcher wanted to know if using personal devices had any influence on student perceptions about the content of the course, such as if using devices in instructional practice changed their opinions in any way about biology.

Procedures for Data Analysis

Descriptive statistics were used to analyze the pre-test and post-test scores to look for normality in the data. This involved the analysis of means. Results of the comparison between pre-test and post-test mean scores and pre-survey and post-survey mean scores for students in the control and experimental groups were compared using a repeated-measures analysis of variance (ANOVA) test. The researcher was interested to learn whether time, or the difference between the pre-test scores and the post-test scores was significant in all groups and levels. She also wanted to know if there was a significant difference between the device group, who learned with the BYOD instructional method, and the no device group, who learned through traditional means. Lastly, the researcher examined the differences in student scores at different course levels by comparing the pre-AP and traditional level students.

In addition to test score mean comparisons, a repeated measures ANOVA was conducted on pre-survey and post-survey mean scores for all groups and levels. The researcher was interested to know if students at different course levels in particular made any significant changes in attitude or perceptions about their personal technology or biology as a result of using it to learn in class. Student surveys also contained opportunities for students to explain their responses to the questions and these responses were coded and analyzed for common themes.

Chapter 4: Results

Results

Test score and survey response analysis provided information about the effectiveness of the BYOD instructional method over the course of the eight-week genetics unit. Pre-test and post-test score data and pre-survey and post-survey score data were collected and analyzed to test the hypotheses stated in the methodology in chapter 3. The goals of testing these hypotheses were to determine if student knowledge of basic genetics content, as required by the high school biology curriculum, was affected in students who used a hand-held technology device to interact with the content as compared to students who accessed the content in a traditional format with no personal technology. Additionally, the perceptions and attitudes students possess regarding their technology devices was analyzed by comparing the before and after responses of students who used their devices to students who did not use their devices at all. Both pre-survey and post-survey scores, as well as written responses before and after the experience were analyzed.

As discussed in the methodology, the researcher was mindful, and thus very selective about which students were chosen to be involved in the BYOD instructional method for the genetics unit. The demographics of each class, as well as the availability of students in the classes to bring their own device with limited difficulties played a big role in choosing sections of classes for the study. Of the two pre-AP and two traditional sections, the demographics of the students were as similar as possible and only a few students in the device groups were incapable of bringing their own device to school each day. Every effort was made to obtain responses from each student who consented, but due to unplanned, time-constrained absences beyond the control of the researcher, one student in each group had missing pre-test and pre-survey data. By levels, 16 of the 24 students were pre-AP students and eight of the 24 were traditional students.

Hypothesis 1

To investigate student achievement results, the researcher hypothesized that a BYOD method in a high school biology class would have no effect on student achievement as measured by the pre-test and post-test scores. The multiple choice and constructed response question test students took before and after the unit measured the same biology curriculum standards and both tests had a maximum score of 25 points. First, the researcher wanted to learn if there was any difference overall in achievement between the device group and no device group in both levels (traditional and pre-AP) combined. This involved the analysis of means. Table 4 shows the means for pre-test and post-test scores by group for both levels combined.

Table 4. Means and Standard Deviations for Pre-test and Post-test Scores By Group

		Pre-test	Post-test
Group	n	*M (SD)*	*M (SD)*
Device	12	4.42 (1.832)	13.58 (6.201)
No Device	12	4.17 (2.125)	13.33 (5.867)

A repeated-measures analysis of variance (ANOVA) test of pre-test score means and post-test score means was conducted on the effect of time (pre-test, post-test) as well as an analysis of the effect of time and group (device, no device). *Box's M* (10.543) was not significant, p (.023) > α (.001), indicating there were no significant differences between the covariance matrices. Mauchly's test indicated that the assumption of sphericity was met because there were only two levels, resulting in perfect sphericity.

The main effect of time on mean test score was significant $F(1, 22) = 49.888$, $p = .000$, $\eta_p^2 = .694$, indicating that students in both the device and no device groups showed significant improvements from the pre-test to the post-test, but the effect of time and group was not significant such that the students who learned using their personal devices in class did not have significantly different test scores than students who did not use their personal devices to learn, $F(1,22) = .000$, $p = 1.00$, $\eta_p^2 = .000$. The marginal means for both the device and no device groups were very similar.

In addition, the researcher wanted to learn if there was any difference between the device group and no device group by levels (pre-AP and traditional) separated. Table 5 shows the means for the pre-AP students only.

Table 5. Means and Standard Deviations for Test Scores of Pre-AP Students

		Pre-test	Post-test
Group	n	*M (SD)*	*M (SD)*
Device	8	4.00 (2.00)	16.38 (4.719)
No Device	8	4.63 (2.326)	15.13 (5.540)

A repeated-measures analysis of variance (ANOVA) test of pre-test score means and post-test score means was conducted on the effect of time (pre-test, post-test) as well as an analysis of the effect of time and group (device, no device). *Box's M* (4.648) was not significant, p (.269) > α (.001), indicating there were no significant differences between the covariance matrices. Mauchly's test indicated that the assumption of sphericity was met because there were only two levels, resulting in perfect sphericity.

The main effect of time on mean test score was significant $F(1, 14) = 71.492$, $p = .000$, $\eta_p^2 = .836$, which indicated that students in the pre-AP groups showed significant improvement from pre-test to post-test. The effect of time and group was not significant, as the pre-AP students who learned using their personal devices in class did not have significantly different test scores than students who did not use their personal devices $F(1,14) = .480$, $p = .500$, $\eta_p^2 =$

.033. This effect supported the assumption that the presence of the technology device had no effect on pre- and post-score means. The marginal means for the device group and the no device group were very similar as well.

Lastly, the researcher wanted to learn if there was any difference between the device group and no device group at the traditional level. Table 6 shows the means for the traditional students.

Table 6. Means and Standard Deviations for Test Scores of Traditional Students

		Pre-test	Post-test
Group	n	*M (SD)*	*M (SD)*
Device	4	5.25 (1.258)	8.00 (5.164)
No Device	4	3.25 (1.50)	9.75 (5.377)

A repeated-measures analysis of variance (ANOVA) test of pre-test score means and post-test score means was conducted on the effect of time (pre-test, post-test) as well as an analysis of the effect of time and group (device, no device). *Box's M* (6.625) was not significant, p (.238) > α (.001), indicating there were no significant differences between the covariance matrices. Mauchly's test indicated that the assumption of sphericity was met because there were only two levels, resulting in perfect sphericity.

The main effect of time on mean test score was not significant $F(1,6) = 5.411$, $p = .059$, $\eta^2_p = .474$, indicating that students in the traditional groups showed no significant difference in the pre-test scores and post-test scores, and additionally, the effect of time and group was not significant such that the traditional students who learned using their personal devices in class did not have significantly different test scores than students who did not use their personal devices $F(1,6) = .889$, $p = .382$, $\eta^2_p = .129$.

The device group students showed a higher pre-test mean score than the no device group, but the no device group mean increased much more than the device group, showing the no device group performed slightly better. This result suggests that students in the traditional level classes who did not use their devices showed improvement, but the students who did use devices did not improve.

Interestingly, the researcher notes that this pattern is opposite the pre-AP student mean scores, as the device group at this level scored slightly higher. The differing results in class levels suggests that possibly students at a more advanced level benefit from using devices. The estimated marginal means graphs indicate a possible slight interaction for the pre-AP and traditional levels separated, as the effect of time differs depending on whether students used their devices.

Considering this analysis of pre-test and post-test achievement score means, the researcher fails to reject the null hypothesis that a Bring Your Own Device instructional method would have no effect on student achievement.

Hypothesis 2

The second and third hypotheses both served to investigate the attitudes students had prior to the unit and following the unit about using their personal devices for learning and how they perceive biology before and after the unit. In the second test, the researcher hypothesized that a BYOD instructional method would have no effect on attitudes regarding devices as learning tools in a high school biology class. To test this, the students completed a pre-survey and post-survey about their attitudes and perceptions about using their personal technology for learning. The maximum score on this survey was 28 points. Examination of these results involved the analysis of means of the survey scores. Table 7 shows the means for pre-survey and post-survey scores from the technology survey by group.

Table 7. Means and Standard Deviations for Technology Survey Scores by Group

		Pre-survey	Post-survey
Group	n	*M (SD)*	*M (SD)*
Device	12	19.00 (1.595)	17.58 (2.193)
No Device	12	18.92 (1.975)	18.83 (2.368)

For both levels of students combined (traditional and pre-AP), a repeated-measures analysis of variance (ANOVA) test of technology pre-survey score means and post-survey score means was conducted on the effect of time (pre-survey and post-survey) as well as an analysis of the effect of time and group (device and no device). *Box's M* (5.205) was not significant, p (.196) > α (.001), indicating there were no significant differences between the covariance matrices. Mauchly's test indicated that the assumption of sphericity was met because there were only two levels, resulting in perfect sphericity.

The main effect of time on the technology survey mean score was not significant $F(1, 22) = 3.629$, $p = .070$, $\eta^2_p = .142$, and similarly, the effect of time and group was not significant such that students overall did not alter their perceptions about using personal technology for learning after the genetics unit of instruction, $F(1,22) = 5.333$, $p = .104$, $\eta^2_p = .115$.

The device group technology survey mean score decreased from 19.00 on the pre-survey to 17.58 on the post-survey, slightly more than the no device group, which hardly changed at all from the pre-survey to the post-survey. Even though these differences were not statistically significant, the researcher notes that students who had the experience using devices changed their perceptions more than those who did not use devices.

In addition, the researcher wanted to learn if there was any difference between the device group and no device group by levels (pre-AP and traditional) separated. Table 8 shows the technology survey means for the pre-AP students only.

Table 8. Means and Standard Deviations for Technology Survey Scores of Pre-AP Students

		Pre-survey	Post-survey
Group	n	*M (SD)*	*M (SD)*
Device	8	19.13 (1.126)	17.87 (1.356)
No Device	8	19.38 (1.996)	19.50 (2.390)

Box's M (5.812) was not significant, *p* (.178) > α (.001), indicating there were no significant differences between the covariance matrices. Mauchly's test indicated that the assumption of sphericity was met because there were only two levels, resulting in perfect sphericity.

The main effect of time on the technology survey mean score was not significant, $F(1, 14) = 1.214$, $p = .289$, $\eta_p^2 = .080$, and similarly, the effect of time and group was not significant such that students in the pre-AP group did not significantly alter their perceptions about using personal technology for learning after the genetics unit of instruction, $F(1,14) = 3.781$, $p = .199$, $\eta_p^2 = .115$.

The device group mean score was lower on the post-survey than the pre-survey suggesting a possible effect of time, though statistically insignificant. The no device group survey scores changed very little from pre-survey to post-survey.

Lastly, the researcher wanted to learn if there was any difference between the device group and no device group technology survey mean scores at the traditional level. Table 9 shows the means for the traditional students.

Table 9. Means and Standard Deviations for Technology Survey Scores of Traditional Students

		Pre-survey	Post-survey
Group	n	*M (SD)*	*M (SD)*
Device	4	18.75 (2.500)	17.00 (3.559)
No Device	4	18.00 (1.826)	17.50 (1.915)

Box's M (1.927) was not significant, *p* (.746) > α (.001), indicating there were no significant differences between the covariance matrices. Mauchly's test indicated that the assumption of sphericity was met because there were only two levels, resulting in perfect sphericity.

The main effect of time on the technology survey mean score was not significant $F(1, 6) = 2.793$, $p = .146$, $\eta_p^2 = .318$, and similarly, the effect of time and group was not significant such that student in the traditional groups did not alter their perceptions about using personal technology for learning after the genetics unit of instruction, $F(1,6) = .862$, $p = .389$, $\eta_p^2 = .126$.

The estimated marginal means graphs show nonparallel lines for all students as well as the two levels separated, indicating a possible interaction effect. The effect of time differs depending on whether students used their devices.

One component of the pre-surveys and post-surveys was an opportunity for students to explain the reason they chose the responses they did in terms of perceptions about using their personal technology in class and whether their attitudes about biology changed. If they agreed or disagreed with a statement in the questions, it was important for the researcher to get an idea why they agreed or disagreed. The information gleaned from student responses, along with observations made by the researcher during the unit, can provide insight into understanding how and why student perceptions were influenced by their experience during the genetics unit.

Technology Survey Themes

To enable students to explain the reasons they agreed or disagreed with the statements about their own technology as a learning tool during instruction, three major topics were included in the survey. These included students' attitudes and experience using technology in school, students' views about technology as a distraction during class, and student perceptions about their own learning with or without technology. At the end of the post-survey, students in the device group were asked to provide their overall opinion about their experience during the instructional unit.

Overall, most students in both groups indicated that they had some experience using their device for learning purposes, but that experience was limited to research about a specific topic or a study website, such as Quizlet. Student E wrote, "if I don't understand a concept in class, I look it up on Google" and Student A: "some teachers have Quizlet and I will use it to study." No one in either group indicated that they had used their device during a class in a deliberate way to learn during an instructional unit. Twenty-two of 23 students indicated that they use their personal devices extensively for social media, listening to music, watching videos, and texting. The single student who reported no personal entertainment-related use was a student who does not own a smart device.

Student attitudes about learning with their device in both the device group and no device group were largely unchanged before and after the unit. Most students who agreed that using their device in their classes would help them do better or not do better in class maintained their opinion. Those who answered that they thought they would do better gave reasons similar to

Student T in the device group. She stated on the pre-survey that “with engaging activities and websites it could be a great benefit” and on the post-survey, “it is beneficial to my understanding of many tough topics.” Others like Student R changed his opinion after the unit. Prior to using his device during class, this student wrote that using devices is “not better because there are some subjects I think would not benefit from the use of devices” and on the post-survey he wrote more positively about the idea when he stated, “good study tools.”

When asked the question about the appropriateness of devices in all classes or just certain classes, the results were similar within the device group and much more specific than responses from the no device group. This suggests that the experience of being in the device group provided these students with a more informed view of possible ways to use technology because most of them indicated which classes would be best for employing devices. Like Student Q, “Sometimes the device could be distracting and in some classes it’s not necessary to use a device” or Student P: “I think a device would be helpful in World Civ because you can look up more info. When teachers talk the whole class I get bored and don’t learn well.” Student V thinks using devices are “appropriate for core classes with apps for different things.” However, students in the no device group had answers that were vaguer. They continued to provide answers related to research about an unknown topic or using a study or game site. Student D wrote, “I use my technology in class when a teacher gives me an assignment requiring research.”

