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Mobile learning: Examining the relationships between the use of mobile devices and student performance in ELA and math within technology and non-technology districts

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Mobile and other internet-connected devices infiltrate society, including K-12 classrooms. A large body of research indicated that these devices might distract students; however, other studies have revealed many benefits when the devices are used for educational purposes. This study aimed to examine the relationships between the use of mobile devices and student performance in mathematics (MA) and English Language Arts (ELA).

The study compared two districts, one that had implemented a 1:1 technology infrastructure for learning and one that had not. Archival data on the Mississippi Academic Assessment Program (MAAP) standardized test were accessed from the two districts, containing fourth-grade students' MA and ELA scores from the assessment. Additional data included students' gender and i-Ready diagnostic test scores in the 1:1 technology district. One-way analysis of variance (ANOVA) tests revealed that MAAP MA scores were significantly higher for students in the 1:1 technology district than for students in the non-technology district. However, no difference was found in students' ELA scores. A Pearson's rho correlation analysis indicated a significant association between i-Ready and MAAP MA and ELA scores for students

in the 1:1 technology district. Linear regression analysis revealed that gender explained a small but significant variance in MAAP ELA scores across the two districts.

The study provided mixed results for using mobile devices for student learning. Students may benefit more from mobile technology in mathematics than in ELA, possibly because specific mathematics skills can be isolated, taught, and practiced using technology. Additionally, because this study took place during the COVID-19 pandemic, future research should attempt to focus on mobile technology and its presence post-COVID-19. Finally, more research should explore making the most effective use of technology solutions to support student learning.

DEDICATION

To my number one fans, Cayden and Allanah, thank you for being the brightest part of every day. You are my sunshine in the rain and my rainbow after. Everything that I do and will do is for you. To my husband, Eric, thank you for being my coach, my cheerleader, and my rock; you always knew when to give me that gentle nudge or a simple hug. I love you all with all my heart.

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CHAPTER I

INTRODUCTION

Mobile devices are small and portable electronic equipment or technology. Mobile devices can perform various tasks anywhere, anytime, and wirelessly. Mobile devices include smartphones, iPods, iPads, laptops, netbooks, and other tablets. Mobile learning, also known as m-learning, can be described as any learning activity that uses a mobile device. *Xyleme* (2019) defined m-learning as education or training conducted on and delivered through portable devices, such as smartphones, tablets, and the like.

From pre-K through adult life, mobile technology has immersed itself into U.S. society's daily living (Lynch, 2015). With 96% of Americans owning a cellphone of some kind or another device (laptops, tablet computers, e-readers), more minor children accessing such devices are inevitable (Pew Research Center, 2019). According to the Pew Research Center (2020), parents surveyed about the types of digital devices their young children use were astonishing. Of children 3 to 4 years old, 64% use tablet computers, 62% use smartphones, and 25% use gaming devices. Children between the ages of five to eight use tablet computers 81% of the time, while utilizing smartphones only 59%. Children between the ages of 9 and 11 operate tablet computers 78% of the time, while laptop usage equaled 73%, smartphone usage 67%, and gaming devices 68%. This research also revealed that children utilizing mobile devices began engaging with the device before they were five. Of children in this survey between 0 and 4, 60% were engaging with a mobile device.

Although some researchers (e.g., Berdik, 2018; Ehmke, 2019; Gordon, 2021) have defined mobile devices as a distraction to such young audiences, other researchers (e.g., Lynch, 2015; Rodriguez et al., 2013) have found the devices beneficial for learning. Lynch (2015) stated the following:

> The International Guidelines on Information Literacy reported that technological education should start early. Embracing technology and digital literacy is crucial in encouraging learning from infancy through adulthood. The impact of technology on learning has roots in the science of how we learn. As such, it has long been important to encourage academic advancement. (p. 3)

Rodriguez et al. (2013) stated that mobile devices had some commonalities appropriate for educational use. These commonalities include portability; a direct touchscreen, where no mouse or stylus is required; and a digital parallel to books or papers. These devices vary in weight but usually weigh less than 5 pounds and include Wi-fi connectivity. The apps are organized, predictable, and accessible, breaking learning into discrete chunks and topics so that children can enjoy independent learning and leisure time. These characteristics make these devices ideal for usage in the classroom, as supported by qualitative evidence from both educators and educational leaders (Rodriguez et al., 2013). This revelation began the idea of technology in the classroom: bring your own device (BYOD)—now more formally known as the 1:1 Technology Initiative (School Tutoring Academy, 2021).

1:1 Technology Initiative

Known by various names, such as the 1:1 device initiative, the mission of the 1:1 technology initiative is to put a mobile device into the hands of every student and prepare each student for a successful life (School Tutoring Academy, 2021). The 1:1 initiative enables educators and educational leaders to stay true to the International Society for Technology in Education (ISTE, 2019) standards, creating an empowered learner, a digital citizen, a knowledge constructor, an innovative designer, a computational thinker, a creative communicator, and a global collaborator. Pioneering school leaders have adopted tablets, and it is only a matter of time before all school district leaders implement the 1:1 initiative (*Virtucom*, 2019). Essentially, these institution leaders would allow enrolled students to use an electronic device to access the Internet, digital course materials, and digital textbooks (*Virtucom*, 2019).

The goal of the 1:1 Technology Initiative is to move learning forward (School Tutoring Academy, 2021). This initiative has also become the main focus of many school districts worldwide due to its benefits. Doran and Herold (2016) stated that when students participate in a 1:1 Technology Initiative, students, on average, could see an impact on English/language arts, writing, math, and science scores. Besides the impact of learning a subject, researchers such as Henderson & Yeow (2012), Hew & Brush (2007), and Murray and Olcese (2011) would agree that this integration also benefits of increased test scores, students can benefit through increased learning, computer skills, organization, and the student review process; using such technology fosters online collaboration with other students. However, mobile devices can also pose issues for students and districts implementing the device, according to Ayres (2015). Therefore, for the district's device uniformity, teacher training is essential.

Additionally, five guidelines must be followed for any district to implement this program successfully (*Virtucom*, 2018). These guidelines include making goals clear, viewing the device as a learning tool, not the principal focus, leading and teaching by example, knowing when not to use a device, and enforcing critical thinking skills to go with technology (*Virtucom*, 2018). One must also remember that no 1:1 initiative adopted by a school or district looks the same.

School Districts to be Studied

Two school districts located in the central and eastern parts of Mississippi were used for this study. District A served over 5,000 students, where 94% were minority students (African American), 51% of these students were male, and 49% were female. Approximately 41% of children in the district lived below the poverty line. Of the children in the district, 57% lived in a single-parent home or with another relative. Moreover, there were over 300 teachers, and the student-teacher ratio was 16:1. All students within this district received free lunch. However, the district had used funding to propel its students forward by adopting the 1:1 Technology Initiative (School Tutoring Academy, 2021).

District A adopted the 1:1 Technology Initiative (see School Tutoring Academy, 2021) in August 2015. This initiative was the catalyst for using digital tools in the classroom to engage students, and the lack of technology became a distant memory. Initially, this initiative provided mobile devices to middle schoolers, but in 2016 the district began offering the devices to high schoolers and fifth graders. By December 2018, every student from Grades 3 through 12 possessed a mobile device.

District A chose Google Chromebooks as the preferred mobile device to pair with students in the classroom. According to District A’s curriculum specialist (C. Martin, personal communication), by 2018, there had been 4,500 Chromebooks issued in the district. These devices were small (touting an 11.6 to 12.1-inch screen), portable, had 8-hour battery life, and had a stellar processor that enabled the device to process applications and other functions quickly. Chromebooks can be in both laptop or tablet form. These devices are secure all data in the Google cloud and the apps come fromt the Chrome Web store. These decives are wideley adopted in schools and Internet connection is mandatory, but some apps can function offline.

Because of Chromebooks SSD storage, these devices boot up fast and require minimal user configuration. Additionally, as a benefit to the school or district, the Chromebook included built-in security, a user-friendly platform, and a central management system to manage, track, customize, and configure all devices on the network.

District B served approximately 20,000 students, where 96% were minority students (African American), 51% were male, and 49% were female. About 36% of children in the district lived below the poverty line. Of the children in the district, 59% lived in a single-parent home or with another relative. The student-teacher ratio was 16:1. All students within this district received free lunch.

Though similar to District A demographically, District B fell on the opposite end of the spectrum regarding technology. This district did not use the 1:1 Technology Initiative (see School Tutoring Academy, 2021). Students in District B were exposed to a more traditional classroom style. Traditional classroom teaching consisted of face-to-face lectures, team, and individual projects. Learning material in the conventional classroom entailed using a textbook for in-class activities. Table 1 shows the comparison of Districts A and B.