Regarding the theme of distractibility, the responses of the students in the device group expose some interesting themes regarding student views about what is meant by “distraction” and how they measure their level of distraction during class. Some students are adamant like Student T that the presence of the device is in no way a distraction. He stated: “I don’t get distracted by my phone” or like Student P who wrote that her phone has “not been a distraction because I'm on my phone anyway." Other students revealed that if they were on task, they were not distracted. Student O said her device was not a distraction to her "if used properly" and Student S replied, "we are old enough to use them responsibly and I try to pay attention." Similarly, more than one student indicated that they must not have been distracted because they either maintained their grade or improved it. Student S said that it "has not been a distraction because I still have an A." Student V was one of the few students who reported that the device would be a distraction before the unit, but she changed her opinion after the unit because "she (the teacher) makes sure we do what we are supposed to." And still another, Student W, who said before the unit he would not be distracted admitted after the unit, "I played on games."

The other question regarding distractions asked students to indicate if they thought using devices would be distractions to other students. For the device group on the pre-survey, six of the 12 students said that other students would be distracted and six of the 12 said they would not be distracted. On the post-survey, nine of 12 said that they thought students were distracted and only three of 12 believed they themselves were not. Students N and P both agreed before and after that students would text and be tempted by social media. Student N wrote, "they text" and Student P said, "it is tempting to get on snapchat or text people." Student Q thought prior to the unit that it would not distract because "most of us want to learn and not take advantage" but changed her mind on the post-survey because she saw that "not everyone wants to use it for their own good and for learning." Student S believed that "we are old enough to be responsible" on the pre-survey and on the post-survey reported that "some other students feel like they have more freedom" (to get off task). Many of the student responses indicated that students are not very concerned about being distracted by their devices.

Within the responses of the no device group, the answers to whether other students would be distracted did not change much at all. Like the device group, about half of these students, seven of the 12, believed that others would be distracted prior to the unit and eight of the 12 maintained that belief after the unit. The temptations present because of the device as well as the advantages available with the freedom of using a device are consistent reasons. Student H replied, “Others have a hard time ignoring their phones.”

An interesting connection between student perceptions of their own distractibility compared to that of their classmates is worthy of consideration. For the students in the device group on the post-survey, seven of the 12 students indicated that they themselves were not distracted by using their device, but they think other students were distracted. Some base their reasoning on whether grades are maintained and others if students access social media when they are supposed to be working on another task in class. Student U (of the device group) had a very interesting take on the issue of distraction when he wrote, “if everyone has their phone out, then they won’t get distracted by someone else’s” suggesting that distraction in this context is regarding distraction from the phone itself, not the activities of the class! All of this begs the question regarding student perceptions about the meaning of the term “distraction” in a classroom setting.

The last theme revealed in student survey responses is the way students perceive the improvements in their learning because of using their devices in class. If both groups are considered together, 22 of 24 students indicated on the pre-survey that they believed that using a personal technology device would improve their learning. Within the no device group, this opinion was maintained from pre-survey to post-survey answers. Eleven of 12 students still believed that the device would help. However, within the device group, seven of 12, down from

11 of 12, still believed that the device improved their learning after the unit. The ones who believed they improved did so because the device increased their enjoyment of the unit, such as with Student Q. She believed that she improved "because I am enjoying the things we are learning." Another student liked that instruction using their device helped make things easier for them. Student T responded that it "made concepts easier" and Student U thought the device instruction was "more convenient." Student R simply replied, "using my device has improved my scores."

While some students had an overall positive view like Student V who said she "learned new ways to learn," there were students who expressed some frustration with the method. Student W said that the BYOD method "added unnecessary difficulties" and Student N had problems navigating the websites and remembering passwords. Student P completely disliked the BYOD instructional method because she felt that the device did the opposite of engaging her. She stated that "when I do things on paper, I'm more obligated to do my work." Finally, Student Z had a complete turnaround of opinion from pre-survey to post-survey as a result of the BYOD method. At first, he thought it "could be more engaging" but concluded in the end that it was "easier just to give us the notes", meaning the traditional teacher lecture method of teaching.

The last overall theme from the technology survey came from a question that asked students in both groups to indicate their preference of using their device for learning in general versus using it only for personal reasons. Seventeen of 24 students reported that they think their personal device can be useful for learning purposes, not just for personal use. The overwhelming condition for this answer was if they could see an improvement in their grades or learning. Student B in the no device group reported that devices are not appropriate for learning because "we have teachers to help us learn", but on the other hand, Student D in the same group wrote, "in the future we WILL need to use technology and we need to start using them as learning devices." Student H agreed with Student D in saying, "why only use it for personal things when it's capable of more and could possibly make learning better?"

Responses from the device group were similar, mostly due to convenience of using their own device to study on their own time. Student Q responded, "I think using my device is very helpful because I always have it with me and I know it'll improve my grades if I am responsible." Others share that they have learned to use their phones on their own time, "even when it isn't assigned" as Student U wrote.

The last question on the device group survey asked them to indicate their overall impression of learning the genetics unit using their devices during class. Eight of 11 students who answered the question (one did not answer) responded that it was a good experience. While most of them cited new study tools, a modern and updated way of learning, and convenience as major reasons, a few liked the way it enabled them to communicate differently with the teacher and each other, as well as being able to self-assess. Student O's response indicated this when she wrote: "Teachers can see how each student is doing instead of taking time out of class" and "I can see how my peers answer questions and ask my teacher questions without disturbing others." Student V liked the versatility of working on assignments from anywhere. "I liked that we had time outside of class to do work that we could do it on our phones."

A few students expressed frustrations and indicated it was an overall bad experience. The main reasons they state included confusion about websites, forgetting passwords, frustration with the network, and the attitudes of other students in the class. Student Z, who was in a traditional class and felt "it prohibited my chance of learning" also wrote, "If you had students who cared about it, it would be different." One student who does not own a device saw little good in it, even when a school device was available for use.

In analyzing the outcomes of this method, suggestions offered by students who experienced it are most helpful. More than one student expressed there were too many websites to maneuver, suggesting that using fewer apps or websites during the unit would reduce the confusion they experienced. Student N, who indicated an overall negative experience, suggested that "we should all have assigned school devices that already have our info." Others liked the websites that were used but did not like taking assessments on their devices and preferred paper-and-pencil tests, like Student P because she feels that "I do better on paper tests". Conversely, Student S liked taking the assessments on the device, but he maintained a consistently positive view about using technology overall. One student indicated that there may have been too much technology. Student U wrote, "Using your own device made reaching the teacher and assignments much more convenient. However, the teaching plans fell too heavily on the devices at times, one or two days of old-fashioned lecture would have been beneficial to my personal overall understanding."

Considering the analysis of pre- and post technology survey mean scores and the student responses on the surveys regarding their attitudes about technology before and after the unit, the researcher fails to reject the null hypothesis that a Bring Your Own Device instructional method would have no effect on student attitudes regarding personal technology devices as learning tools in a high school biology class.

Hypothesis 3

Like Hypothesis 2, the third hypothesis tested the assumption that a Bring Your Own Device instructional method will have no effect on student attitudes about biology in a high school class. To test this, before and after the genetics unit, the students completed a pre-survey and post-survey about their attitudes and perceptions about biology as a subject they learn in school. The maximum points possible on this survey was 20 points. Like the previous survey, examination of these results involved the analysis of mean scores of the surveys. Table 10 shows the means for pre-survey and post-survey scores by group from the biology survey.

Table 10. Means and Standard Deviations for Biology Survey Scores by Group

		Pre-survey	Post-survey
Group	n	*M (SD)*	*M (SD)*
Device	12	13.67 (1.969)	13.42 (1.782)
No Device	12	13.67 (2.964)	14.00 (2.089)

For both levels of students combined (traditional and pre-AP), a repeated-measures analysis of variance (ANOVA) test of biology pre-survey score means and post-survey score means was conducted on the effect of time (pre-survey and post-survey) as well as an analysis of the effect of time and group (device and no device). *Box's M* (2.297) was not significant, *p* (.558) > α (.001), indicating there were no significant differences between the covariance matrices. Mauchly's test indicated that the assumption of sphericity was met because there were only two levels, resulting in perfect sphericity.

The main effect of time on the biology survey mean score for all students overall was not significant $F(1, 22) = .007$, $p = .936$, $\eta_p^2 = .000$, and similarly, the effect of time and group was not significant such that students did not alter their perceptions about biology after the genetics unit of instruction, $F(1,22) = .328$, $p = .573$, $\eta_p^2 = .015$.

Interestingly, both the device group and no device group had the same mean score on the biology pre-survey, but the no device group mean score increased and the device group mean score decreased on the post-survey.

In addition, the researcher wanted to learn if there was any difference between the device group and no device group by levels (pre-AP and traditional) separated. Table 11 shows the biology survey means for the pre-AP students only.

Table 11. Means and Standard Deviations for Biology Survey Scores of Pre-AP Students

		Pre-survey	Post-survey
Group	n	*M (SD)*	*M (SD)*
Device	12	14.13 (1.126)	14.13 (1.458)
No Device	12	14.75 (2.659)	14.50 (2.390)

Pre- and post-survey mean score data for the pre-AP no device and device groups were analyzed using a repeated measures ANOVA on the effects of time and time and group. *Box's M* (6.511) was not significant, p (.138) > α (.001), indicating there were no significant differences between the covariance matrices. Mauchly's test indicated that the assumption of sphericity was met because there were only two levels, resulting in perfect sphericity.

The main effect of time on the biology survey mean score was not significant $F(1,14)$ = .050, p = .826, η_p^2 = .004, and similarly, the effect of time and group was not significant such that students in the pre-AP classes did not alter their perceptions about biology after the genetics unit of instruction, $F(1,14)$ = 050, p = .826, η_p^2 = .004. The device group perceptions did not change at all, but the no device group perceptions decreased slightly. While these changes are statistically insignificant, it is important to note no change in perceptions of the group that used their devices.

Lastly, the researcher wanted to learn if there was any difference between the device group and no device group biology survey mean scores at the traditional level. Table 12 shows the means for the traditional students.

Table 12. Means and Standard Deviations for Biology Survey Scores of Traditional Students

		Pre-survey	Post-survey
Group	n	*M (SD)*	*M (SD)*
Device	12	12.75 (3.096)	12.00 (1.633)
No Device	12	11.50 (2.517)	13.00 (.816)

Pre- and post-survey mean score data for the traditional no device and device groups were analyzed using a repeated measures ANOVA on the effects of time and time and group. *Box's M* (3.323) was not significant, p (.548) > α (.001), indicating there were no significant differences between the covariance matrices. Mauchly's test indicated that the assumption of sphericity was met because there were only two levels, resulting in perfect sphericity.

The main effect of time on the biology survey mean score was not significant $F(1, 6) = .117$, $p = .744$, $\eta_p^2 = .019$, and similarly, the effect of time and group was not significant such that students in the traditional classes did not alter their perceptions about biology after the genetics unit of instruction, $F(1,6) = 1.052$, $p = .345$, $\eta_p^2 = .149$.

The pre-survey mean scores for the device group were higher than the no device group mean scores, but on the post-survey, the results were opposite. The device group mean survey score decreased and the no device group mean score increased, resulting in a very similar overall mean score for both groups.

The estimated marginal means graphs show no parallel lines for any of the tests, indicated a possible interaction effect. Students in the pre-AP level classes had very different perceptions about biology at the beginning of the unit than traditional students, and both levels had opposite perceptions at the end of the unit, causing the interaction effect.

Biology Survey Themes

For the surveys about student attitudes about learning biology with personal technology, three major themes emerged from student responses. One evident theme is that student attitudes about biology as a subject did not change for any of the students in either level (pre-AP or traditional) or group (device or no device). Questions 1 and 2 asked students about their current feelings about biology as a favorite subject and whether they have a positive attitude about biology. In the device group, overall attitudes about biology as a subject did not change at all. About half of the students agreed that they liked biology before and after the unit, and half disagreed that they liked it before and after the unit. However, in the no device group, four of twelve students changed their response from “disagree” to “agree” when asked to respond to the statement, “Biology is one of my favorite subjects.”

The subsequent question asked students to indicate whether they have a positive attitude about biology. Their explanations suggested that even if the subject is not a favorite of theirs, they felt positive about it because of their willing efforts. On the pre-survey, Student G, a student in the no device group responded, “I try and make sure my classes are taken care of and try my best” and on the post-survey, the same student wrote, “it’s my last science class so I’m trying to pass.” Similarly, a student in the device group, Student Q, admitted to struggling with the content but maintained the attitude of trying her best both before and after the unit. Before the unit, she expressed, “Even though I struggle in biology sometimes I like to learn about it and know I will make good grades” and after the unit, “I am enjoying the things we are learning now and know that I am improving in class.” Her response is unclear whether the presence of the device during instruction had an impact on her perception of improvement, but she remained confident in her own abilities, showing that using the device in class did not hinder her perceptions about the subject. Overall, because it is a required class to graduate, most students have a resigned attitude about biology regardless of whether they like it or the method of instruction they experience.

A second theme that is revealed in student responses about biology is most students in the device group indicated in the pre-survey that they thought using their device would motivate them to try harder, help them learn more, and improve their overall attitude about the class, but the post-survey responses were mixed. The majority of the students in the device group, seven out of 12, continued to agree that using the device helped improve their learning and overall attitude about biology. Student O appreciated being able to learn at her own pace. She wrote, “By using my device I can go at my own pace and comprehend things better.” Similarly, on the pre-survey Student S thought that using his device would “be more interesting and fun” and after the unit responded, “it is more interesting and a modern way of learning.”

Some students described how they recognized that using a device might align better with their own learning style. Student Q of the device group wrote, “I personally learn better by interacting with the lesson rather than reading out of a book or staring at the board” and on the post-survey, she wrote, “I’ve improved in biology by using my device so I think I have a better attitude about getting good grades.” Student R learned from experiencing instruction with the device that they can be a “great study tool” and “have easy access to things.”

While most students in the device group indicated on the post-survey that they thought they actually learned better using the device, a few expressed that the presence of the device did little to improve or change their overall attitude. Student U from the device group explained on the pre-survey that using his device in biology “would make learning more hands-on.” He also wrote on his post-survey in response to the same question that it “makes learning more complex than necessary.” Along the same line, other students in the device group wrote responses on the pre-survey like Student N: “it would help me be more focused and help my visual learning.” On the post-survey, Student N responded to the same question, “there are some things I don’t understand on my phone and it is hard to keep logging in.”

A final theme related to attitudes about biology from the surveys is that responses differ in the traditional students and the pre-AP students regarding the question, “I think I would be able to learn more in biology by using my device than in the traditional way.” On the pre-survey, 15 of 16 pre-AP students agreed that they believed they would be able to learn more by using a device and 11 of the 16 maintained that response on the post-survey. Of the four who changed their answer, three of them were in the device group, but none of them indicated a reason. In the traditional level, five of eight students agreed that they believed they would learn more using a device on the pre-survey and only two maintained this answer on the post-survey. Student Y of the device group explained his disagreement about whether the device helped him after the unit this way: “it did to an extent but sometimes it had more reading on a subject than necessary.” Student Z in this group strongly agreed on the pre-survey that he thought using a device would help him learn more and on the post-survey he changed his response to strongly disagree. His responses changed from “because I would like to try something new” to “it prohibited my chances at learning.”

Considering the analysis of pre- and post-biology attitude survey mean scores and the information from student responses regarding student attitudes before and after the unit, the researcher fails to reject the null hypothesis that a Bring Your Own Device instructional method would have no effect on student attitudes about biology in a high school class.

Chapter 5: Conclusions

Conclusions

This study served to investigate how including personal technology devices within the instructional aspects of a classroom environment could affect student achievement in the class, as well as student perceptions about using the technology for learning. Based on observations during the instructional unit, the analysis of test score and survey results, and student survey responses, the researcher has drawn some conclusions about the effects of personal technology in a Bring Your Own Device setting and offers some suggestions for further consideration and reflection regarding this topic and its relevance in preparing students for 21st century success.

Technology in the classroom, particularly hand-held personal technology devices, is readily available to students. Building a bridge between the attraction high school students in general have for their tech gadgets and the potential that exists to use them beneficially for learning was the intent of this study. The results of the effects of such devices on student achievement provided some evidence that leads to the conclusion that students who used their devices in class did not show significant improvements in their learning compared to similar students who did not use devices.

Similarly, this study provided some evidence that leads to the conclusion that when students used their devices during class as instructional tools, the use of devices did not significantly influence their attitudes or perceptions about using their technology in one way or another. Finally, the study provided evidence that leads to the conclusion that when students used their personal devices in biology class, their attitudes about the subject of biology did not change. These conclusions were made from the comparisons of results of achievement and survey scores of specific classes during a specific time. The implications from this data and the conclusions that follow it, along with observations from the study experience, provide the researcher an opportunity to share insights about the influences of technology on high school students and their learning.

Discussion

Regardless of the evidence in this study that indicates no significant effect of devices as learning tools in this particular setting and context, the researcher learned valuable information about Bring Your Own Device implementation, student preparation for a BYOD classroom, and other ways BYOD influences learning and the classroom environment. This learning improved the researcher's competence and confidence to help others. Additionally, while test score means did not indicate an effect of group (device or no device), the researcher's experience during this study reveals important insights that support the use of BYOD methods in specific and appropriate settings.

When the design of this study was being developed, the researcher was very interested in studying this issue because of the current dilemmas associated with students and cell phones she and other high school teachers face each day. After much reading and reflecting, giving up and not facing it was not an option because ignoring a problem does not eliminate it; often it exacerbates it. Teachers and students, whether they recognize or appreciate technology or not, need practical options that can help them proactively handle the distractions and interference that students with their devices bring to the classroom.

A Sensible Approach to the Issue

One option, of course, is to ban cell phones from the classroom completely. In certain settings, a ban is appropriate, such as for safety reasons in a laboratory setting or to ensure assessment security. However, in today's world, a cell phone ban is short-sighted and a negative reaction that discounts the potential benefits cell phones can offer. A ban of cell phones creates another rule to enforce and there are already plenty of those without adding another. Especially in school buildings where students can have and use their personal devices everywhere in the school as allowed by administrators and school policy, a constant battle ensues in classrooms where teachers make the decision that cell phones are not allowed. The researcher in this study decided that in her classroom the cell phone battle is not a worthy fight. She also decided that it cannot be ignored. With the attitude that solutions can be found to solve this problem, this study was envisioned, developed, and conducted. Considering current research in this area, the magnitude of the problem, and the setting of the study, the results of the data analysis reveal information that is not very surprising, but helpful in addressing this issue in classrooms.

Devices and Achievement

Pre-tests and post-tests.

The first conclusion related to student achievement failed to support the idea that the use of personal technology by high school biology students would improve test scores. In this analysis, the only significant effect was that of time on scores. All students scored very low on the genetics unit pre-test and this was expected since almost all the content in this unit was completely new to them. In fact, on many of the pre-tests, especially the written portions, the answers were left blank because students did not know where to start developing a response. However, on the post-test, most students performed considerably better. As shown in mean scores in Table 1 of the results, both groups combined produced a nine point, or 36%, mean increase overall.

While the post-test scores showed a significant increase from the pre-test scores because of time and effort given to learning during the unit, the effect of group was not significantly different. Students who used their devices did not show significant differences in their test score means as compared to the students who did not use devices. When considering all the capabilities that technology use can provide to students if used appropriately, and their attachment to them, this result is surprising. However, considering other factors that influenced the unit and responses of students after their experience with the unit, the result of the analysis is not as unexpected. Factors such as reading difficulties experienced by some of the traditional students, absences due to illness, and lack of prior experiences in using their devices to learn as indicated by students on the surveys should be taken into consideration when analyzing these results.

Significance of Course Level.

Further analysis of this data reveals an interesting finding when the pre-AP students' data is separated from the traditional students' data. As shown in Table 5, the analysis reveals a significant difference in the pre-test and post-test score means of the pre-AP students with a 44% increase of over eleven points. The means graph shows that both groups increased at a similar rate, but the device group increased faster and outscored the no device group by a slight margin. However, like the combined results, the effect of time and group was statistically insignificant. The researcher cannot say with certainty that the device group performed any better than the no device group, however, there is qualitative evidence to support that some students show an aptitude for learning with their devices.

Furthermore, during observations of the pre-AP device group, the researcher noticed very little off-task behavior. After she gave instructions about assignments, she walked through the room watching students work and they were focused and attentive on their work. Even the ones who struggled at the beginning and never fully embraced the method participated and gave their best efforts. Observations of the no device group reveal that students did not always stay on task, even at the pre-AP level, and did not work with the same tenacity as the device group students. Regardless of the significance of scores, the teacher noticed a visible difference in how focused students were in class when they used their devices. These students were always busy, but the students who used traditional books and handouts showed more signs of boredom. As indicated on the post-survey responses, students in the pre-AP level device group experienced fewer frustrations than those at the traditional level.

The researcher concedes that the presence of the device was not a major factor in their success, but for some students, it played a role in motivation. In addition, the more time and experience they got in working with their devices in biology class, the more proficient they became. This is evident in not only the scores they achieved, but the amount of time required for them to complete assignments decreased as the unit progressed. From the researcher's notes, about halfway through the unit she wrote about the pre-AP class, "a few logging-in glitches, but within 2-3 minutes everyone was working and submitted within 30 min." Because of the improved abilities to use the device, students could get work completed faster and move on to something else they needed to do. By the end of the unit, very little time was wasted during the pre-AP device class due to technology issues. The researcher believes that if this class continued using devices on a more consistent basis, the effect of using the devices would be more significant to the outcomes of their achievement.

Analysis of the traditional students' data produced some disheartening results to the researcher. The result that there was no significant difference in the mean scores of students as a reflection of time from pre-test to post-test is a bit surprising and deflating to the researcher. Regardless of the presence of a device or not, students should show significant growth over time.

One consideration that is important to note is the significance value of $p = .059$ is very close to being considered significant. The means graph shows that both groups increased mean scores from pre-test to post-test with an increase of over four points, a doubling of the pre-test score. Even though the statistical results showed insignificant changes, the researcher believes that the traditional students experienced some growth as evidenced by the answer sheets on the pre-test and post-test. This group certainly had many blank answer spaces on the pre-test, but there were fewer blanks on the post-test and some of their responses were at least partially correct. Perhaps they did not show significant growth, but growth nonetheless.

Probable obstacles for traditional-level students.

This point about the traditional students' achievement is stressed for an important reason that might help explain the lack of significant improvement in their scores. Other factors besides the presence of the device may have contributed to the results of the students in this level. Out of the eight traditional level students in both the device group and no device group, four of them are enrolled in a Response to Intervention reading or Success Lab class. These are classes for students who have not met grade-level reading benchmarks or have failed classes and need to recover credits because they failed courses in previous years. None of the pre-AP level students are enrolled in these courses. Students who have difficulty with reading or struggle in school in general most likely will not show the same margin of growth as students who read at or above grade level. From the results of this investigation, it seems the integration of personal technology did not reduce the influence of this common obstacle.

In addition to the statistically insignificant effect of time, the results also show an insignificant effect of time and group as well. The traditional students who used their devices did not show any significant difference from the students who did not. The means for both groups are very similar, suggesting no effect but an interaction between group and time is indicated on the marginal means graph. The effect is insignificant and the graph shows that the no device group at this level showed a greater mean increase than the device group. Perhaps in this case, the device was a hindrance to the traditional students. Because they have trouble reading and understanding information, regardless of the method by which it is presented, the phone or tablet is an ineffective device for learning and a distraction to them. The temptation of using their devices inappropriately overcomes the intended purposes for learning.

This supports the idea that using a device as an instructional tool alone, whether personally owned or not, is not enough learning support for every student. The technology needs to be employed with other research based strategies suited for struggling students in appropriate ways. Perhaps individual students can benefit from a structured plan that includes technology, but the use of personal device for some students is not the best way for them to learn. The observations the researcher made of the traditional groups also supports these thoughts.

During the traditional device group classes, most days were quite different from the pre-AP group classes. The researcher found it much more difficult to keep students in this class on task. They needed a greater amount of help using the devices as well as maneuvering through the websites and content. What was intended to be an instructional method to enable students to access the content more easily, many days became a compounded problem of overcoming the device issues and then sometimes barely getting to any content at all. Considering these observations along with the statistical results, the researcher believes it is possible that the presence of the personal technology device in the traditional class was more of a detriment than a help. Notes from the researcher’s own observations support this assumption. On January 6, which was early in the unit, she wrote, “tough day! They try, but shut down at a challenge, instead of trying on their own, they want me to help them or do it for them." Then again on January 31, about halfway through the unit, again she wrote, "disaster, most could log in without problems, but then struggled with the content! The majority were unmotivated to log in and get started working."

These observations indicate that students made some progress in their ability to use their devices properly in class, but when that barrier was broken down, the next obstacle of comprehending the content was another issue to handle. The problem for the researcher with this group and the barriers they face is how difficult it is to know if their lack of achievement is due to technology issues or other reasons, like reading comprehension difficulties or lack of motivation. The similar results shown by the no device group at the traditional level indicate that the obstacles for these students in general are due to a variety of reasons, not only one. The researcher cannot determine with certainty whether the device alone influenced learning with this level of student.

Devices and Attitudes

The other two conclusions drawn from the data analysis regarding their respective hypotheses reveal similar information as the conclusions about test score means. Just as the researcher fails to reject the hypothesis that BYOD instructional methods have no effect on achievement, she also fails to reject the hypothesis that using devices as learning tools have no effect on attitudes about personal technology and student attitudes about biology. For each of the last two hypotheses, the statistical analyses, student responses, and researcher observations clarify what can be learned from this portion of the study. The researcher contends that while improving student achievement is the ultimate goal of education, other factors such as perception and attitude play a big part in creating an environment and culture in classrooms that support improvement. As the literature supports, the way students perceive their devices is important to how successful they are as tools for learning, not just in the classroom, but seamlessly from one life stage to the next.

Attitudes about personal device for learning.

The data reveals that overall student perceptions about their technology as indicated by survey score means was insignificant for time and time and group. This implies that the way students perceived their personal technology before learning the genetics unit did not change because of using their devices. While statistically insignificant, the device group survey mean at both levels combined decreased, while the no device groups at both levels stayed relatively the same. This suggests that students who used their devices in class developed a more negative perception of using them after the unit. When separated by level, the pre-AP and the traditional students' mean scores both remained statistically insignificant for time and group and each level showed a more negative perception on the post-survey.

For all three sets of comparisons (all students, pre-AP, and traditional), the possible interactions of time and group suggest that while time nor group were statistically significant, it might be that the time spent and experience of the unit had somewhat of an influence on altering student attitudes about using technology. The students who used devices reported a more negative perception about their devices as learning tools after the unit.

A change in perception.

At the beginning, before any BYOD instruction happened, students seemed to have a positive perception of using their personal devices in class. From their pre-survey responses, it seemed that they had the opinion that it would be something different or a more fun way to learn. As some of the students described, they thought getting to learn with their own technology would be engaging, more up-to-date, and less boring to them. The decrease in the survey mean scores on the post-survey, while statistically not significant, when considered with some of the students' new perceptions as indicated on the post-survey, show that some of the students in fact changed their minds about how they perceived using devices for learning. Just as previous research supports, using a device as a tool with the purpose to learn is different than using it for entertainment. As noted in the survey responses in the results section, almost none of the students had used their devices purposefully for learning, but almost all had used them for videos, games, and social media. The researcher has learned that overcoming students' strong affinity to use their device solely to communicate and interact with their friends is more difficult than she thought.

The concept of distractions.