Table 1

District Comparison

District name	Population size	Male	Female	Socio-economic status	Family environment	Minority ratio	Technology Within District
A	Approx. 5,000	51%	49%	41% Below poverty	57% single parent/other	94% African American	Yes - 1:1 technology platform
B	Approx. 20,000	51%	49%	36% Below poverty	59% Single parent/other	96% African American	No

Learning Management Systems: i-Ready

The adoption of the 1:1 initiative was essential in providing access to District A's learning management system (LMS): i-Ready. i-Ready is a digital- or cloud-based educational platform that integrates assessment and rich insights with valuable and engaging instruction in reading and math to address students' individual needs (Curriculum Associates, 2018). According to Curriculum Associates (2018), the intuitive program can help teachers make more informed decisions instructionally. This software also puts students on a personalized learning path, identifies trends across student groups, and predicts performances. There are 7 million students actively using i-Ready today (Curriculum Associates, 2019).

Because i-Ready is a cloud-based program, students need access to the Internet to log in and complete the assessments and learning sessions. During the initial phase of implementing the i-Ready program within the study district, teachers were tasked with scheduling lab and computer time for students. According to the district's Education Specialist, teachers may have one to two computers in their classrooms for students to use, therefore splitting computer time for a class of 20 to 25 students. Those who did not have computers in the classroom, which were many, had to schedule students for the lab. The lab sessions entailed the students going to the school's computer lab 1 to 2 times a week for 45 to 50 min each time, generally in a different location inside or outside the classroom building. Therefore, it became apparent that maintaining the student's schedule and having enough computers were difficult. Students needed a tool to aid them in meeting the recommended criteria set forth by i-Ready. At the time of this study, students no longer had to wait to access devices. They were assigned their mobile devices; therefore, students could access the Internet, digital learning platforms, i-Ready, and digital textbooks/media.

Servicing students in Grades K to 8, i-Ready was delivered online and driven by insights from the i-Ready diagnostic tool. The i-Ready program provided tailored learning based on student performance to get students on the appropriate achievement level for their respective grades. i-Ready recommended that each student complete the i-Ready diagnostic at the beginning, middle, and end of the academic school year. i-Ready's diagnostic tool provided the teachers with actionable insight into the student's needs, and the results set a personalized learning path for the student. The personalized learning path also ensured that students worked on instruction that matched their unique learning needs. The Curriculum Associates (2019) also recommended that students have at least 18 weeks of i-Ready instruction during the academic school year for an average of 45 minutes per subject. The Curriculum Associates (2019) found that when following the above criteria, "i-Ready is an effective intervention and an effective system for accelerating student growth and progress toward proficiency in various categories of study (reading, math, writing). i-Ready instruction also meets the criteria for the Every Student Succeeds Act (ESSA)" (p. 3).

During the first few years of i-Ready's adoption, the teachers in District A discovered that students did not participate in the online activities but logged in, allowing the 45 minutes to pass and claimed completion for the week. Therefore, i-Ready provided school leaders with materials to promote incentives for mastering the instructions to encourage more participation in i-Ready instruction than before. The incentive program began in August 2018 and varied for each school within the district. This material included classwide bar graph charts, progress certificates, beads, bulletin board material, sticker charts, and much more. This incentive provided positive feedback to the students to view growth and compare their accomplishments to other classmates. However, District B did not use the i-Ready LMS during the 2018-2019 academic school year.

Assessing Academic Achievement – Mississippi Academic Assessment Program

Both Districts A and B used the Mississippi Academic Assessment Program (MAAP) to evaluate student performance relative to the Mississippi College and Career Readiness Standards. Mississippi's statewide accountability system began in 1999; however, MAAP was not formally introduced nor used until the 2015-2016 school year. MAAP replaced Mississippi Curriculum Test and the Subject Area Testing Program for English language arts (ELA) and math (MA). This assessment was given once a year during the spring semester. Students were assigned two scores: the raw score and a scaled score. Then, the scaled score facilitated conversion to performance levels (PL). These levels ranged from PL5 to PL1, with PL5 being advanced, PL4 proficient, PL3 Passing, PL2 basic, and PL1 minimal (Mississippi Department of Education [MDE], 2018, p. 5). MAAP was the required state assessment for ELA and math (MA) for Grades 3 to 8, representing a formal way of ensuring that students remained on track for the next grade and success after high school.

Statement of Problem

Though there is a plethora of information available regarding using technology, there is little research on using mobile devices in the classroom as a learning tool to increase student achievement. Therefore, the problem addressed in the study is whether a relationship exists between student performance and the use of mobile devices. This research is vital because it is relatively limited, and the effectiveness of mobile devices as a learning tool is still uncertain. Therefore, this research was designed to identify the use of mobile devices on students' learning by comparing student scores in MA and ELA. This comparison was made by comparing District A's (technology) and District B's (non-technology) MAAP scores in math and ELA during the 2018-2019 academic school year. This research further explores the student scores regarding gender and LMS use, such as whether gender plays a role in student performance on the MAAP exam and if students with access to LMS perform better on the MAAP exam than those who do not have access.

Purpose of the Study

This study aimed to examine the relationships between the use of the mobile device, Google Chromebooks, and student performance in MA and ELA. The researcher compared students' math and ELA scores during the 2018-2019 academic school year. The results of this study may provide leaders of the school district and various educators with information on the use and non-use of a mobile device to complete the criteria for the district's supplementary learning program.

Research Questions

The following research questions were used to guide this study:

1. Is there a significant statistical difference between the MAAP mathematics scores for District A (technology district) and District B (non-technology district)?
2. Is there a significant statistical difference between the MAAP English language arts (reading) scores for District A and B?
3. Is there a relationship between i-Ready scores and MAAP scores for District A in math and ELA?
4. Is there a relationship between the students' gender and the student scores in mathematics and English language art for Districts A and B on the MAAP exam?

Significance of Study

It is common for children of all ages to use or be familiar with a mobile device in today's digital age. The findings of this study may determine whether there is a relationship between mobile device use and student learning, particularly in math and ELA. Academic leaders and educators may use this research to see whether mobile devices are beneficial as a learning tool and whether to invest in such devices. Knowing the mobile device's efficacy or lack thereof is significant, especially during the COVID-19 pandemic, because school leaders now have access to CARES Act funds to invest in technology. Lastly, this research provides additional literature to the educational community regarding the use of mobile devices, i.e., Chromebooks, on student learning and student scores.

Limitations

There were a few limitations to this research. First, the students' MAAP and i-Ready scores were taken from only two districts in Central and East Mississippi; therefore, the generalizability of the results was limited to the study districts and no other school districts. Another limitation of this study was that only the MAAP scores were used to measure student learning, limiting comparing results across assessments. Lastly, a limitation was the type of mobile device used in this study; only Chromebooks were used by the students, making it difficult to generalize the results to other mobile devices.

Delimitations

The delimitation of this study was that only student scores in math and ELA for fourth grade were collected for the 2018-2019 academic school year. The study did not include Grades K to 2 or 9 to 12, as students in K-2 did not receive the assessments.

Definition of Terms

The following terms were used in the study:

Chromebook refers to a laptops/tablets that runs Google's Chrome OS and Chrome Web browser. Chromebooks are designed as an Internet appliance that provide a more secure system different from other competing brands by storing data in Google cloud, and all apps come from the Chrome Web Store (PC Magazine, n.d.).

i-Ready refers to an integrated blended learning program that personalizes learning for all students with diagnostic tools and differentiated instruction.

Mississippi Academic Assessment Program, also known as MAAP, is designed to measure student achievement in English Language Arts (ELA), Mathematics (MA), Science, and US History. Students are assessed in grades 3 through 8 in ELA and Mathematics. The results of all MAAP assessments provide information to be used for the improvement of student achievement (MDE, 2021).

Mobile devices refer to electronic equipment, such as a mobile phone or small computers used in different places and the technology connected with them. This study focused on Chromebooks.

Mobile learning, or M-learning, refers to learning that is wireless and ubiquitous (Alexander, 2004).

Mobile technology refers to portable technology—a device carried with or on a person to perform a wide variety of tasks. The technology allows those tasks to be performed via wireless, movable networks (i.e., cellular networks; Kabali et al., 2015).

One-to-One technology initiative refers to academic insitutions, such as schools or colleges, that allow each enrolled student to use an electronic device to access the Internet, digital course material, and textbooks.

Student Performance is measured using grade point average (GPA), high school graduation rate, annual standardized tests, and college entrance exams.