Of all the learning the researcher gained from this study, one thing became evident from reading the device group student responses, particularly on the post-survey. The concept of what a "distraction" is to students is often different from what teachers consider it to be, especially in a classroom environment. Earlier in this chapter, as well as extensively in the literature review, the researcher discussed the problem of distractions caused by cell phones and other smart devices in the classroom. Much writing in the literature was about how teachers see devices as distractions, but the researcher could find nothing about student perceptions about them. Because this was an important aspect of this study, the researcher included questions about distractions on the surveys to evaluate what students would say about their own distractibility and that of their classmates. What the researcher did not anticipate learning was that the students' ideas of a classroom distraction would not be the same as that of a teacher. Interestingly, the responses of students show evidence that what they perceive as a distraction is not the same thing that teachers see as distractions.

Typically, a distraction in class in the mind of a teacher is anything that prevents or inhibits instruction. Perhaps someone, either the students or teacher, is unable to pay attention or to comprehend the instruction because of the actions or interference of another source. This description of distraction is why cell phones are deemed as such to most teachers. A typical teenager with a device in his hand would prefer to play a game or interact with social media instead of pay attention to a lesson in class. The temptation to let the cell phone distraction win is very strong and often, unless students are engaged in a focused activity the entire class period where phone use is impossible, they will check their phone a few, if not multiple times, during one class period. And to most teachers who are aware of the behaviors of their students, the previously mentioned device activities would be considered examples of being distracted, simply because students are not fully involved or engaged. But, surprisingly, the responses of students in the device group who experienced the BYOD instruction and used their personal devices almost every day in class for approximately two months indicate a different outlook about what it means to be distracted.

Seemingly, from some of the responses, students do not view the presence of their phones in class as distractions, regardless of whether they have permission to use them. The student who reported that her phone was not a distraction because she is “always on it” might unknowingly always be distracted by her device, living an oblivious existence with her constant phone connection. Or, the student who thought that what is meant by a distraction is whether another student’s device would distract him from his device seemed unconcerned about the fact that there is a lesson going on during this “distraction.” Both students are certainly unaware that they might be missing some things while their attention is concerned with their devices. Similarly, more than one student used their grade in class as their criterion for determining whether they are distracted. The student who thinks that if he keeps an A in the class thinks that this must mean he is not distracted by his phone. While it is unclear whether this correlation can be made, at least this student is aware that the device could distract him from making the best grades possible.

Understanding what students believe a distraction is helps in interpreting the other responses about distractions and cell phones the students gave on the surveys. Most of the students indicated on the pre-survey that they would not be distracted by their device in class and they maintained this view about themselves on the post-survey. Along with this, on the post-survey most of the students believed that other students were in fact distracted by using their device in class. The reality that seven of 12 students indicated that they themselves were not distracted but they think others were, shows that what students see in others they are unable to see or admit about themselves. If other students perceive that a student is distracted, it might not mean they are, but they must be exhibiting some behaviors that indicate distraction.

The researcher sees this theme as worthy of discussion because if students are to become proficient at using their own personal technology for learning, they must develop a level of self-awareness that tells them when they are distracted and unproductive. Average high school students are possibly not mature enough to develop the awareness to know when their devices are not helping them, but instead hindering them. This is more evidence that improved digital literacy is critical for today's students. Teachers who are trained and skilled at teaching with technology should be able to assist students and guide them to know when the device is no longer appropriate and other learning methods should be used, but students equally need self-awareness. Along with technology training for students, this finding reinforces the need for professional development in proper practices for teachers who use personal technology as an instructional tool.

Attitudes about biology.

Just as the presence of the devices in class did not significantly influence students' perceptions about their personal technology, it did not influence their attitudes about biology either. For most students in both groups, the attitude they had before the unit did not change after the unit. In other words, if they already had a positive outlook about biology, they kept a positive outlook and if they hated it before, they continued to not like it after the unit. This supports the idea that technology does not have much impact on changing a student's mind about a subject they are required to learn.

Student responses on the survey, particularly for the pre-AP levels, suggest that students' desire for good grades overcomes any like or dislike for the class. They will do whatever they need to do to earn the grade they want and they really do not show an interest in developing any more positive feelings about the subject. At the traditional level, device group students revealed completely opposite perspectives compared to the no device students. Many of them showed unconcern for achieving high grades, but simply to pass was enough for them. The survey did not measure what would motivate students to change their attitudes besides technology, but according to this study results, technology does not do it. What the surveys revealed however, was that some students could recognize the device experience helped them think about their learning.

Metacognition.

Again, like the technology survey results, when the levels are considered separately, the results diverge a bit. While most students in the pre-AP level who indicated on the pre-survey and the post-survey alike that they would be able to learn more using their device, more students in the traditional device group changed their minds after they experienced the BYOD method, and the change was a negative one overall. These students expressed that in some ways the device prevented them from learning. While this is not a result that the researcher would wish for, more can be learned and concluded from these responses as they align with the previous conclusions about devices being counterproductive in some situations.

The fact that students are aware that the presence of their own technology in the context of learning does not help them is very valuable information for teachers. With this knowledge, teachers can make smart decisions about which students might not benefit from using personal technology, as sometimes knowing what not to do can be as beneficial as knowing what to do. Additionally, when students can acknowledge that a certain learning method is not helping them, they have developed some level of metacognition about their learning. The researcher sees this as evidence that the experience with devices in the traditional group students possibly provided some insightful benefit to them, even if it was not in learning about genetics.

Self-awareness.

Interestingly, while students for the most part seem unaware of their own distractibility due to their devices, some of the device group pre-AP students revealed some awareness about their specific learning styles from the experience with the devices. They had the experience of accessing material exclusively through an online format. This was different enough from what they were familiar with in the form of a book or handout that they could recognize whether it was conducive to the way they learn.

One student particularly was a very quick learner using her smartphone. Evidence in her work early in the unit revealed that she could maneuver the device well. Before the unit, she was a good student, but not much more than compliant in participating in class. During and after the unit, this student could be described as not only compliant, but engaged in the activities of the class. She learned on her own how to use her phone to research information, embed it into a presentation, share it with others, and present it to the class without using anything but her phone and the classroom projector. She continued submitting assignments using her device even after the conclusion of the genetics unit.

Another student in the pre-AP device group did not own her own device and had very little experience with phones or tablets prior to this unit. She did not even know how to turn on an IPad in the beginning. This student was quite hesitant to work with the device, but she was willing and very cooperative because she wanted to do well in class. She was a very quiet student and the researcher spent time helping her stay caught up with the others because her willingness to learn was so positive and inspiring. By the end of the unit, she was using the device with more competence and communicating with the teacher much more than she did in a face-to-face manner and submitted some excellent work. This student grew in her ability to use the device, but the device enabled her, despite her shyness, to communicate in ways that showed what she really knew and could do as a student. This aspect of the results encourages the researcher because regardless of whether the BYOD instructional method changed their achievement or attitudes about biology, at least it required students to think about their own learning in general and learn new ways to communicate.

Relationship of Conclusions to Other Research

The intent of this research is to examine whether personal technology can have an influence on the learning of today's high school students. In addition, it is the hope of the researcher is that this study could provide evidence for some positive benefits to learning, as well as discover ways to modify the way students view their own devices. Regardless of the conclusions drawn in the previous section, the results of this study provide some support to already existing research as well as extends the reach of some other studies and new avenues of study. The evidence of this study does not strongly support the use of personal devices during instruction as effective in increasing achievement of all students, but in considering the complexity of the variables involved as well as the urgency to overcome the problems associated with it, the researcher contends the results are not inconsequential overall. The final intent of the researcher in a practical sense is to offer a discussion about the impacts that personal technology in the hands of students might have on the way they learn, their ability to succeed in school, and their potential contributions as a valuable member of the workforce.

Personal Technology and Learning

The way that educators respond to the presence of student-owned technology is important for several reasons. Hand-held, or even smaller technology devices like smart watches, will most likely only become more pervasive with the advancement of web-based applications and other programs currently in development. No one could have imagined when the first bulky, awkward desktop computers were placed in classrooms or computer labs that today those would be replaced by machines much more powerful and capable, even to the extent of learning solely through technology (Yahya, S., Ahmad, E. A., & Jalil, K. A., 2010). Educators with innovative ideas strive to meet the needs of students in the 21st century. Efforts in e-learning, m-learning, blended learning, and other forms of virtual learning experiences have evolved as new technology has become available for today's teachers and classrooms.

Learning in transition.

A constantly connected world has emerged because of today's technology. Brick and mortar school buildings with a live teacher are not the only places formal learning occurs today. Virtual spaces have created endless possibilities for acquiring and understanding new knowledge. A person with a technological mindset who believes he can learn independently without complete reliance on a teacher or other resource can experience seamless learning in a variety of contexts and environments. This is not to suggest that teachers and school buildings are inconsequential or outdated; instead the implication is to view learning opportunities in an uninhibited and less restricted way that welcomes all varieties of learning formats for different learners. The perfect learning scenario for every student is an environment that meets each of his unique needs and at the same time provides him with unlimited learning opportunities. For the first time in the history of education, technological advances have made the way for huge progress in making learning scenarios more "perfect" than they have ever been for students.

One-to-one programs and Bring Your Own Device methods are attempts by school districts and teachers to integrate devices into learning and respond to the needs of students to gain technological skills to compete more effectively. In the setting of this study, the implementation of a BYOD method was appropriate because the study sought to understand how achievement is affected when students use their own devices and how it affects the way they view them as learning tools. The researcher wanted to understand whether a seamless transfer can take place from students solely using their technology for personal use and entertainment to using them for learning, too. If such a shift can occur, and students develop a different perspective on the appropriate use of their technology, the hope is that the issues of smart device distraction in the classroom can be minimized, if not eliminated.

Different perceptions and new behaviors.

For seamless, or continuous learning to take place, students must be able to move from one location to another, take their device with them, and skillfully use the applications provided by the device. If they can use their technology correctly for learning, and have the view that it can be a great resource to them for learning, the possibilities of what their teacher can do and what they can do independently greatly increases. Improved digital literacy of students at all grade levels is critical. Part of literacy is understanding and properly using a device for good purposes (International Society for Technology in Education [ISTE], 2017). The earlier in a student's life this mindset is adopted the better, because students with limited knowledge about technology cannot improve their abilities to manipulate it for learning. The more they can learn about it and use it in a proper way, the more options they will have and better prepared they will be for a possible yet-to-be created career opportunity (Renfro, 2012).

During this study, the researcher observed that students were very adept at "scrolling," that is, quickly moving the screen to skim and read those things that caught their eyes. This is a familiar tactic in perusing social media, but it is a skill that does not serve students well when they are required to read a passage for understanding. Specifically, when students were assigned an article online to read about a genetics concept, the researcher noticed that students scrolled up and down and back again over the article, with many of them not stopping long enough to actually read the article. Again, learning the right skills for the right purposes are important in using technology devices.

The importance of teaching children the right ways to use technology to modify their perceptions or alter their behaviors cannot be overstated. To truly create innovative and competent graduates, potential professionals, and skilled workers, it is reasonable to suggest that students should have a perception of technology, including their own personal devices, as constructive, beneficial resources they can use in a positive way their entire lives. Instead of seeing and using their smartphones exclusively for texting friends and posting pictures to social media, they can use them to improve themselves through learning and eventually use them daily at their place of work or home to make a positive impact on the world around them. If they compartmentalize their devices and only think they should use their computer for school and their phone for social media, they have not accepted a holistic view of the technology available to them.

This research, like other similar studies, sought to determine if a BYOD method of instruction could help students achieve better and change their views about what role their devices should play in their lives. Other studies suggest that for instructional technology to be effective at all, it should be focused, structured, and thoughtfully considered, especially in the K-12 setting (Cristol & Gimbert, 2014). The teacher must facilitate the instruction, but the role of the student is a very important consideration too because in an ideal BYOD classroom, students must be more independent and have a certain level of competence (Parsons & Adhikari, 2016). Additionally, students can be more engaged and take more ownership in their own learning through BYOD methods that are built into their daily schedule. These settings have shown to improve achievement and be more authentic in preparing students for the workplace (Horn & Staker, 2015). The results of many of these studies are quite telling about the importance of student agency in the effectiveness of this type of instructional method. The researcher concurs with this thinking as the lack of student agency was a factor in this BYOD study.

Bring Your Own Device

Supervision.

The experience of using a Bring Your Own Device (BYOD) instructional method from the researcher's point-of-view in this biology class shares some of the same effects and observations made in previous studies by other researchers, while in some ways, it diverges a bit. Common themes that relate this study to other current research about Bring Your Own Device methods include: the regulation of student use and expectations for use, the struggles of "digital natives" to properly maneuver devices, applications, and websites, consistency of device use, and engagement of students during class. As much of the research describes, whenever this type of instruction is employed each of these concerns become apparent. The implications of this study indicate concurrence with these themes.

As discussed in the literature, one of the hesitations schools have about BYOD instruction is the increased regulation and supervision required by teachers and others responsible for the electronic safety of students (Lam & Tong, 2012). From the experience in these biology classes during the unit about genetics, the researcher agrees with this very important consideration. A huge challenge for a teacher, who may have twenty or more students in a class, is to supervise the activities of all twenty students on their own personal devices at the same time. As supervision is a challenge and requires active engagement on the teacher's part, the researcher made a very deliberate effort at the beginning of the study to communicate with students her expectations about proper use. Despite constant efforts to supervise, the researcher admits that it is impossible to regulate the movement of every student at the same time, particularly on their own devices, but by maintaining a secure network and establishing a strong set of expectations with consequences for failure to meet them, students knew the limits about how far they could stray from the standard given them. For the most part, students in the device groups stayed on task during the study period and this was not a serious concern.

A different mindset.

To make learning opportunities as just described for students a reality with even a chance at successful reality, the first step involves a change in attitude by everyone. In schools and classrooms, administrators, teachers, and students must adopt more of an acceptance of technology, particularly personal technology, as a learning tool. Then, efforts should be made to apply it deliberately, with thoughtful planning by teachers and cooperation by students. While it might sound overwhelming, these efforts can begin with something simple.

For example, during the genetics unit, the teacher spent a great amount of time designing the lessons and planning activities to support the content students needed to learn. Part of the planning involved designing short, formative assessments that students could access using their phones or tablets. These were given through use of Google Apps, including Forms and Docs for the students in the device groups. She could give these assessments to find out quickly who grasped the concept and who did not and communicate with individual students through Google Classroom. Not only were these applications time-saving, they gave the teacher opportunities to clear up misconceptions that otherwise might have gone unchecked. The no device group had to wait until the next day to get results and this was not only more time-consuming, but it resulted in a loss of momentum in the learning process. The point of this example is to illustrate that the integration of student devices does not have to completely change the way teachers teach, but it does require a change in the way they perceive the devices.