CHAPTER II

LITERATURE REVIEW

This chapter includes literature about mobile learning with mobile devices and their roles in the classroom. This literature review entails details about student learning, student achievement, and mobile devices in these areas. The following themes are discussed in this literature review: (a) the advantages and disadvantages of mobile learning and devices; (b) teacher and student experiences and perceptions of using mobile devices; (c) mobile devices as a learning tool, such as student learning/achievement; and (d) i-Ready.

Mobile Learning and Devices

Union et al. (2015) stated:

> The twenty-first-century classroom is heavily influenced by information technology, such as students using computers in the computer lab on a limited basis or in a more integrated approach whereby many students in the classroom have personal laptops, iPads, or other similar forms of technology. (p. 71)

Mobile devices and their impacts on student learning have gained momentum for years. Wylie (2019) defined mobile devices as "versatile, motivating, and an active learning tool" (p. 1). Tomlinson (2015) also indicated that mobile technology harnessed making teaching more efficient and manageable. According to Chmiliar (2017), "The digital age has reached early childhood, and the use of touch screens by young children is commonplace. With ownership of devices increasing in families, many young children now have access to the use of touchscreen tablets" (p. 1). Access to mobile devices in the home of U.S. families with young children is increasing—mobile device usage increased by 23%, from 52% in 2011 to 75% in 2013. Tablet computer usage increased by 32%, from 8% in 2011 to 40% in 2013. Children would use mobile devices for at least 67 minutes a day (Rideout, 2013).

Researchers have suggested that U.S. society has entered a new era of technology-enhanced learning characterized as mobile learning (Sharples et al., 2005), seamless learning (Chan et al., 2006), and ubiquitous learning (Rogers et al., 2005). McCarrick and Li (2007) indicated that "computers provide individuals with a wealth of information, entertainment, and convenient services" (p. 73). Therefore, mobile technology can engage 21st-Century learners while linking them to real people and issues in the world. The use of mobile technology in the classroom can contribute to more effective thinking, problem-solving, and learning. These devices can also make it easier to provide feedback to students and send alerts/reminders and directions. As Tomlinson (2015) stated, "Mobile technology really could revolutionize teaching and learning – blow open the classroom, restructure it, reinvent it, lift it out of its 19th-century educate-the-factory-workers orientation and plant it firmly in a 21st-century mode" (p. 86).

Advantages and Disadvantages of Mobile Learning and Mobile Devices

The increased use of interactive mobile technology has become a powerful tool for education (National Association for the Education of Young Children, 2012). Hew and Brush (2007) indicated that most research studies had shown that technology could improve students' scores, creative thinking, self-concepts, and motivations. As the birth of digital natives rises and technology becomes intertwined in our lives, school leaders have attempted to provide the best learning experience for children through technology (Henderson & Yeow, 2012).

Although this technology is beneficial in certain academic aspects, it can have negative implications. Thus, Ayres (2015) listed several advantages and disadvantages of technology in education as a learning tool. The benefits of a mobile device include the following:

- Promotes independent learning in students;
- prepares students for the future, keeping with ISTE standards;
- has the potential to lower textbook and tuitions prices;
- allows teachers to create an exciting way to educate students; and
- encourages the development of new teaching methods (Ayres, 2015, p. 1).

Ayres (2015) listed the following as disadvantages that students might face:

- Lack of interest in studying,
- vulnerable to potential pitfalls (i.e., technical problems, computer malfunctions, device capabilities),
- negative perceptions of technology,
- instructional challenges, and
- diminished value of in-person education (p. 4).

One can anticipate a mobile device's following advantages: portability, ubiquity, relatively lightweight and small size, lack of peripherals, an intuitive interface, a multi-touch interface, peer-to-peer sharing capability via Bluetooth, long battery life, and a built-in microphone. Many researchers (Dhir et al., 2013; Henderson & Yeow, 2012; Hew & Brush, 2007; Murray & Olcese, 2011) agreed that mobile devices provided many advantages to learning. According to Henderson and Yeow (2012), mobile devices allow the students to feel more inspired and involved in learning, keeping them interested in learning for extended periods.

However, Henderson and Yeow pointed out the drawbacks of mobile devices, such as device failures, updates, connectivity issues, software compatibility problems, costs, and distractions.

To understand and explore how iPads were used in an educational setting, Henderson and Yeow (2012) conducted an exploratory case study. They sought to uncover critical features, factors, and issues that might occur in an educational setting. Henderson and Yeow studied why the iPad was the chosen device, how the device was used in an educational context, and if the students had any issues using the iPad. They studied students from 5 to 12 years old and used three semi-structured interviews to collect data from students. The schools' personnel also conducted these interviews, and three essential themes were found after analyzing their contents. These themes entailed collaboration, engagement, and distraction. Henderson and Yeow found that depending on the subject being taught, the mobile device was used individually or in groups in one of two ways. Individual use of the mobile device typically occurs in 20-minute intervals. The teachers found that this type of mobile device promoted better collaboration when compared to a desktop, and the portability contributed to this advantage.

In Henderson and Yeow's (2012) research, the second theme was engagement. After students' novelty effects wore off, teachers reported that the mobile device was viewed as a conventional education piece. Therefore, though the novelty effect wore off, it did not reduce the student's engagement. Teachers also reported that the learning curve was nonexistent because students found the device simple to use. In most instances, students could help the teacher and other students solve problems with the device. Students reported feeling engaged and empowered by their work.

Despite Henderson and Yeow (2012) reporting promising findings for collaboration and engagement when using a mobile device, the third finding or theme was a distraction. The teacher recognized that distraction was an issue with the mobile device and regarded it as an inevitable experience. Students were excited to use the device to entertain themselves. However, "because the mobile device is so open and visual, the teachers can see if the students are off task" (Henderson & Yeow, 2012, p. 85). Therefore, expectations were made clear at the beginning of each class on expected behaviors with mobile device use. Once the students understood that the device was a tool to aid in learning, students treated the device as such by only using the device to complete assignments/tasks.

Dhir et al. (2013) highlighted the common misconceptions and conflicts about mobile devices and their use in educational environments to determine the effects of mobile devices on learning, affordances, and collaborative influence. Dhir et al. reviewed 153 articles to complete this research, but only 72 research papers were used after analysis, classification, and evaluation. The researchers outlined the advantages and challenges of the successful integration of mobile devices. Based on the main argument and research questions, the researchers focused on current research updates, instructional, pedagogical benefits, and drawbacks of mobile devices. Dhir et al. (2013) agreed with the previous studies that mobile devices had "a positive effect on student performance due to their unique affordance, bright multi-touch screen, and multimodal interaction support" (p. 715). The researchers also pointed out that mobile devices could support users anytime and anywhere. According to the researchers, mobile devices could aid classroom demonstration, small group teaching, e-leadership, interactive and collaborative learning, localization support, a broad spectrum of applications, communication tools, and energy efficiency. Dhir et al. identified some challenges, such as teachers with a limited information technology background and lack of troubleshooting skills; and the lack of the Internet at the school for integration. According to Dhir et al., apart from technical difficulties, the adoption of mobile devices might be challenged by pedagogical and administrative obstacles and inflexible curriculum. Dhir et al. offered the following conclusions and recommendations:

- Customization is essential when using a mobile device (text, images, and sounds).
- Give teachers more planning time to invent ways to include mobile devices in the classroom.
- Establish what learners expect from the mobile device as a learning tool.
- Teachers with limited information technology experience should have more support and training to deal with glitches.
- Schools should calibrate their curriculum and pedagogy to incorporate challenging yet exciting assignments and projects for the children.
- Teachers should include game-like activities to help develop students' exploratory learning skills in and outside the classroom.

Like Dhir et al. (2013), Hew and Brush (2007) also studied barriers to integrating mobile technology in the classroom as a learning tool. Hew and Brush (2007) analyzed existing studies from 1995 to the spring of 2006, identifying 123 barriers from past empirical studies' review to examine the current obstacles and strategies. There were six categories classified, from most to least impactful. These categories included (a) resources, (b) knowledge and skills, (c) institution, (d) attitudes and beliefs, (e) assessments, and (f) subject culture. Hew and Brush identified strategies to overcome these barriers, including (a) having a shared vision and technology integration plan, (b) overcoming the scarcity of resources, (c) changing attitudes and beliefs, (d) conducting professional development, and (e) reconsider assessments. Essentially, Hew and Brush stated that having a shared technology integration plan and vision for learning and teaching could be the catalyst for overcoming leadership barriers and technology usage.

Teacher/ Student Experience with Mobile Devices

As mentioned in Chapter 1 mobile devices are small and portable electronic equipment or technology. Such technology includes, but is not limited to smartphones, iPods, iPads, laptops, netbooks, Chromebook, wearables, and tablets. Such devices make learning possible anywhere, at any time and wireless. This section will breakdown the teacher/student experience with these devices.

Chromebooks

District A utilized Chromebooks as part of their 1:1 technology initiative. Though the specific reasons why this device was chosen were not mentioned, Marden and Mainelli (2020) said that “schools’ budgets are often tight, and educational administrators looking to provide students with ubiquitous access to computers must do so with cost in mind” (p.2). Marden and Mainelli’s (2020) research through International Data Corporation (IDC) found that Google Chromebooks offer an affordable device solution which allows schools to put digital technology in the hands of many more students. According to Mainelli and Marden (2015), IDC interviewed ten school systems in seven countries to research the teachers, students, and administrators’ experiences with utilizing Chromebooks as a support tool for teaching and learning. There were 2,034 teachers, 543 administrators, and 29,462 students interviewed, spanning seven countries. These countries included the United States, Canada, the United Kingdom, Sweden, Denmark, Australia, and New Zealand. On average, 56.3% of students used Chromebooks, 9.4% of teachers, and 3.3% of administrators. Desktop computers were the second largest technical device used among students, teachers, and administrators, according to Marden and Mainelli (2015).

Marden and Mainelli (2015) found Chromebooks cost-efficient, with prices averaging 45.8% less than the other devices. School districts also reported I.T. benefits, such as easy deployment, less management time, straightforward troubleshooting problems, and less time-consuming security settings. Chromebooks also minimize student interruptions and potentially lose productive time for teachers and administrators. Students felt that Chromebooks were user-friendly, and glitches were fixed within a few minutes. Teachers reported that students were happier using Chromebooks, and the device proved reliable. Marden and Mainelli (2015) found that teachers and administrators believed Chromebooks increased students' collaboration and engagement. Also, with Chromebooks averaging a lower price, districts can provide Web-based learning devices to more students, thus closing the gap to one-to-one device targets.

Fink (2015) said that with Chromebooks, students could tap into the power of the Internet. Also, because the devices include keyboards, students build essential keyboarding skills required by the Common Core and many state standards as they research, collaborate, learn, and create (Fink, 2015, p. 36). Teachers enjoy utilizing Chromebook applications to aid in teaching and exploring subjects that typically care less engagement. Seyala et al. (2019) sought to find the value of Chromebooks versus alternative devices or traditional computer laboratories for library classrooms. To carry out this research, the researchers surveyed 185 traditional undergraduate students during library information sessions in the fall 2017 and spring 2018 semesters. A university-wide subscription to Qualtrics was used to create a survey to capture the students' responses. This survey was composed of multiple question types, such as Likert-type scale, closed-ended and open-ended. Before each information session, the librarians provided a brief tutorial regarding primary Chromebook usage and connecting to the university Wi-Fi. After each session, a link to the survey was given via three methods: projected on the screen, embedded in the course management software by the instructor, and printed on paper handouts distributed to students after the session to complete at their convenience. According to Seyala et al. (2019), students found Chromebooks easy to use, mobile, lighter than most laptops, and have faster boot time. However, most students still preferred traditional devices such as laptops and desktops over the device. Researchers found this preference possibly due to unfamiliarity with the Chromebook, their perceived lack of full-featured productivity tools, durability, and Wi-Fi accessibility. Seyala et al. (2019) reported that students have a preconceived perception that Chromebooks lack robust features and access to mainstream software, including the operating system. Also, it was found that the librarians did not utilize the full capability of the Chromebooks. Despite these findings, Seyala et al. (2019) concluded that creating a mobile Chromebook laboratory versus traditional alternatives proved compelling, as this device is an easy-to-use, cost-effective technology tool for instruction.

Ahlfeld (2017) performed a similar study of compiled articles and research to understand the impact of Chromebooks in American schools. Google has achieved dominance in the American classroom in just five years. Thousands of teachers and students now use Google as a search engine and utilize Google's software products to conduct their daily schooling business. Utilizing a tech survey of 2,500 school personnel published in November 2016, Ahlfeld (2017) found that 50% of teachers had one-to-one devices for their students, 75% of teachers used technology daily with their students, and 80% of teachers felt optimistic about the use of technology. The same results showed that over 60% of teachers had access to a Chromebook. In the students' case, Ahlfeld (2017) discovered that many students found clicking and looking for information via the Chromebook more satisfying than finding an article and reading it. Also, "using text-to-speech features of the Chromebooks has helped our students to persist in reading articles by following along with the computerized reading voice" (Ahlfeld, 2019, p. 288). Lastly, this research found that teachers or other educators should share their strategies and build habits with students of all ages. This will result in thinkers, researchers, and creators being in control of the tool instead of being controlled by the tool (Chromebook).

Many, such as Marden and Mainelli (2015) and Fink (2015), would agree that Chromebooks are cost-effective. Sahin et al. (2016) would also agree but focused on the teachers' perspectives and attitudes towards Chromebook laptops and the integration of the device. Using a mixed methods approach to investigate, Sahin et al. (2016) sought to find whether teachers' experience and the number of technological tools available are associated with their comfort of teaching with technology. Sahin et al. (2016) also investigated the teachers' attitudes toward technology after the device was integrated into their classrooms. Data were collected from public schools located in the Southwestern United States. A survey was sent to 658 Grade 6-12 mathematics and English teachers from 30 schools, and 553 teachers completed the survey. These schools were chosen because they distributed laptops to their Grade 6-12 teachers and students to use in their math and English classes during the 2012-2013 school year and chose Chromebooks.

The survey utilized in this research included multiple-choice and open-ended questions totaling 12 items. Sahin et al. (2016) found that teachers' years of experience are not correlated with their comfort level of teaching with technology. However, the number of technical devices the teachers' have are significantly correlated with their comfort of teaching with technology. After teaching with technology for one year, the teachers' attitudes decreased toward technology. Also, recurring themes arose in this research after the teachers' experience with the Chromebook, and these themes were split into two sections: concerns and recommendations. The teachers' concerns included restrictions, technological problems, distractions, and disappointment.

When assigned the Chromebooks, teachers reported that students were enthusiastic about schoolwork. However, after websites were blocked, the Chromebook became a paperweight. Teachers felt that these restrictions hindered the student's learning process. There were also minor reports of compatibility issues with printers. Teachers also reported the Chromebook's fragility. Teachers also felt that Chromebooks were distracting to the students. Sahin et al. (2016) also noted that teachers noticed that "…they can easily unblock or hack them and spend more time on entertainment rather than education" (p.370). Teachers also expressed that Chromebooks did not meet their hopes suitably, driven by the restrictions and tech problems. Otherwise, according to Sahin et al. (2016) research, teachers reported that it could have been an excellent tool for students to use in their classes.

Lastly, according to Sahin et al. (2016), the recommendations offered by teachers consisted of careful monitoring, proper training, and not blocking but filtering. The participants believed that to use Chromebooks for educational purposes efficiently, monitoring the usage of Chromebooks was essential in school and at home. Another recommendation included proper training before allocating Chromebooks to students. Some teachers even mentioned extensive training for teachers and students on proper and improper use and Internet safety. Lastly, teachers agreed that there should be appropriate filtering systems rather than blocking the entire internet system, which obstructs research. The blocking systems also impacted the teachers' ability to communicate with their students.

Kaur (2020) completed a similar study to find factors influencing K-12 teachers' use of iPads and Chromebooks, using a post-positivist approach. A post-positivist approach assumes reality is multiple, subjective, and mentally constructed by individuals. Open-ended survey questions were given to the participants to provide freedom to express their experiences and beliefs without being limited to predetermined or forced responses. Participants for this study were K-12 teachers enrolled in online graduate education programs at a university in the south. There were 61 participants who responded to the survey, most having taught mathematics, followed by ELA, science, special needs, and social studies. A majority of the participants used iPads compared to Chromebooks in the classroom. Four themes arose in this research as to why teachers chose these devices: availability, familiarity, functionality, and targeted professional training.

Essentially, Kaur's (2020) findings showed that regardless of the type of device used in the classroom, the availability of the device is essential in helping teachers decide whether or not to use it in the classroom. The participants also considered the ease of use an essential factor when deciding on using iPads or Chromebooks in the classroom. Most teachers leaned towards the easy-to-use interface of the device because they wanted the student to conveniently use technology without having to spend a considerable amount of class time teaching how the device worked. Most participants in this study preferred iPads over Chromebooks because they were more familiar with the device. However, though most were more familiar with this device, this did not mean they knew how to use it or promote student learning. Essentially, when students have access to technology and teachers are well-trained in using technology to support pedagogy, both learning and teaching thrive, according to Kaur (2020).