Digital competency.

Another commonality from the literature shared by the researcher in this study is the competency level of students in today's classrooms, previously described as "digital natives." Even students who have grown up in a world of Internet access have struggles in properly navigating it. This is something for teachers to consider as they integrate technology more extensively (Parsons & Adhikari, 2016). Both device classes of this study, the pre-AP and traditional levels, had students who struggled with using the technology for a learning purpose. Interestingly, all the students who own a smartphone or tablet could follow the functions they find familiar, like Snapchat or texting, but when they had to access websites, set up accounts, remember passwords, and navigate specific websites facilitated by the teacher, a few of them became frustrated. They showed that they were not as digitally competent as they think or we assume them to be simply because they are teens. This reveals that integrating technology into new environments, especially quickly and intensely, can cause anxiety in not only teachers, but students too.

Perhaps not in the high school classroom, but in many places, the intense pace of technological developments is overwhelmingly positive. Transitioning to a heavier dependence on technology has improved pertinent segments of life and made things easier for many people. However, in some instances technology has brought frustration and anxiety to people, as just discussed for some students. For the high school classroom specifically, the tech devices themselves have not caused the problems, but instead the interference they can cause in traditional classroom operations. The studies in the literature that show positive effects of using mobile learning devices have a common theme throughout: consistency (Cristol & Gimbert, 2014). In studies that showed the greatest success using devices, students were given adequate time to become accustomed to using devices more consistently and with repetition had greater opportunities to grow and improve their digital competency, thus eliminating the frustration with the device.

An important implication relevant to the current study is that students in the device classes were not given the opportunity to gradually accept the use of devices during instruction. They were provided information about what would be expected of them, but they were ultimately asked to "jump in" and get started on the first day of the unit. Research supports the idea that the more students use devices, the more they like them (Tessier, 2013). This very likely could have played a role in the attitudes of the students and the overall success of the BYOD instructional method.

Engagement.

The last common area that this study shares with the relevant literature is engagement of students. Many teachers, particularly at the high school level, view this as a major problem they face daily in all subject areas and all levels. Overcoming barriers of distraction from a variety of sources is a struggle and many different approaches have been attempted to reduce them. One such approach is the use of technology. In considering this, one might think that technology use in general might be a motivator to engage students with the content of a lesson, but that personal technology use might only encourage students to be less engaged because they can access other sites and applications that are more appealing to them. The researcher acknowledges that many people view hand-held technology devices owned by students as a threat to their abilities to engage and instruct students, but it goes back to expectations and establishing an appropriate mindset in students that influences their behavior with devices. A classroom culture based on trust and high expectations greatly reduces any threats posed by personal devices.

At the beginning of this study, the researcher established a set of guiding expectations for the students in the groups using devices. She was very clear about what she expected in terms of staying on task. As discussed previously, it is impossible to guarantee that every student is always focused, but this is true in any classroom setting. During this unit, there were instances when the students needed redirection, but these times were very few. The researcher was more interested in teaching students to maneuver through the capabilities of the device than policing the time spent on specific sites. For the most part, the students were cooperative and engaged.

Most innovative educators would probably agree that a goal of education is to teach students to be more independent in how they engage with learning opportunities made available to them and to develop a sense of accountability for their own success. These are 21st century job skills. Employing mobile devices in learning and encouraging students to use their own device appropriately promotes more independent learning because students are required to explore for themselves instead of being told what to learn by the teacher. In using the Internet, teachers can guide students in the direction about what they should investigate and teach them the skills needed to be a good researcher and give them the freedom to find it for themselves. Not only does this increase the responsibility put on the student for their learning, but it allows them creativity in accessing information in the way that interests them. Teaching students in this way is exciting to the researcher, but from the experience in the study, describing it is much easier than implementation.

In the traditional classes particularly, the researcher observed in several instances that most students could not work independently, even with a mobile smart device. They wanted the teacher to tell them every step to take and they needed validation at every step that they were right. This helpless type of behavior is common with traditional students in a regular classroom setting without technology, but the researcher wanted to know if their device would change this behavior. This is ironic because when they "play" on their devices, they feel completely uninhibited to click on tabs and swipe the screen without any fear. The constant need for help by the students astonished the researcher, even dumbfounded her, the first time she experienced it because she really believed they would be less dependent than they were. However, she realized that it reinforced an issue that is common in students who typically perform at lower levels, like the ones in the traditional biology classes.

This issue includes low expectations and the inability of teachers to let students experience a productive struggle. All too often, teachers want to do what they were trained to do, that is, help students. What is often a negative effect of too much help though, is students learn that if they quit trying early enough, the teacher will step in and bail them out, providing help. This effect was no different when students had a technology device in their hands with Internet access to any help they could find. Students continued to want to rely on the teacher for help every step of the way.

Overall, proper integration of technology into instruction, including a BYOD method, requires that the learning environment, content of the class, and the students involved all connect in an appropriate situation that maximizes the benefits available. This was not only revealing to the researcher in this study, but this concept is supported in the literature (Melhuish & Falloon, 2010). Technology use does not ensure learning any more than another instructional practice. Not every subject matter can be most effectively learned by employing technology either, so teachers need to be aware of when it is best applied and how to apply it. Other aspects of awareness are whether the environment supports technology use in proper network availability, Internet safeguards, and user agreements. Lastly, for it to work at the highest possible level, students should own some of the responsibility for their learning and have the self-sufficiency and digital knowledge and skills to be an active participant.

A New Paradigm for Teachers

Much is found in the literature regarding not only addressing student technology needs, but the needs of teachers too. How unrealistic it sounds to expect teachers to automatically have the skills they need to be effective in teaching with technology, yet this happens frequently. An aspect that often is not considered is how important it is to remember that using technology is very different than teaching with it (Johnson et al., 2015). Lack of proper professional training in this area is one reason teachers remain hesitant and even fearful of trying to teach in newer ways that are more relevant for today's students. The researcher in this study made the decision to overcome any hesitancy and fear and give a bold effort to try to improve the environment as well as the achievement of her students. What she learned most from it, and others in the literature who support courageous risk (Dweck, 2014), was that what she learned regarding how to implement the BYOD method she sought out and learned on her own.

From reading and studying about how others employed it, the researcher developed a teaching plan and used it to integrate student-owned devices into instruction while striving to maintain certain pedagogical aspects she knew to be crucial in any learning environment. Despite her efforts, she knows that she needed more preparation and skill development herself to make the experience more productive for the students. For her and other teachers interested in developing these skills, due to other requirements of full-time educators, it is very difficult to find time and motivation to add something else to their full agendas. With this in mind, the researcher suggests that the preparation and training of preservice teachers needs to include greater emphasis on digital literacy. As described in the literature review, current research indicates that over half of future teachers who will replace the next wave of retirees do not have any different perspectives about personal technology use than older teachers (Thomas & O'Bannon, 2013).

Using technology effectively as a learning tool in a classroom or other setting must be structured and meaningful. Understanding natural phenomena or real workplace problems can be greatly improved if students can use technology to create or manipulate their own models (Looi, C., Seow, P., Zhang, B., So, H., Chen, W., & Wong, L. 2010) or learn in a non-traditional setting (Martin & Ertzberger, 2013). The researcher concurs with this concept, but effective use is a much bigger challenge than one might imagine. More thought and planning is required beyond turning on the device and letting students use them. Effective instruction requires teachers and other educational leaders to make intentional efforts to overcome the barriers that exist in the unstructured world of personal technology in which students have already found comfort and pleasure. This study reveals some additional information about the effect of personal technology use in class on student achievement and adds some interesting insights related to how students view their devices and their willingness to broaden their perspectives about the capabilities they possess.

This study was narrow in focus regarding how personal technology affects learning by employing it as a learning tool in a specific classroom setting, but the conversation about the influence of personal technology is much broader and transcends the scope of this study. The researcher hopes that the learning from this work will provide support and validation for the effort to create learning environments that support personal technology use while simultaneously guiding students to new mindsets about how to best employ their devices in and out of classrooms.

Limitations of the Study

As predicted in the design of the study, certain limitations are worthy of discussion. The researcher thought in the beginning that the availability of personal devices might be an issue that would inhibit the effectiveness of the BYOD method, but this issue was very insignificant. The large majority of students owned a device of some kind, either a tablet or smartphone, and could use it during class. In each device class, there were on average each day one or two students who needed a school-owned tablet to use. Most of the instances of this were simply because the student did not own his own device. The researcher was not surprised that students rarely forgot to bring their devices to class because they hardly ever put them down. They want to use them as much as they can every minute they have a chance. The only minor issue was that sometimes the devices were not charged. In this case, students had to change their seating so they could reach an outlet for power.

Another potential limitation that ended up not being an issue was inclement weather. The mild winter led to no missed days for snow and the school calendar was not affected. Thus, classes met regularly during the weeks spent on the genetics unit. However, a different schedule-related dilemma that caused slight hindrances in instruction was the issue of absenteeism. Unpredictably, students in both device and no device groups experienced illness that kept them away from school and caused them to get behind. This common problem happens every year in all classrooms and is often one reason students fall behind and do not experience growth or progress as they should. Not in every instance, but most commonly, the traditional students tend to miss school more often than pre-AP students for a variety of reasons, not solely because of sickness. Often, frequent absences are a trend in many of these students' school histories and might possibly be a reason they are placed in traditional classes. They require a slower pace because they have difficulty catching up after missing so much instruction and additionally, they are less motivated to seek out extra help from the teacher outside of class time. The researcher cannot make any conclusions about the influence of absences on the results of this unit, but absenteeism is an issue that affects instruction in a general sense regardless of method.

A third limitation of this study that deserves consideration is the sample size of each group. Fewer students and their parents provided permission for the researcher to analyze their test scores and survey data as predicted. Perhaps if a greater number of students' data had been considered, the results would have been different, but at the same time, the results might not have changed. After considering the scores and results of all the students collectively, the researcher thinks that the samples of each group were accurately representative of the whole because the students who were included were typical. The low sample size was especially true for the traditional student groups. The reason the researcher thinks the sample size was limited was because it was difficult to get high school students to complete the form, get their parents to sign and return the form, and turn it in to the right person. The researcher was not involved in the process of handing out or collecting forms, as she needed to remain unbiased and unaware of who returned forms. No incentives, which often work well for high school students, could be given and the researcher believes this decreased the return rate of the forms.

Another issue that might have been impactful to the results and interpretation of the conclusions is the issue of time. The BYOD instructional method lasted approximately eight weeks and during this period the students in the device group used their devices almost every day in one way or another. They conducted research, read articles, watched videos or animations, or submitted individual assignments. To some students, this was a bit overwhelming and the researcher realized after a few weeks that she needed to slow the pace and scale back the number of different applications and websites she asked them to use. This is when the researcher became aware of the students' lack of confidence and competence in using their devices for more than entertainment. They might have had a more successful encounter with the unit if they possessed more previous experience with using their devices in this way or if the way they used them was a bit different. This was not true for every student however, as some students caught on very quickly and were able to use the sites very efficiently and complete assignments well.

Along with a great learning curve for students, the researcher recognizes the learning that was required of her to be the teacher during a BYOD unit. She spent months preparing, researching, and practicing different methods, and even so, knows that she could have spent much more time preparing before the unit began. She was more than willing to step out and try and was not afraid to experience failure, but admits that she could benefit immensely from professional development and more practice before she could say that she was effective at it. Just like any instructional method to work well, a teacher must practice it and refine the skills needed to make it effective. Using technology in teaching is certainly no different.

Because students have constant access to their own devices, it is impossible for the researcher to know if students in either group used their devices to learn outside of class by their own choice. There is a possibility that the confounding variable of outside learning affected the results. Students in the no device group could have used their devices to help them with assignments or get extra help outside of class and this could have made an impact on their learning in one way or another.

The last potential limitation that was predicted by the researcher in the methodology was the fact that the researcher of the study was also the teacher of the classes. In the methodology, the researcher indicated that as a classroom teacher, she has fervent interest in this issue. Because she has experienced the same frustrations as teachers who battle the distractions of devices every day, but also believes that there is still great potential for them to be effective lifelong learning tools, it was important for her to gain the experience herself. The researcher has no doubt that experiencing the BYOD method as the teacher in the forms of observer, evaluator, and planner in the classroom, in addition to being the researcher, helps her to know even more intimately what changes should be made in the way our students use and perceive their devices and how teachers can effectively use them.

Recommendations for Further Research

Technology and how it is used effectively in the classroom, is a topic that is worthy of further research. This research about personal technology and high school instruction needs additional study. The scope of this research was limited to high school biology and could be expanded to consider other subject areas in the high school, as well as different grade levels, with appropriate regulation. The researcher was surprised at how different the levels of classes, pre-AP and traditional, were at learning through BYOD instruction, so further investigation of how personal devices influence students at different achievement levels would be a good area of follow-up to this study.

Considerations for future teachers.

An area for consideration for further study includes how teachers are developed as users and facilitators of personal technology in the classroom overall, especially preservice teachers. College students currently studying to become teachers will replace many current teachers in the next decade. If new teachers enter the profession with little to no understanding of how to integrate devices into their instruction, the same problems that current teachers face will occur.

However, if new teachers begin work with some training on when using devices is most appropriate and how to integrate them, they can plan, instruct, and assess in a way that supports proper and manageable integration of student devices in an environment that supports learning and responsible use of devices. Perhaps if the expectations given to students by teachers included that they would have learning opportunities using their devices, students would start seeing their devices more like tools. Free and appropriate uses of devices could replace the distractions of sneaky texts and games.

Student Perceptions.

One of the most striking implications of this study is that student ideas and attitudes about using their personal devices to learn are important to consider in using any kind of blended learning model like the one explored in this study. The willingness of students to fully engage is an important component in a successful BYOD implementation. To further investigate this area of research, it would be pertinent to conduct a qualitative study using interviews of students or student focus groups before and after their experiences in using devices to learn. By comparing what students with limited experience think to students with more and varied experience, it would be interesting to see if prolonged and more extensive use might have an impact on perspectives. The researcher is interested to know whether more time spent in meaningful BYOD instruction would help students develop a greater comfort level and enhance their experiences so they can develop more positive thoughts about using their technology for learning purposes.