Moreover, Kimmons et al. (2017) completed a quantitative comparison of 8th-grade student essays with paper versus Chromebooks. This study utilized 458 original essays composed by eighth-grade students. Chromebooks were chosen as the testing device in this study over traditional laptops or tablet alternatives for several reasons:

- Chromebooks would require the least management overhead and classroom time for support.
- Chromebooks had a low price point.
- Participating schools had access to a web-based word processor (Google docs) for writing and submitting essays.
- Because of their rapid adoption rate in schools, the study results would be more beneficial than if a less popular device was studied (p. 17).

Because the data analysis required all essays to be in an electronic format, researchers manually typed handwritten essays precisely as presented. Handwritten essays totaled 319, and Chromebook submissions totaled 139. Two different readers with advanced degrees in English and education scored each essay using the Flesch-Kincaid formula. Results revealed differences between medium groups (a binary variable representing handwritten or Chromebook) on both scores. Overall, handwritten essays have a Flesch-Kincaid grade level score of 5.73, while Chromebook essays score 6.59. Also, the handwritten essays received a reading ease score of 78.6, while Chromebook essays scored 74.51, denoting greater difficulty.

The results of this research, per Kimmons et al. (2017), were as follows:

- Handwritten essays were generally longer than Chromebook essays.
- Chromebook essays use more unique words (or a larger vocabulary diversity).
- Chromebook essays were more advanced or difficult to read (i.e., higher grade level, lover readability).
- Chromebook essays had fewer unique and total spelling errors.

- Handwritten essays had fewer unique and total capitalization errors (p. 21).

Other Devices

Hill (2011) stated that an educator or educational leader who saw technology only as a distraction realized that technology in the classroom was significant and did not want it to change. Simply put, the teachers/leaders did not want change as they were comfortable with traditional classroom methods of teaching. According to Hill, this reluctance prevents educators from seeking beneficial applications to promote mobile learning. The educator's hesitance also prevents them from using the device for more project-based learning in the classroom. Domingo and Garganté (2016) explored this presumption by researching how the teachers' opinions impact student learning and influence the use of specific apps in the learning process. Using data collected from 12 schools, Domingo and Garganté used a Likert-scale questionnaire to poll 102 teachers. All 12 schools maintained a full technology infrastructure consisting of the following:

- At least 30 tablets.
- Internet access.
- Private educational Intranet.
- Eighty educational apps, with the freedom to download as many free educational apps as desired.
- A flexible budget.
- Technical and pedagogical support for teachers.

Domingo and Garganté (2016) found a positive correlation between teachers' positive perceptions of technology and learning when paired with mobile technology in the classroom. Therefore, if the teacher's perspective was positive, learning was positive. Additionally, Domingo and Garganté found that students learned better when teachers incorporated mobile technology. Their findings supported that students were more engaged when learning mobile technology based on teachers' responses to the questionnaires. Students' engagement levels and interest in accomplishing tasks increased in mobile technology classes.

Heflin et al. (2017) investigated mobile technology's efficacy in a collaborative learning environment to evaluate the students' experiences with mobile technology and its effect on learning, student engagement, and the demonstration of critical thinking. A quasi-experimental research design investigated mobile devices' effectiveness in a collaborative learning environment to facilitate student engagement and critical thinking. The researchers divided the students into (a) common practice, (b) intentional practice, and (c) HeadsUp. The students read prompts aloud in the common practice group and were not assigned groups or roles. Students were intentionally assigned roles within the groups; the teachers read and distributed written prompts, randomly assigned roles to group members, and self-selected into groups. Lastly, the HeadsUp group was the most formal; teachers read prompts and distributed them to students' mobile devices. Each group met in the learning research lab for 1 hour, allowing the researchers to conduct video research. Various sources were used to collect data, such as student questionnaires, classroom behavioral observation, and a written product. The participants in this study were taken from six classes, totaling 159 participants.

After reviewing and coding video footage, Heflin et al. (2017) found that the HeadsUp group demonstrated more signs of disengaged behavior. A significant difference was observed across all group's behavior totals. Secondly, written responses were required of the participants. The researchers found no significant difference between Groups 1 through 3, implying that each group showed critical thinking skills. This finding indicated that all groups read and understood prompts, whether collaboratively or alone, regardless of how the prompt was distributed (i.e., written, read, or distributed to mobile devices). After each session, students were invited to participate in a brief survey, and the researchers found no significant differences in students' experiences across groups.

Al-Emran et al. (2016) investigated teachers' and college students' attitudes toward using mobile learning in higher education by performing an exploratory study on the usefulness of mobile devices in an educational environment. Students were given various surveys to collect data about the experiences and usages of mobile devices in the classroom. After analyzing the students' mobile technology information, Al-Emran et al. found that 71% owned a smartphone, and 28% had a tablet. Although the devices were used to surf the web or check e-mail, 82% used their mobile devices to study. The study showed that 57% of faculty owned a smartphone, 38% owned a smartphone and a tablet, and 52% used their mobile devices to browse the web and access e-mail. The analysis also found that student attitudes toward mobile devices did not significantly differ in attitudes toward mobile learning regarding gender, academic major, or age. However, the researchers found a statistical difference in students' attitudes toward mobile learning and the ownership of a mobile device. Al-Emran et al. found that students who owned a mobile device had a more positive outlook on mobile learning than those who did not own a device.

Cavus et al. (2008) reported similar results after exploring the opinions of information technology students on the use of mobile devices in a mobile learning environment. Cavus et al. surveyed 317 students in higher education, and this survey consisted of 15 items. Results showed that communication tools such as e-mail, forums, and chat applications were essential in mobile learning environments. These devices made using such tools and collaboration or communication with classmates and instructors simple. Overall, the students believe that immersing themselves in a mobile learning environment is essential to learning and navigating new technologies would aid them in their everyday lives. Therefore, students' perception of mobile learning with a mobile device was positive due to the freedom to communicate, collaborate, and participate with anyone at any time and place.

Additionally, Swan et al. (2005) explored mobile device use and its effects on student learning. Data were collected from two sites during the 2003 to 2004 school year. The first site consisted of a classroom with technology, and the other site was a suburban middle school where the students qualified for free and reduced lunch. Overall, 465 K-12 students participated, and data came from lesson plans, usage data, work samples, teacher interviews, and classroom observations. The researchers found that mobile devices could benefit learning inside and outside the classroom. Data also indicated that unique cultures of use evolved within classes and groups, showing higher levels of personal appropriation. The findings also showed that mobile devices were used most frequently for writing activities.

Moreover, Swan et al.’s (2005) teacher interviews revealed that students' motivation and engagement in learning activities improved when using a mobile device, resulting in increased productivity and work quality. Additionally, students stated that they preferred to use mobile devices over handwriting; it made assignments easier and fun and aided them in learning. Therefore, Swan et al. concluded that mobile devices could enhance learning processes and increase the motivation to learn, inadvertently increasing the time spent on learning activities. Essentially, their findings indicated that using mobile devices in education amplified learning.

Furió et al. (2014) stated that "mobile learning is a new learning paradigm that exploits the use of mobile devices in education, and this mobile platform is becoming the platform of choice for casual games" (p. 190). In this study, Furió et al. believed that game-based learning promoted student motivation to learn; and, therefore, performed a comparative study of mobile learning versus traditional classroom lessons. In order to begin the study, Furió et al. developed an application to use on the students' mobile devices to teach and reinforce lessons on the water cycle, with content extracted from their textbooks for the game. The target age for this study was 8 to 10 years old, and 38 children participated in the study. These participants were then placed in two groups: Groups A and B. Group A used the mobile device first and completed the traditional classroom lesson. Group B first took the traditional classroom lesson and then used the mobile device. Both groups had the same number of participants, 19.

Moreover, five questionnaires were used to collect data from the students. One was a pre-test given to all students at the beginning of the study. Another questionnaire was filled out by the group of students playing the game and the group taking the traditional classroom session. Later, these same students changed activities and completed the opposite questionnaire. For example, those learning through traditional classroom methods switched to mobile devices and answered the appropriate questionnaire.

Furió et al.'s (2014) study results showed that the post-test scores were significantly higher than the pre-test scores, where the post-test score average was 4.82, and the pre-test score average was 4.05. The study also revealed no significant difference between the iPhone and traditional classroom lessons. Here the iPhone method averaged 4.89 and the traditional classroom method 4.74. Essentially, the analysis of these methods indicated similar results. However, statistical significance was discovered when students were asked which teaching method they preferred. 100% of the students in Group A preferred the iPhone method over traditional classroom learning, and roughly 84% in Group B preferred the iPhone method over traditional classroom learning. The students were delighted with using the mobile device for both the lessons and the game, and the students indicated that they preferred using games and mobile devices to learn new material.

Mobile Devices and Student Achievement

Research has shown favorable impacts on student learning when teachers' and students' perceptions are positive and when mobile devices are used in the classroom as a tool to aid in learning. Henderson and Yeow (2012), Lynch (2015), and Rodriguez et al. (2012) agreed that mobile learning devices (MLDs) would complement students' learning process. As digital natives "born into or brought up in the age of digital technology" (Halton, 2021, para. 1), many U.S. 21st-century learners can delve into online learning environments. Such learning environments include Blackboard, Canvas, Docebo, Schoology, and i-Ready. Each of these platforms is conducted within an online environment and caters to most, if not all, learning styles. In addition to those learning styles, Pitts (2012) indicated that the more senses were engaged during learning (sight, sound, touch, smell), the more likely students were to retain the information. Mobile devices allow students to learn via sight, sound, and touch. The following sections discuss literature about mobile devices as learning tools and their influence on students' learning or achievements in language arts (reading), mathematics, and writing.

Language Arts

According to Godwin-Jones (2016), Naismith et al. (2004), and Reinders and Pegrum (2017), mobile devices may enhance language learning. Enhancements may include improving the interactivity and mobility of the learning experience and engaging in situated learning, augmented reality, and game-based learning. Sung et al. (2015) stated,

> Mobile devices offer features of portability, social connectivity, context-sensitivity, and individuality, which desktop computers might not offer. Mobile devices have made learning movable, real-time, collaborative, and seamless, and the use of these devices may be called "mobile learning" in general. (p. 69)

According to Sung et al. (2015), these qualities or unique properties have been incorporated into language learning and teaching, forming the emerging research field, mobile-device-assisted language learning (MALL). Sung et al. conducted a meta-analysis of 45 articles to explore the effectiveness of mobile technology in education on language achievement by students. They found that approximately 71% of the learners using a mobile device performed significantly better than those learning without a device. They also found that MALL had a similar effect on students' achievements and helped language learning. Sung et al. (2015) stated that "mobile devices generally generate larger effects than desktop computers in supporting language learning and teacher" (p. 76) because those using a mobile device performed significantly better than those who did not use one.

Other researchers, such as Godwin-Jones (2016, 2017), Naismith et al. (2004), and Reinders and Pegrum (2017), would agree that mobile devices have enormous potential to enhance language learning, augmented reality, and game-based learning by improving mobility and interactivity of the learning experience. Therefore, Chen et al. (2020) decided to examine the effectiveness of using mobile devices in language learning. Chen et al. performed a meta-analysis on 84 research studies to complete this research. To ensure a comprehensive review of articles was included, the researchers conducted an electronic and manual search of journal articles, conference proceedings, and doctoral dissertations published during 2008-2018. Initially, the search yielded 1758 journal articles, 56 doctoral dissertations, and 14 conference proceedings. However, the following criteria were applied to the selected research articles to determine the eligibility for inclusion in the meta-analysis:

- The study adopts an experimental or quasi-experimental design that includes a control group. Qualitative studies or pre-experimental studies of single group designs were excluded.
- The use of mobile devices is the examined variable in the intervention. Experiments that only compare different learning approaches or strategies were excluded.
- The study reports experimental results of learning achievement measured by test scores. Studies only reported affective variables, such as motivation, attitudes, and perceptions.
- The study has sufficient information to calculate effect sizes, such as mean, SD, sample sizes, t value, or F value (Chen et al., 2020, p. 1774).

In order to examine the impact of different variables on the outcomes of MALL, all eligible studies were coded. The coding scheme consisted of educational level, device type, application type, instructional approach (including self-directed learning), learning context (including classroom, outdoor, and unrestricted learning contexts), intervention duration, target language skills, target language, and L1/L2 (first language, L1 and second language, L2). Once the coding was finalized, the Comprehensive Meta-Analysis 3.0 software was used to compute the effect size. These studies yielded a .722 on a 95% confidence interval of .611-.833. These results are consistent with a medium to large effect size and thus can conclude that using mobile devices for language is significantly more effective than learning with other approaches.

Additionally, Chen et al. (2020) study revealed that regarding the variables mentioned above, 52% of the studies were conducted in a post-secondary educational setting and yielded a significant effect. A medium effect was found for kindergarten, elementary, and secondary school students engaging in MALL. The researchers found that the effects of using mobile devices in language learning increased from kindergarten to college. Secondly, intervention durations lasting longer than four weeks revealed a decline in the effect of MALL; four weeks yielded the most significant difference. Smart handhelds and non-smart handhelds outperformed other devices with larger screens. Chen et al. attributed this to the smaller handheld devices encouraging learners to study anytime and anywhere. The educational-purpose applications were better tailored to the student's needs and pedagogical goals for the application type variable. The researchers also found that in terms of instructional approach, MALL produced are more significant effect with self-directed learning and mobile-assisted collaborative learning. The game-based approach produced a medium effect on MALL. Implementing MALL in an unrestricted and outdoor setting significantly affected learning with mobile devices, whereas implementing MALL in a formal classroom yielded a medium effect. Finally, Chen et al. concluded that using mobile devices to learn English is more effective than learning other languages. More success has been achieved by adopting mobile devices to enhance speaking, listening, writing, and vocabulary learning.

In addition, Sendurur et al. (2017) studied the mobile learning experience of language learners in informal settings, also using MALL with Duolingo users. Sendurur et al. mentioned that they deliberately chose a group of adult language learners having mobile learning experience on the Duolingo application. Of the delivered invitations, 18 users accepted the invitation for an interview. These users also used at least one language learning application, in addition to

Duolingo; the researchers did not specify why users used multiple language learning applications. The most studied language among the users was English. The users also used the app to learn German, Spanish and Italian. Sendurur et al. collected data through semi-structured interviews lasting 10-15 minutes, and the questions were created to capture user experience with Duolingo. The interview questions were categorized into three themes: demographics, the usage pattern of the mobile learning app, and perceived advantages and issues with the Duolingo app. These interviews were recorded, transcribed, and coded by the researchers.

Sendurur et al. (2017) found that the participants of this study frequently used mobile language learning applications. In addition to Duolingo, the popular mobile learning apps were Busuu, Memrise, Mondle, HelloTalk, Toeic Game, English Central, and others. The participants also use dictionary apps frequently. Participants felt that most language learning apps alone were not enough to learn a foreign language. The additional applications were complementary tools to aid in vocabulary and basic grammar practice. Because all participants had life-long learning goals, they felt that learning another language would create new opportunities for their professional careers. Another reason that participants used mobile language learning applications was because these apps were convenient to use; anytime, anywhere. Also, some of the participants could not participate in formal language learning courses, and the application did not demand much time.

Moreover, Sendurur et al. (2017) found that regarding the participant's experience with Duolingo, this application provides a variety of exercises in a gamification manner, which is attractive to many users. This study revealed that all participants reflected positively on the application (Duolingo). Additional advantages to using Duolingo included entertaining, engaging, and free of charge with no embedded advertisements. The participants also reported liking the step-by-step method of the application, utilizing repetition and rich pronunciation practice. The participants described the immediate feedback and performance summary as a powerful feature.

On another note, Duolingo sends notifications to the user to remind them to practice; two participants reported deleting the application because of the worrisome notifications. However, eleven participants described the reminders as valuable regulators or motivators to start studying. Though the general feedback for Duolingo was positive, the users reported some problems, such as the internet connection, headphones needed in crowded places to hear the pronunciation exercises, small screen, high demand on the battery, and software bugs. Overall, Sendurur et al. (2017) concluded that user experience effective and efficient use of the app is essential and satisfaction. The findings also reported that participants found mobile learning apps convenient.

Union et al. (2015) found similar mobile device impacts on students' performances in ELA by researching the use of eReaders in the classroom and at home to help third-grade students improve their Reading and ELA standardized test scores. A mixed-methods approach was utilized to conduct this investigation. The quantitative data were taken from the students' scores in "Ms. H" class, who used the eReaders and similar eBooks to complete Nook assignments in the classroom during the 2012-2013 school term. Ms. H's students were compared with the academic performance of four other third-grade classrooms from the same elementary school that did not use eBooks or Nooks. Ms. H's class participants included 16 students who used the eReader and 65 students in the other four classes who did not use the eReader. Also, the mandatory Georgia Online Assessment System (OAS; pre-data) and the Criterion-Referenced Competency Test (CRCT; post-data) were used to measure how well students acquired the skills described in state-mandated content standards in ELA. In the qualitative portion of this research, the Union et al. (2015) recorded notes and logs of daily events associated with using the devices as a tool in the classroom and at home by third-grade students in Ms. H's class. Participating students ranging from eight to eleven were not explicitly identified to ensure confidentiality during the research period.