Long-term consequences.

Regardless of the path this research topic takes in the future, personal technology is not disappearing. In fact, with advances in capabilities and affordability, it will only become increasingly prevalent in the lives of everyone, including students. Another consideration that the researcher continues to ponder related to the presence of personal technology, considering the discoveries of this study, is the consequences of any potential long-term effects, perhaps both good and bad, of technology on lives of students. Disregarding the deep-seated attraction that students, particularly high school and even college students, possess for their devices is a mistake. The impacts of being constantly connected to a device, either visually, audibly, or otherwise, are unclear and unknown today, but a conversation of the social impacts of constant digital connection is worthwhile in conjunction with how it affects learning. While technology devices are great sources of information and extremely convenient, it is important to be aware of how much influence they might have on our students and ourselves.

Researcher as Learner

While the teacher as researcher might not be the ideal for a study like this, the researcher was able to gain some interesting new insights and support some previous ideas that she had prior to the study. These insights have potential to become new research interests. As such, it is important to continue to observe and pay close attention to the effects of the study on her own development as teacher and researcher, as well as how students have been affected.

Individualized Approaches.

The researcher is pleased that a few students in the device groups continued to use their devices to work on assignments and submit work to her even without being instructed to do it that way. This is an indication to her that these students gained skills in using their own personal technology in new and meaningful ways. For students in the device groups, technology use continued to be an option for many assignments they were given, regardless of how they were instructed. Some students used their devices extensively to complete and submit assignments without being prompted. As mentioned previously, one student continued to learn on her own new ways to create presentations and share them with the class using her own device. The researcher thinks this is evidence that even though the statistical results showed no significance by level and group, individual students showed growth in how they can successfully use their devices to learn.

Resistance.

Despite these success stories that show positive changes in learning can happen with teens and their phones, some students are resistant to changing their attitudes about their own personal technology. Students in the device group of the study who expressed negativity about the use of their device in learning, all share some common beliefs as evidenced in the survey responses. First, these students want to depend on the teacher to tell them what they need to do and know. Next, they become very uncomfortable when learning gets challenging and they have a fear of trying anything new because it might be a hard for them. And lastly, students might have to work harder to earn the same grade they did with traditional methods. Ultimately, they all have a fixed mindset about learning and their technology. They have the attitude that they do not want to use their personal devices for learning because it takes away the fun they associate with them for social purposes. Sadly, these students in high schools today are common because somewhere in the progression of their education, they started believing that change and failure were negative and not an opportunity to grow. The goal of school became getting certain grades instead of a time to experience learning.

Device Etiquette.

The observations and findings about students' reluctance to learn with devices is intriguing and leads to many new questions. This study reveals that student attitudes about their phones and tablets vary depending on their own level of comfort and skill. A question that remains is whether personal devices should be used at all. Based on the findings of this study, the researcher continues to contend that a cell phone ban is not the right approach. Simply because some students are resistant to changing their attitudes about how they use their phones does not mean they cannot or should not be changed. The reasons for modifying any type of instructional method should be based on improving learning opportunities for students and ultimately their achievement. Students can benefit if they can be taught to broaden their perspectives about all of the possible learning options they have and adopt the attitude that learning with their devices does not have to eliminate the fun and enjoyable aspects of it. A cell phone ban is not necessary when students know how to use their devices in a variety of settings appropriately and respectfully.

The researcher suggests that for any instructional method using personal devices to be adopted and implemented successfully, students need proper instruction in cell phone and device etiquette. Two of the characteristics of a student who shows good digital literacy are empowerment and responsibility. An empowered learner "leverages technology to take an active role in choosing, achieving, and demonstrating competency in their learning goals" (ISTE, 2017) and they "recognize the rights, responsibilities, and opportunities of living, learning, and working in an interconnected digital world, and they act and model in ways that are safe, legal, and ethical" (ISTE, 2017). When students are taught what is expected of them while they use their personal devices during classes, they can learn when it is proper to have it available to use and when it is appropriate to keep it hidden. At the same time, they understand when the time is appropriate to "play" with their favorite applications or websites. Over time and with consistent reinforcement, the researcher predicts that student attitudes can be modified so that they are capable learners using devices without giving up the fun things they enjoy with them. Unfortunately, students may possess a personal technology device with countless capabilities for use in a learning setting, but rarely experience the instruction of how to do so.

Because technology is so influential in every aspect of life today, the skills that today's students and tomorrow's workers need will include the ability to effectively use and manipulate technology in countless fields including business, government, military, education, and many other areas (Collins & Halverson, 2009). A change in mindset is required that sees technology, even personal technology, as a great source for learning. Often, a student's personally-owned smart technology is their first experience with using and manipulating all the information found in the Internet and it needs to be a source for seeking answers and solving problems. Millennial and Generation Z students in classrooms today have grown up in the age of the Internet (McAlister, 2009; Wiedmer, 2015). Because of this, they have the foundation to establish a mindset around technology to learn appropriate skills to use it efficiently and effectively in all aspects of life, including the classroom as a student and a professional in the workplace.

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Appendix A

Examples of How Technology Activities Connected to Genetics Content

Genetics Content	Technology Application
Monohybrid/Dihybrid Cross Practice	Students were given a Google Doc with various genetics crosses for practice. They could print it and submit the paper copy or download and edit the document on their devices. (most students chose the latter)
Information about Mendel's Laws of Inheritance	Students were given multiple formats to access this information. The teacher created a slideshow in Google Slides and posted it to Classroom. She also converted it to PowerPoint for those who preferred it. The slideshows were uploaded to Nearpod, so students could interact with the content as it was discussed in class.
Mitosis vs. Meiosis Check Quiz	Quick, effective formative assessments were conducted often using Google Forms. For example, the teacher wanted to make sure they understood the difference between the two kinds of cell division, a common misconception students have. She created a Form with the specific questions she needed to ask to find out if students knew the difference.
DNA and RNA	Students were directed to a set of lessons on the CK-12 Foundation website that explained the discovery of DNA and RNA and the many technological advancements since the 1950's. YouTube videos and other diagrams are embedded for students to select to view as they read through the lesson.

Appendix B

Parental Consent Form

MSU Student Researcher: Susan Beatty

MSU Faculty Sponsor: Dr. Teresa Clark, Assistant Professor, Murray State University, 3233 Alexander Hall, Murray, KY 42071. (270) 809-6956

Date: December 6, 2016

Study Title: The Effects of a Bring Your Own Device Instructional Method on Learning in a High School Biology Class

The following information is provided to inform you about a research project and your child's participation in it. Please read this form carefully and if you need to ask questions, please feel free to contact the faculty sponsor listed above. Please make a copy of this form for your records before returning it to school.

1. **Purpose of the Study**: The purpose of this study is to learn more about how personal technology devices (cell phones, tablets, laptops) affect student achievement and student attitudes about using technology to learn.
2. **What we will ask the student to do:** For one unit of study, students will be asked to use a technology device during biology class. Students will complete assignments, activities, and other tasks like quizzes and tests using either a personal device or one provided by the school to use during class.
3. **Risks:** There is very minimal risk to students in this study. The teacher will monitor student work and grades very closely, as well as how students use the technology.
4. **Benefits:** Benefits of this study include exposing students to different educational experiences using technology. Students have a strong interest and attachment to their devices and this study seeks to help them learn to use them as learning tools.
5. **Compensation:** Students will receive no compensation or extra credit in the class for participating in this study. Grades will be determined using the same methods as described in the class syllabus.
6. **Voluntary:** The use of your child's test scores and survey answers in the study is your choice. By consenting, you are agreeing for your child's test scores and survey responses to be included in the study. You and your child have the right at any time to decide for their data to be excluded. Your student will not be punished, lose any privileges, or face any negative response based on your decision to allow or disallow their scores and responses to be included in the study. The researcher will not be aware of which students and parents have agreed for their data to be used in the study until after final grades are submitted. Ms. Amy Forsee will keep all parent consent, student assent, test scores, and survey results until this time.
7. **Confidentiality:** In analyzing student data, no names or personal identifiers will be used. Data regarding your student's work, including scores, survey responses, and consent and assent forms will be kept in a secure location by Ms. Forsee during the study and by the researcher after the study for at least one year after your child turns age 18.
8. **Whom to Contact:**
   Dr. Teresa Clark, Advisor, Murray State University - (270) 809-6956 or tclark24@murraystate.edu

I have read this informed consent document. I freely and voluntarily choose to allow my student to participate in this study under the conditions outlined above.

This document must be returned by December 16, 2016 if you would like your child to participate.

Printed Name of Student:

____

Signature of Parent/Guardian: Date:

____

THE DATED APPROVAL STAMP ON THIS CONSENT FORM INDICATES THAT THIS PROJECT HAS BEEN REVIEWED AND APPROVED BY THE MURRAY STATE UNIVERSITY INSTITUTIONAL REVIEW BOARD (IRB) FOR THE PROTECTION OF HUMAN SUBJECTS. ANY QUESTIONS PERTAINING TO YOU OR YOUR CHILD'S RIGHTS AS A PARTICIPANT SHOULD BE BROUGHT TO THE ATTENTION OF THE IRB COORDINATOR AT (270) 809-2916 OR msu.irb@murraystate.edu . ANY QUESTIONS ABOUT THE CONDUCT OF THIS RESEARCH PROJECT SHOULD BE BROUGHT TO THE ATTENTION OF DR. TERESA CLARK: tclark24@murraystate.edu OR (270) 809-6956.

Appendix C

ASSENT TO PARTICIPATE IN RESEARCH

Ms. Beatty is working on a project for her doctoral degree. The name of the project is "The Effects of Bring Your Own Device (BYOD) Methods on Student Achievement and Attitudes About Learning." This means that she is going to try to use some different kinds of teaching methods using tech devices like cell phones, tablets, and laptops. You are being asked to agree to allow her to use your test scores and survey responses in the data collection for the study. She will use this data to see if using technology devices improves scores and/or changes student views about technology in the classroom.

Some classes will continue to learn in the regular way with technology such as the Smartboard, but other classes will use handheld technology devices a lot more. Students in these classes will be expected to use their own personal device or a school device during class. Ms. Beatty will go over the expectations for using devices when the study begins. Regardless of what way your class learns the content, for your individual data to be included (test scores and survey answers), you must give permission. If you change your mind, you can ask for your scores and responses to be excluded from the study at any time.

She does not foresee any risks to you that could result from this study. Names will be removed from all documents and you will not be personally identified in the study. She will continue to monitor your work and progress very closely throughout the unit as she normally would and if she sees problems in your understanding of the content, she will adjust instruction as needed.

You will receive no extra benefits, such as extra credit, if you consent for her to use your data results and you will continue to be graded as usual. You will also receive no punishment or negative impacts if you do not agree to let her use it. Ms. Forsee will administer and collect all forms and documents and keep them secure until after the data collection time is over and your grades have already been reported to the office. Ms. Beatty will not know who has given consent until after that time. Your grades will still be based on tests/quizzes, projects and labs, and in-class work regardless of how instruction is delivered.

Signing your name at the bottom means that you agree to allow your test score and survey response data to be used in this study. You will be given a copy of this form after you have signed it.

____
Signature of Subject

____ ____________________
Printed Name of Subject Date

Appendix D

Mendel/DNA Unit Pre-Test **Name ___________________________**

<u>Multiple Choice: 13 Questions</u>

Choose the correct answer to each question.

1. What combines with sugar and a phosphate group to form a nucleotide?

   A. Amino acid
   B. Deoxyribose
   C. Glycerol
   D. Nitrogenous Base

2. Nondisjunction can occur during which of the following phases?

   A. Metaphase I only
   B. Anaphase I only
   C. Metaphase I and II only
   D. Anaphase I and II only

3. Keisha passes a local dairy farm that has many brown cows, but only a few white cows. A dominant allele produces brown hair in cows and a recessive allele produces white hair. Which characteristic of any brown cow can Keisha identify?

   A. The genotype of both of the cow's parents.
   B. The genotype of the cow's hair color.
   C. The phenotype of both of the cow's parents.
   D. The phenotype of the cow's hair color.

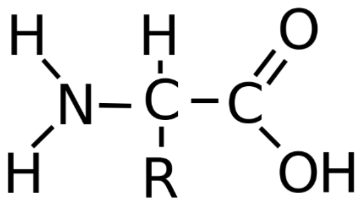
4. In humans, pigmented skin is dominant to non-pigmented skin (albinism). What is the genotype of an individual with albinism?

   A. Carrier
   B. Heterozygous
   C. Homozygous dominant
   D. Homozygous recessive

5. Cystic fibrosis is a genetic disease in which excess mucus accumulates in the lungs and digestive system of affected individuals. Males and females must inherit 2 alleles with this mutation to have the disease. What is the mode of inheritance of cystic fibrosis?

   A. Autosomal dominant
   B. Autosomal recessive
   C. Sex-linked dominant
   D. Sex-linked recessive

6. This molecule is an example of which substance?



   A. Amino acid
   B. Carbohydrate
   C. Fatty acid
   D. Nucleotide

7. Despite the diversity of nature, most organisms contain the same 4 DNA bases. This table shows the DNA composition of 3 organisms as reported in a classic 1950s experiment.

	Base Composition	(percent)		
Organism	Adenine (A)	Guanine (G)	Thymine (T)	Cytosine (C)
Human	29	21	29	21
Wheat Germ	27	23	27	23
E.coli	25	25	25	25

   Based on this study, what did scientists conclude about the DNA composition of all organisms?

   A. A, G, T, and C occur in equal percentages.
   B. A and G occur in equal percentages, and T and C occur in equal percentages.
   C. A and T occur in equal percentages, and G and C occur in equal percentages.
   D. A and C occur in equal percentages, and T and G occur in equal percentages.