The research was conducted in five stages to determine how students' behaviors reflected responsibility and durability when using mobile technology. These stages consisted of the following, according to Union et al. (2015):

- Stage 1 – Introduction (Aug. 6-9). During this period, Ms. H introduced her class to the researchers and briefly summarized the research and expectations. The Nooks were issued to the students along with training.
- Stage 2 – Nook Familiarization Period (Aug. 14 – Dec 6). The students continued to master Nook functionalities in the classroom only in ELA blocks or sessions during this stage. The students also completed Nook assignments during this time.
- Stage 3 – Refresher training and take Nooks home (Jan. 8 – March 22). At this time, students were returning from Christmas Break, and the researchers felt that students needed a refresher on the functionalities of the Nook. Students were also allowed to take their devices home over the weekend to complete assignments during this stage.
- Stage 4 – Nook or book (April 5-15). This stage fell during the student's spring break. Students were given a paperback and electronic version of their Nook of *Mr. Macky is Wacky*. Students were tasked with choosing either the paperback or eBook version to complete the Nook assignment.

- Stage 5 – Permanent Nook issue to students (Apr. 26 – May 22). During this stage, the researchers sought to determine if the students were responsible for keeping the Nooks until the last week of school. Therefore, the students had the Nooks in their possession (during class and while home).

Union et al.'s (2015) found that the average reading score for students learning with the eReader improved following the integration, while the reading scores for students without the eReader declined. Also, the students using eReaders improved their ELA scores, and students without the eReaders exhibited little change. Students also demonstrated technological skill sets as they successfully operated the functionalities of the Nook during the study, and there were no issues with lost or damaged devices. Essentially, electronic books have been shown to engage students and motivate them to read. As a result, the student is motivated and engaged in reading comprehension, and their vocabulary improves. Union et al. also concluded that using eReaders in the classroom and at home by third-grade students, integrated with classroom lessons provided by the teacher, could improve the students' reading performance.

Mims et al. (2018) also sought to show the effects of mobile device use by applying systematic instruction to teach ELA skills using fictional novels using an iPad app. Four students, ranging from 9 to 12 years old, participated in this study. Mims et al. (2018) stated that all students were from a self-contained classroom that served students with significant intellectual disabilities. The inclusion criteria included the following: (a) use of sight words or symbol reading repertoire, (b) a diagnosis or educational eligibility of moderate to profound intellectual disability or autism, (c) ability to make selections from an array on the mobile device, (d) available for the study three times a week, (e) in Grades 5 to 8, and (g) participating in their states alternated assessment based on alternate achievement standards. All students suffered from significant intellectual disabilities. Two of the participants were 12 years old and on a pre-k/K reading level, and both the nine and 11-year-olds were non-readers.

This study took place in a quiet setting away from other students in the classroom to control for overexposure. The sessions occurred a minimum of three times per week. They lasted approximately 40 minutes per session, and a multiple probe across participants was conducted to evaluate the efficacy of the comprehension intervention. The study phases included baseline, intervention, generalization, and maintenance. Three baseline sessions were conducted with each participant before the intervention began. At the end of the intervention, the teachers completed a five-point Likert-type scale survey on their perception of the study.

Mims et al. (2018) developed two versions of an iPad app for the study by Attainment Company: a baseline and an intervention version. Both versions of the app reflected an adapted version of *Outsiders*, a fictional novel used in middle school ELA. The text was adapted for non-readers by summarizing text using controlled vocabulary, reducing the overall Lexile level to a second to third-grade reading level, and pairing keywords with pictures. The chapters were also shortened and could be read in one session. The students responded to questions built into the application by selecting one of three response options, which included a combination of picture symbols and words. In the intervention version, instructional strategies were programmed into the application to deliver instruction as needed throughout the session. Also, constant time delay (CTD) was built to teach vocabulary identification and definitions. The application also included error correction and positive feedback. The dependent variable was the percentage of correct unprompted responses to ELA tasks. In addition, Mims et al. collected data on student responses to comprehension questions in the following areas: literal recall, inferential, three-step sequence, application, analysis, main idea, the main character, setting, problem, and solution. The teachers scored student responses on a paper datasheet as the student used the app; the app, however, was also programmed to collect data during vocabulary, definition, and comprehension probes.

Student one began the study with a 26.6% baseline mean; however, she increased her performance to 81.6% during intervention. This pattern stood constant for the remaining chapters (3-10), as student one's baseline score decreased to 25%, and the intervention significantly increased. Overall, student one increased her baseline mean of 26% to an intervention mean of 77%. Student two showed similar progress with a baseline mean of 28.75% and an intervention mean of 81.25%. Students three and four are non-readers; therefore, their mean percentage increased but not as much as Students one and two. Student three's baseline mean began at 33% and increased to 55%. Also, Student four began with a baseline mean of 32%, correct to an intervention mean of 38%.

Results revealed using an iPad with embedded systematic instruction to improve students' listening comprehension. The research also improved students' responses beyond recall, increasing their percentages of independent correct vocabulary and definition identification and responses to comprehension questions after using the iPad and the language arts app. Three of the four students made significant gains across all of the skills, but Student 4 made small gains, which were still impressive as he did not show gains in other areas during the school year. Lastly, Mims et al. (2018) found that teachers enjoyed the grade-aligned content and materials, and students were also engaged during the iPad app lessons. The teachers also reported that the application in small group instruction was more interested in utilizing the application in a one-to-one session, as it required more instructional time during the one-to-one sessions.

Mathematics

In addition to mobile devices being used to aid ELA, the use of technology in mathematics has been highlighted by researchers over the past two decades. Cheung and Slavin (2013) sought to study the effectiveness of educational technology application for enhancing mathematics achievement in K-12 classrooms utilizing meta-analysis. Comprehensive Meta-Analysis Software version 2 calculated the effect sizes and performed other meta-analysis tests. The researchers determined that their effect size was +0.16. Cheung and Slavin (2013) followed several critical steps in the meta-analysis of articles. These critical steps included:

- Locate all possible studies.
- Screen potential studies for inclusion using preset criteria.
- Code all qualified studies based on their methodological and substantive features.
- Calculate effect sizes for all qualified studies for further combined analysis.
- Carry out a comprehensive statistical analysis covering average effects and the relationships between effects and study features. (p. 94)

For an article to be included in the study, 11 inclusion criteria were established. For example, the studies must involve the student in K-12, pre-test data has to be provided, and a minimum of 12 weeks was required for the study's duration. After all, articles were checked and determined for inclusion, 74 qualifying studies were included in the final analysis. The 74 qualifying studies included 56,886 K-12 students, 45 elementary schools, and 29 secondary studies. Also, the qualifying studies fell into four research design types: randomized experiments, randomized quasi-experiments, matched control studies, and post hoc studies.

After analyzing their qualifying articles, Cheung and Slavin (2013) listed several findings. Overall, Cheung and Slavin's findings indicated that technology applications produce a positive but modest effect on math achievement. Also, their study indicated that three types of educational technology/instruction showed an effect on mathematic achievement; these types of educational technology were Computer-Assisted Instruction (CAI), with an effect size of +0.19. The second was Computer-management learning (CML), with an effect size of +0.09. The third was comprehensive programs with an effect size of +0.06.

The researchers also pointed out several findings. According to Cheung and Slavin (2013), studies with small sample sizes produce, on average, twice the effect sizes of those with large sample sizes; this was thought to be attributed to smaller-scale research being more closely controlled. Also, because standardized tests are more often used in extensive studies, the variables are less sensitive to treatments. They also found that educational technology had a more significant impact on elementary school students. However, the effects sizes reported in their analysis revealed a +0.17 effect size in elementary studies and an +0.14 effect size for secondary studies, which is not significantly different per the researchers. Fourth, a statistically significant difference was found in the time spent on Integrated Learning Systems (ILS). For example, applications that require computer use for 30 minutes or more per week had a more significant impact. Lastly, Cheung and Slavin found that student improvement was hard to find over time. They found no such positive trend in recent studies.