8. Consider this mRNA codon chart:

Second Position

First Position (5' end)	U	C	A	G	Third Position (3' end)
U	UUU Phe UUC Phe UUA Leu UUG Leu	UCU Ser UCC Ser UCA Ser UCG Ser	UAU Tyr UAC Tyr UAA *Stop* UAG *Stop*	UGU Cys UGC Cys UGA *Stop* UGG Trp	U C A G
C	CUU Leu CUC Leu CUA Leu CUG Leu	CCU Pro CCC Pro CCA Pro CCG Pro	CAU His CAC His CAA Gln CAG Gln	CGU Arg CGC Arg CGA Arg CGG Arg	U C A G
A	AUU Ile AUC Ile AUA Ile AUG Met	ACU Thr ACC Thr ACA Thr ACG Thr	AAU Asn AAC Asn AAA Lys AAG Lys	AGU Ser AGC Ser AGA Arg AGG Arg	U C A G
G	GUU Val GUC Val GUA Val GUG Val	GCU Ala GCC Ala GCA Ala GCG Ala	GAU Asp GAC Asp GAA Glu GAG Glu	GGU Gly GGC Gly GGA Gly GGG Gly	U C A G

The mRNA sequence ACU codes for the amino acid Thr. A mutation occurs, and the resulting mRNA sequence is AUU. What amino acid will replace Thr?

A. Val
B. Met
C. Ile
D. Ala

9. Suppose that a *Brassica rapa* plant has 2 alleles for dark green leaf color and has dark green leaves. A second *B. rapa* plant has 1 allele for dark green leaf color and 1 allele for yellow-green leaf color and has dark green leaves. Based on this information, which term best describes the relationship between these 2 alleles, in terms of the resulting phenotype, assuming that the leaf color character is controlled by a single gene?

A. The alleles for the gene coding for leaf color are sex-linked.
B. The alleles for the gene coding for leaf color are codominant.
C. The allele for dark green leaf color is dominant to the allele for yellow-green leaf color.
D. The allele for yellow-green leaf color is dominant to the allele for dark green leaf color.

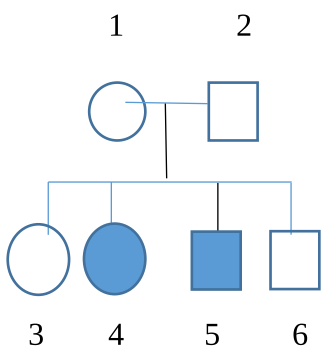
10. How does the regulation of gene expression lead to cell specialization?

A. Enzymes degrade necessary DNA.
B. Methylation of some regions of DNA prevents transcription.
C. Mutations change certain RNA sequences.
D. Removal of exons from RNA prevents translation into protein.

11. The manner in which chromosomes separate into gametes during meiosis is the molecular mechanism behind which of Mendel's laws, if either?

    A. Law of independent assortment only
    B. Law of segregation only
    C. Both the law of independent assortment and the law of segregation
    D. Neither the law of independent assortment nor the law of segregation

12. Alkaptonuria is a genetic disorder of protein metabolism. The disorder is determined by 2 alleles at 1 locus. What is the genotype for Individual 1 in the diagram?



Key: A filled in shape means

The person is affected

    A. AA or Aa
    B. AA
    C. Aa
    D. Aa

13. Horses born to 2 palamino (golden-coated) horses have a 25% chance of having a white coat, a 25% chance of having a chestnut (brown) coat, and a 50% chance of having a palamino coat. Which description of inheritance best explains the coat-color trait in these horses?

    A. Palomino coat color is a recessive trait.
    B. Palomino coat color is a dominant trait.
    C. Coat color is an incompletely dominant trait.
    D. Coat color is a sex-linked trait.

Constructed Response: 3 Questions

Write a complete response to each question.

14. A form of hemophilia is a human X-linked recessive disorder that affects blood clotting. Phenylketonuria (PKU) is a human autosomal recessive disorder that affects the body's ability to use the amino acid phenylalanine. Females are less likely to inherit this form of hemophilia than are males, but males and females are equally likely to inherit PKU.

Use your understanding of genetics to:

A. Describe the difference between sex chromosomes and autosomal chromosomes in humans.
B. Explain why females are less likely to inherit this form of hemophilia than males.
C. Explain why males and females are equally likely to inherit PKU.

15. Color blindness is an X-linked recessive trait. Sue is not color-blind, but Ruth (Sue's mother) and Luke (Sue's brother) are color-blind. Stan (Sue's father) and Tom (Sue's husband) are not color-blind, and neither is Mark (Sue and Tom's son). Sue and Tom are expecting their second child.

Use your understanding of genetics to:

A. Assign specific allele designations and genotype labels for each phenotype.
B. Diagram the pedigree for this family, indicating each named individual's genotype and phenotype for color blindness. Color-blind individuals will have a filled-in circle or square.
C. Determine the probability of Sue and Tom's second child being color-blind if that child is a boy. Draw a Punnett square and use it to determine this probability. Explain your answer.
D. Determine the probability of Sue and Tom's second child being color-blind if that child is a girl. Explain your answer.

16. A biologist identifies the DNA sequence, or gene, that codes for a protein that stops the production of eggs in mosquitoes. She labels this gene Sequence 1. During her investigation of the replication, transcription, and translation of the gene, she observes mosquitoes in which the protein coded by this gene does not function. She labels the DNA sequence for this version Sequence 2. The first table shows one DNA strand for each gene sequence. Use the mRNA Codon Chart to complete the following tasks.

Sequence #1: TACATACTAGGTCGAGGCATC

Sequence #2: TACATGACTAGGTCGAGGCATC

Second Position

First Position (5' end)	U	C	A	G	Third Position (3' end)
U	UUU] Phe UUC UUA] Leu UUG	UCU] Ser UCC UCA UCG	UAU] Tyr UAC UAA *Stop* UAG *Stop*	UGU] Cys UGC UGA *Stop* UGG Trp	U C A G
C	CUU] Leu CUC CUA CUG	CCU] Pro CCC CCA CCG	CAU] His CAC CAA] Gln CAG	CGU] Arg CGC CGA CGG	U C A G
A	AUU] Ile AUC AUA AUG Met	ACU] Thr ACC ACA ACG	AAU] Asn AAC AAA] Lys AAG	AGU] Ser AGC AGA] Arg AGG	U C A G
G	GUU] Val GUC GUA GUG	GCU] Ala GCC GCA GCG	GAU] Asp GAC GAA] Glu GAG	GGU] Gly GGC GGA GGG	U C A G

A. Determine the mRNA sequence that complements Sequence 1.
B. Use the mRNA Codon Chart to translate the mRNA sequence from A into an amino acid chain.
C. Identify the type of mutation in Sequence 2 and describe how this mutation specifically affects the amino acid sequence of the protein.
D. Describe the role of the ribosome and tRNA in translating the mRNA sequence into an amino acid chain.

Source of test questions: ACT Quality Core © Test Builder – biology
Retrieved from https://forms.act.org/qualitycore/test_builder/test_builder.html

Appendix E

Mendel/DNA Unit Post-Test Name ___________________________

<u>Multiple Choice: 13 Questions</u>

Choose the correct answer to each question.

1. DNA molecules differ from RNA molecules in which of the following ways?
   I. DNA molecules contain a different type of pentose sugar than do RNA molecules.
   II. DNA molecules contain the nitrogenous base cytosine while RNA molecules do not.
   III. RNA molecules contain the nitrogenous base uracil while DNA molecules do not.

   A. I and II only
   B. I and III only
   C. II and III only
   D. I, II, and III

2. A trisomy of chromosome 21 causes what condition?

   A. Albinism
   B. Dwarfism
   C. Down Syndrome
   D. Color blindness

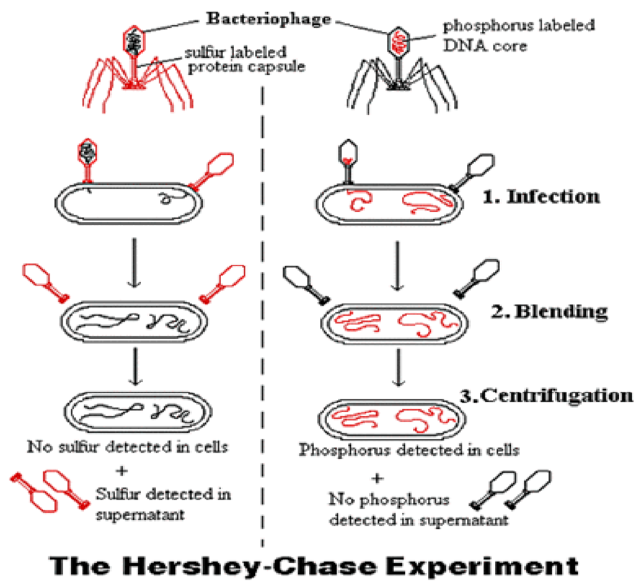
3. During metaphase I of meiosis, which of the following occurs?

   A. Centrosomes of replicated chromosomes line up along the cell's equator
   B. Sister chromatids separate and move toward opposite poles of the cell.
   C. Paired homologous chromosomes line up along the cell's equator.
   D. Homologous chromosomes separate and move toward opposite poles of the cell.

4. Suppose Condition A is an autosomal recessive trait that affects the nervous system. In one family, the father, mother, daughter, and elder son do not have Condition A, but the younger son has Condition A. Both of the individuals in which of the following pairs MUST be carriers of the Condition A allele?

   A. Father and elder son
   B. Mother and daughter
   C. Daughter and elder son
   D. Mother and father

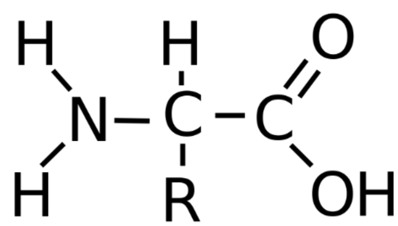
5. Bacteriophages infect bacterial cells causing them to produce more bacteriophages. The Hershey-Chase experiments used radioactively labeled bacteriophages as shown in the table.



What was the conclusion of the Hershey-Chase experiments?

A. DNA from the bacteriophage entered the bacteria.
B. DNA from the bacteriophage became bacterial DNA.
C. Protein from the bacteriophage entered the bacteria.
D. Protein from the bacteriophage became bacterial DNA.

6. This molecule is an example of which substance?



A. Amino acid
B. Carbohydrate
C. Fatty acid
D. Nucleotide

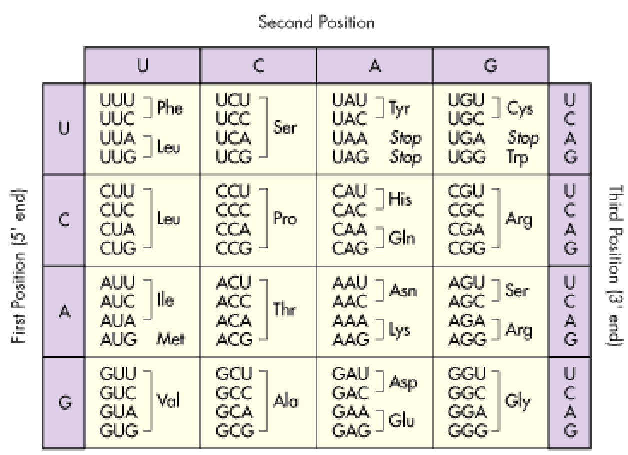
7. Which example best illustrates Mendel's law of independent assortment?

   A. Two short-haired cats produce a litter of 4 kittens including 1 long-haired and 3 short-haired.
   B. A color-blind man and a woman with normal vision produce a son with normal vision and a color-blind daughter.
   C. A tall purple-flowered pea plant and a short white-flowered pea plant are crossed, producing offspring including tall white-flowered pea plants.
   D. A red-flowered snapdragon and a white-flowered snapdragon are crossed, producing offspring with pink flowers.

8. Two black guinea pigs bred and produced 3 black offspring and 2 albino offspring. Assuming no mutations, which guinea pigs must be heterozygous?

   A. All 3 black offspring
   B. Exactly 2 of the black offspring
   C. Both albino offspring
   D. Both parents

9. Consider this mRNA codon chart.



Which of the following mRNA sequences codes for valine (Val), glutamic acid (Glu), and serine (Ser), respectively?

   A. UGG-AGG-CUA
   B. GUA-GGG-AGC
   C. GUC-GAA-ACU
   D. GUG-GAG-AGC

10. Suppose that in humans, a certain type of color blindness is a recessive, X-linked trait. The chromosomes and alleles associated with this type of color blindness are represented in this chart.

X = X chromosome
Y = Y chromosome
B = allele for normal color vision
B = allele for color blindness

Which of these could NOT be a biological child of parents having the genotypes X^BX^b and X^BY?

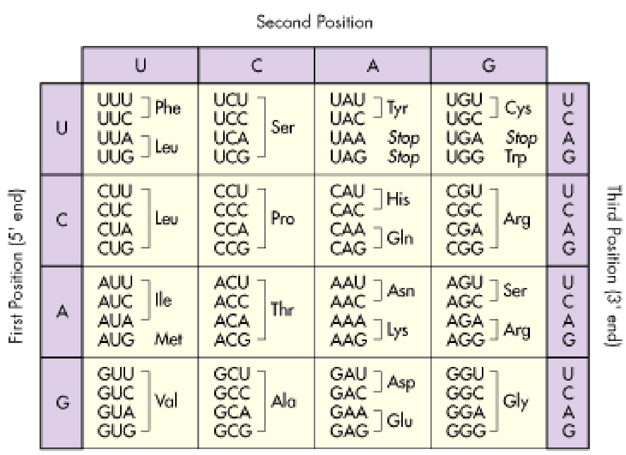
A. Color-blind son
B. Color-blind daughter
C. Daughter with normal color vision
D. Son with normal color vision

11. Persons A and B have similar mRNA sequences with the exception of 1 nucleotide.

Person A: AUGGUUACUAAGGGCUGA

Person B: AUGGUUACUGAGGGCUGA

Use the genetic code chart to determine how this difference affects the sequence of amino acids in the resulting protein.

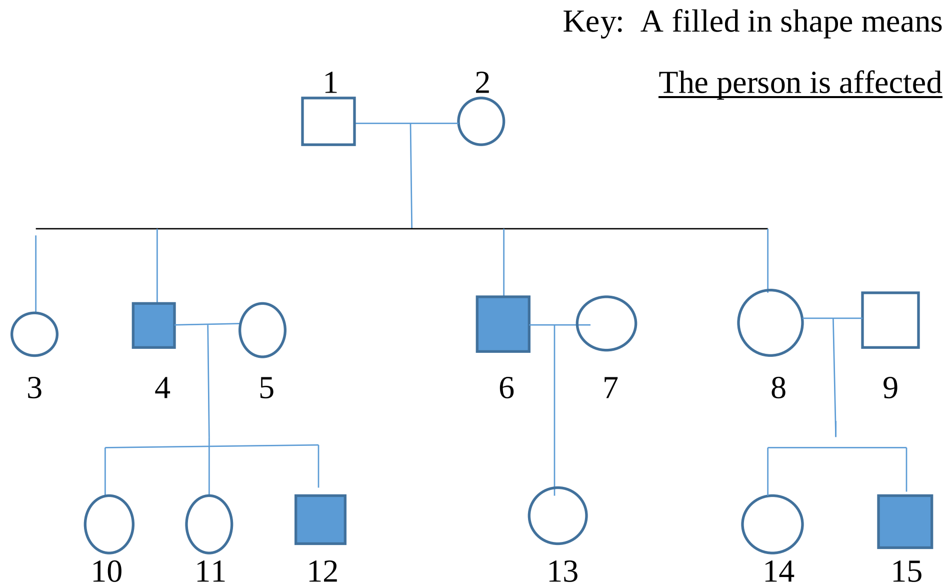


A. Lys in Person A is replaced with Glu in Person B.
B. Phe in Person A is replaced with Leu in Person B.
C. Persons A and B have identical amino acid sequences.
D. A stop codon is generated in Person B and not in Person A.

12. An individual with the genotype AaBb is crossed with an individual with the genotype AaBb. Assuming that these 2 genes are unlinked, what is the percent chance that their offspring will have the genotype AaBb?

A. 50%
B. 25%
C. 12.5%
D. 6.25%

13. This pedigree shows 3 generations of a family in which some members exhibit a particular X-linked recessive trait.



The 2 females in which of the following pairs must have the same genotype?

A. 3 and 5
B. 7 and 11
C. 8 and 13
D. 10 and 14

Constructed Response: 3 Questions

Write a complete response to each question.

14. A form of hemophilia is a human X-linked recessive disorder that affects blood clotting. Phenylketonuria (PKU) is a human autosomal recessive disorder that affects the body's ability to use the amino acid phenylalanine. Females are less likely to inherit this form of hemophilia than are males, but males and females are equally likely to inherit PKU.

Use your understanding of genetics to:

D. Describe the difference between sex chromosomes and autosomal chromosomes in humans.
E. Explain why females are less likely to inherit this form of hemophilia than males.
F. Explain why males and females are equally likely to inherit PKU.

15. Tylosis is an autosomal dominant disorder that causes thickening of skin on the hands and the feet. Erin and Kate (Erin's mother) do not have tylosis, but Bryce (Erin's brother), Liam (Erin's husband), and Kyle (Erin and Liam's son) all have tylosis. Jana (Erin and Liam's daughter) does not have tylosis. Erin and Liam are expecting their third child.

Use your understanding of genetics to:

A. Assign specific allele designations and genotype labels for each phenotype.
B. Determine Ryan's (Erin's father) genotype and whether he has tylosis. Explain your answer, using a Punnett square if helpful.
C. Diagram the pedigree for this family, including Ryan, indicating each individual's genotype and phenotype for tylosis.
D. Determine the probability that Erin and Liam's third child will have tylosis. Use a Punnett square to determine this probability, and explain your answer.

16. A biologist identifies the DNA sequence, or gene, that codes for a protein that stops the production of eggs in mosquitoes. She labels this gene Sequence 1. During her investigation of the replication, transcription, and translation of the gene, she observes mosquitoes in which the protein coded by this gene does not function. She labels the DNA sequence for this version Sequence 2. The first table shows one DNA strand for each gene sequence. Use the mRNA Codon Chart to complete the following tasks.

Sequence #1: TACATACTAGGTCGAGGCATC

Sequence #2: TACATGACTAGGTCGAGGCATC

Second Position

First Position (5' end)	U	C	A	G	Third Position (3' end)
U	UUU, UUC Phe UUA, UUG Leu	UCU, UCC, UCA, UCG Ser	UAU, UAC Tyr UAA *Stop* UAG *Stop*	UGU, UGC Cys UGA *Stop* UGG Trp	U C A G
C	CUU, CUC, CUA, CUG Leu	CCU, CCC, CCA, CCG Pro	CAU, CAC His CAA, CAG Gln	CGU, CGC, CGA, CGG Arg	U C A G
A	AUU, AUC, AUA Ile AUG Met	ACU, ACC, ACA, ACG Thr	AAU, AAC Asn AAA, AAG Lys	AGU, AGC Ser AGA, AGG Arg	U C A G
G	GUU, GUC, GUA, GUG Val	GCU, GCC, GCA, GCG Ala	GAU, GAC Asp GAA, GAG Glu	GGU, GGC, GGA, GGG Gly	U C A G

E. Determine the mRNA sequence that complements Sequence 1.
F. Use the mRNA Codon Chart to translate the mRNA sequence from A into an amino acid chain.
G. Identify the type of mutation in Sequence 2 and describe how this mutation specifically affects the amino acid sequence of the protein.
H. Describe the role of the ribosome and tRNA in translating the mRNA sequence into an amino acid chain.

Source of test questions: ACT Quality Core © Test Builder – biology
Retrieved from https://forms.act.org/qualitycore/test_builder/test_builder.html

Appendix F

Pre- and Post-surveys

Student Attitudes about Learning Biology Using Technology

Control (pre/post)

Read each statement below and decide whether you strongly agree (4), agree (3), disagree (2), or strongly disagree (1).

1. **Biology is one of my favorite subjects.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

2. **A. Whether it is a favorite subject or not, I have an overall positive attitude about biology right now.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

   B. Explain why you chose the answer you did to question 2A.

____

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3. **I think that using my device would improve my motivation to try harder on the assignments in biology class.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

4. **I think that I would be able to learn more in biology class using my device rather than learning it the traditional way.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

5. **A. I think that using my device for learning in biology class would improve my overall attitude about biology.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

   B. Explain why you chose the answer you did to question 5A.

____

____

____

Student Attitudes about Personal Technology as a Learning Tool

Control (pre/post)

Read each statement below and decide whether you strongly agree (4), agree (3), disagree (2), or strongly disagree (1).

1. **A. On my own time, I spend a lot of time with my personal technology device, such as my phone or tablet.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

   B. If you answered 3 or 4 for question 1A, tell what kinds of activities you do with your phone or tablet.

___

___

___

2. **A. I have used my personal device on my own time to learn about a topic or study for school.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

   B. If you answered 3 or 4 for question 2A, describe how you used your device for learning or studying.

___

___

___

3. **A. I have used my personal technology device for learning purposes in a class in school.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

   B. If you answered 3 or 4 for question 3A, briefly describe how you used it for learning in school.

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4. **A. I think that using a technology device as a learning tool would improve my learning in this class.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

B. If you answered 3 or 4 to question 4A, describe how you think your learning would improve.

5. **A. If I were able to use my technology device in all my classes, I think I would do better in school.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

   B. Explain why you chose the answer you did for question 5A.

6. **I think that using technology devices during class would be a distraction to me.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

7. **I think that using technology devices during class would be a distraction to other students.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

8. **With your answers for questions 6 and 7 in mind, explain how you think that using devices during class WOULD or WOULD NOT be a distraction to you or others.**

9. **A. I think I would prefer to only use my device for personal things, not as a learning tool.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

   B. Why did you choose the answer you did for question 9A?

Student Attitudes about Learning Biology Using Technology

Experimental (pre)

Read each statement below and decide whether you strongly agree (4), agree (3), disagree (2), or strongly disagree (1).

1. **Biology is one of my favorite subjects.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

2. **A. Whether it is a favorite subject or not, I have an overall positive attitude about biology right now.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

   B. Explain why you chose the answer you did to question 2A.

   ____

   ____

   ____

3. **I think that using my device would motivate me to try harder on the assignments in biology class.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

4. **I think that I would be able to learn more in biology class by using my device rather than learning in the traditional way.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

5. **A. I think that using my device in biology class would improve my overall attitude about learning biology.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

   B. Explain why you chose the answer you did to question 5A.

   ____

   ____

   ____

Student Attitudes about Learning Biology Using Technology

Experimental (post)

Read each statement below and decide whether you strongly agree (4), agree (3), disagree (2), or strongly disagree (1).

1. **Biology is one of my favorite subjects.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

2. **A. Whether it is a favorite subject or not, I have an overall positive attitude about biology right now.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

   B. Explain why you chose the answer you did to question 2A.

   ____

   ____

   ____

3. **I think that using my device motivates me to try harder at the assignments in biology class.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

4. **A. I think that I have learned more in biology class by using my device rather than learning in the traditional way.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

   B. If you answered 3 or 4 on question 4A, explain how using your device helped you learn more.

   ____

   ____

   ____

5. **A. I think that using my device in biology class has improved my overall attitude about learning biology.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

   B. Explain why you chose the answer you did to question 5A.

   ____

   ____

   ____

Student Attitudes about Personal Technology as a Learning Tool

Experimental (pre)

Read each statement below and decide whether you strongly agree (4), agree (3), disagree (2), or strongly disagree (1).

1. **A. On my own time, I spend a lot of time with my personal technology device, such as my phone or tablet.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

   B. If you answered 3 or 4 for question 1A, tell what kinds of activities you do with your phone or tablet.

____

____

____

2. **A. I have used my personal device on my own time to learn about a topic or study for school.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

   B. If you answered 3 or 4 for question 2A, describe how you used your device for learning or studying.

____

____

____

3. **A. I have used my personal technology device for learning purposes in other classes in school.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

   B. If you answered 3 or 4 for question 3A, briefly describe how you used it for learning in school.

____

____

____

4. **A. I think that using a technology device as a learning tool would improve my learning in this biology class.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

B. If you answered 3 or 4 to question 4A, describe how you think your learning would improve.

5. **A. If I were able to use my technology device in all my classes, I think I would do better in school.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

   B. Explain why you chose the answer you did for question 5A.

6. **I think that using technology devices during class would be a distraction to me.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

7. **I think that using technology devices during class would be a distraction to other students.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

8. **With your answers for questions 6 and 7 in mind, explain how you think that using devices during class WOULD or WOULD NOT be a distraction to you or others.**

9. **A. I think I would prefer to use my device for personal things only, not as a learning tool.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

   B. Why did you choose the answer you did for question 9A?

Student Attitudes about Personal Technology as a Learning Tool

Experimental (post)

Read each statement below and decide whether you strongly agree (4), agree (3), disagree (2), or strongly disagree (1).

1. **Since I started using my device as a learning tool in this class, I spend some of my own time using it to help me study.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

2. **A. I think that using a technology device as a learning tool has improved my learning in this biology class.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

   B. Explain why you chose the answer you did to question 2A.

___

___

___

3. **A. If I were able to use my technology device in all my classes, I think I would do better in school.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

   B. If you answered 3 or 4 to question 3A, how do you think using your device in your classes would help you do better in school?

___

___

___

4. **A. I think that using technology devices would be good in some classes, but not every class and not every day.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

   B. Explain why you chose your answer to question 4A. Specifically, if you agree or strongly agree, in what classes do you think devices are most appropriate? For which classes are they least appropriate? If you disagree or strongly disagree, why?

___

___

___

5. **I think that having technology devices available during class has been a distraction to me.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

6. **I think that having technology devices available during class has been a distraction to other students.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

7. **With your answers for questions 5 and 6 in mind, explain how you think that using devices during class HAS or HAS NOT been a distraction to you or others.**

___

___

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8. **A. I would prefer to use my device for personal things only, not as a learning tool.**

   (4) Strongly Agree (3) Agree (2) Disagree (1) Strongly Disagree

   B. Why did you choose the answer you did for number 9A?

___

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9. **Do you think the Bring Your Own Device policy is a good thing? Explain your feelings about your experience using your device in this class for the unit we just completed. Be specific about what you liked and what you did not like. Can you suggest ways to improve the way devices are used as learning tools?**

IRB Approval

MURRAY STATE
UNIVERSITY

Institutional Review Board

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TO: Teresa Clark
Educational Studies Leadership and Counseling

FROM: Institutional Review Board
Jonathan Baskin, IRB Coordinator

DATE: 11/21/2016

RE: Human Subjects Protocol I.D. – IRB # 17-074

The IRB subcommittee has completed its review of your student's Level 2 protocol entitled *The Effects of a Bring Your Own Device Instructional Method on Learning in a High School Biology Class*. After review and consideration, the IRB has determined that the research, as described in the protocol form, will be conducted in compliance with Murray State University guidelines for the protection of human participants.

The forms and materials that have been approved for use in this research study are attached to the email containing this letter. These are the forms and materials that must be presented to the subjects. Use of any process or forms other than those approved by the IRB will be considered misconduct in research as stated in the MSU IRB Procedures and Guidelines section 20.3.

This Level 2 approval is valid until 5/31/2017.

If data collection and analysis extends beyond this time period, the research project must be reviewed as a continuation project by the IRB prior to the end of the approval period, 5/31/2017. You must reapply for IRB approval by submitting a Project Update and Closure form (available at murraystate.edu/irb). You must allow ample time for IRB processing and decision prior to your expiration date, or your research must stop until such time that IRB approval is received. If the research project is completed by the end of the approval period, then a Project Update and Closure form must be submitted for IRB review so that your protocol may be closed. It is your responsibility to submit the appropriate paperwork in a timely manner.

The protocol is approved. You may begin data collection now.

Opportunity afforded

murraystate.edu

Ed.D. Student's Bio

Susan P. Beatty is a doctoral student at Murray State University in the P-20 Education and Community Leadership Program. With over 17 years of classroom teaching experience at the middle and secondary levels, she has taught various science courses at all levels throughout her career. Her latest interest in personal technology devices and learning emerged from her experiences as a digital immigrant trying to prepare digital natives for college and careers.

When she isn't reading about teaching science with technology, she enjoys reading for fun about a variety of topics, and enjoys exercising through walking and yoga. A wife and stepmother, she divides her time at home between family and playing with her dogs and cat.