Like the previous researchers, Kiger et al. (2012) examined the influence of a mobile learning intervention on third-grade math achievement. Kiger et al. implemented a mobile learning intervention (MLI) at Park Elementary during the third quarter of the 2010-2011 school term to carry out this study. A total of four third-grade classrooms were used to complete this study. Student participation was voluntary, and the parents of the students were sent informational packets asking for parents' permission. The first two third-grade classrooms selected for this study utilized Everyday Mathematics (EM) and daily practice techniques (i.e., flashcards). These classes had a total of 46 students and two teachers. The other two classrooms (the comparison students) were coupled with EM and daily practice with iPod touch devices preloaded with selected math applications. These applications were Multiplication Genius lite, Mad Math Lite, Pop Math, Flash To Pass, Math Drills Lite, Math Tappers: Multiples, Multiplication Flashcards To Go, Brain Thaw, Math Magic, and FlowMath. The district's instructional technology administrator (ITA) and Park's learning resource teacher (LRT) selected these applications. The third-grade teachers participating in the study decided who/which classrooms would use the mobile learning intervention tool. The teachers also complete a pre-intervention survey to identify and control for pre-existing group differences. Also, other pre-intervention data such as student test scores, report cards, and attendance records were collected. Plus, a 50-item "late" multiplication pre-test was given to all students by the teachers after the iPod touch devices and math applications were introduced. Kiger et al. also administered a 100-item multiplication test after the intervention.

In preparation for the study, the ITA worked with District Technical Support to ready the mobile devices. The ITA also conducted meetings with the LRT and the four teachers to identify and reinforce multiplication topics covered during the study. It was also established that all students would practice for 10 minutes each day, using the iPod touch devices or traditional means. Essentially, Kiger et al. (2012) found that the mobile learning intervention students answered more items correctly on the post-intervention test, with a mean of 54.5 than the comparison students (students using traditional means such as flashcards) who had a mean of 46.3. Also, the performance of the MLI students on the double-digit multiplication items answered more items correctly than the comparison students. The MLI students' mean score was

11.6, and the comparison students' mean score was 8.2. Kiger et al. concluded that the MLI participation was a significant indicator of test performance, and the MLI students outperformed the comparison students in the post-intervention.

According to the National Council of Teachers of Mathematics (as cited in Zhang et al., 2015), "technology is essential in teaching and learning mathematics; it influences the mathematics taught and enhances students' learning" (p. 20). Therefore, Zhang et al. (2015) conducted an exploratory study in an inclusive fourth-grade classroom to determine if using math apps improved student learning. There were 18 fourth-grade students from the same class who participated in this study, with an average age of 9 years old. The sample included 7 females and 11 males. Of the participants, 17 were of Hispanic descent, and 1 was African American. Four participants were identified with at least one disability (i.e., autism, emotional disorder, learning disability). Six students were identified as at risk for problematic behavior. The remaining seven were identified as having no condition, and one student in this group was classified as gifted.

The participants used Slash Math, Motion Math Zoom, and Long Multiplication applications during four class sessions over one month. Each session lasted for roughly 80-90 minutes. The teacher or researcher spent the first 5 to 10 minutes explaining how to use the app. While using the app, the teacher/researcher provided help to students experiencing problems with the task. During the four sessions, the students used Splash Math for session one (40 minutes), Motion Math Zoom for session two (30 minutes), Splash Math for session three (no time noted), and Long Multiplication for the fourth session (one hour). In addition to the applications, the students were given three paper and pencil assessments. These assessments were administered to the students to measure their learning from the math apps.

Zhang et al. (2015) found that all students included in this study improved their performance after using the math applications. The *t*-tests indicated that the pre-and post-test differences were statistically significant. The researchers found that using mobile devices and applications improved student learning. Zhang et al. supported that using such devices and applications could close the achievement gap between struggling and typical students. These applications allowed the learners to work at their pace and provided immediate feedback. Zhang et al. suggested that providing immediate feedback reinforced student learning.

Schmidt and Williamson-Kefu (2020) explored the benefits of using digital technology to support and enhance students' understanding of mathematics. Schmidt and Williamson-Kefu performed a case study based on a Year 6 classroom at a primary school in a suburban Australian city. At this school, all students had access to a mobile device for at least four years of their schooling, and the school agreed to participate in a mathematical inquiry research project. Additionally, the teachers committed to teaching at least one mathematical inquiry per term during the school year. According to Schmidt and Williamson-Kefu (2020), this mathematical inquiry would require the teachers to guide their students by addressing rich and complex problems, such as those that appear in the real world and contain ambiguities using mathematical evidence. The case study used a 4D guided inquiry model with four phases. Schmidt and Williamson-Kefu (2020) defined these phases as follows:

- Discover – explore the ambiguities and concepts in the question.
- Devise – strategies about how the question can be answered.
- Develop – collect and collate the evidence to prove one’s answer.
- Defend – present one’s answer, evidence, and justification to the class (p. 24).

The students were given a question to answer if they ate nutritious breakfast cereal. The students were tasked with using their mobile devices to research, gather information, tackle a range of mathematical concepts, and calculate measurements. The students were broken into six groups and began to work through the 4D model of inquiry, previously taught or learned in the classroom. After the students completed the inquiry, Schmidt and Williamson-Kefu (2020) found that "the use of digital technology allowed students to embrace and learn from the transdisciplinary nature of mathematical inquiry" (p. 27). The digital technology (mobile device) allowed the students access to information that traditional methods of solving math could not, essentially removing the glass ceiling that would otherwise limit their learning to only data provided to them. Overall, Schmidt and Williamson-Kefu found that using technologies in math and mainly math inquiries can make teaching these concepts engaging and effective. These technologies would also enhance students' knowledge and understanding while forging a connection to the mathematical domain.

Watson-Huggins and Trotman (2019) took a slightly different approach, but mobile technology remained present in their research. Their research occurred in an eastern Kingston inner-city primary school in Jamaica. The researchers focused on Jamacia because of worsening math scores plaguing the Jamaican education system in primary and secondary schools. The worsening scores also encouraged the government of Jamaica to find effective ways to inspire students to learn mathematics to increase scores. In 2018, the government implemented the Tablets in Schools Project, where 91,000 mobile devices were given to over 1,106 schools across the island.

Sixth-grade students were selected to complete this research because they were preparing to take the national standardized exam, Grade 6 Achievement Test, and the Edufocal gamification mathematics application piloted. Sixty-one students were randomly assigned to two classes based on the Diagnostic Mathematics pretest scores. Group one (35 students) was given complete access to the Edufocal gamification application for instructional purposes. Group two (26 students) received traditional mathematics instruction. A posttest was given after the investigation to determine student achievement. Watson-Huggins and Trotman (2019) concluded that gamification applications motivated group one to learn mathematical concepts. However, more research is required to determine student achievement because though both groups were eager to learn, their performance differences were not statistically significant.

Writing

In addition to mobile devices being beneficial in mathematics, some researchers have found that mobile devices can impact writing. Patchan and Puranik (2016) explored the effect of intrinsic and extrinsic feedback on preschool children when teaching them to write letters using a mobile device and stylus. Students were recruited from 10 classes in six preschools. Students were screened to qualify for the research and given pre-tests to assess their letter knowledge as part of the screening process. Children who could write letters one through eighteen were not eligible to participate in the study. After screening, 54 participants were put into 21 small groups, with two to three students in each group. The students ranged from the age of three to five.

Each small group was randomly assigned to one of three conditions: (a) finger interaction with the mobile device, (b) stylus interaction with the mobile device, or (c) pencil and paper. Patchan and Puranik (2016) used iPads for this study. Of the 46 who completed the study, 16 practiced writing with an iPad and their finger, 14 practiced writing with an iPad and stylus, and 16 practiced writing with paper and pencil. Trained assistants instructed the participants three times a week for eight weeks, with a different letter taught each week for eight weeks. Each small group was taught a different set of eight letters, and all 26 letters were taught across the small groups. Each lesson lasted approximately 20 minutes. The participants using the iPad utilized a Writing Wizard application to practice writing each letter.

A series of one-way, between-subject analyses of covariance (ANCOVA) was complete, and the results revealed no pre-existing differences between the instructional conditions on any pre-test measures. The between-subjects ANCOVA showed significant differences between all groups' post-test letter writing scores. Patchan and Puranik (2016) concluded that children using the stylus wrote a similar number of letters correctly as children in the paper and pencil condition. They also found that participants using their fingers with the mobile device wrote more letters correctly than children using the stylus condition.

Patchan and Puranik found that two types of feedback were likely to support learning to write letters using mobile devices: extrinsic feedback and intrinsic feedback. The information provided by an external source during and after one performs a task is referred to as extrinsic feedback. This type of feedback differed from visual feedback in that visual feedback occurred naturally and required internal processing before the learner detected an error. Therefore, visual feedback was a form of intrinsic feedback, the second type of feedback likely to support learning to write letters. Patchan and Puranik provided students with an extrinsic and intrinsic feedback experience (using the stylus, the student's finger, and pencil and paper) during various writing tasks. This study proved that using mobile devices to teach preschool children to write their uppercase letters is beneficial.

Lynch (2015) also discovered that students' learning experiences increased after fifth and eighth-graders used a tablet for learning in class and at home. Lynch collected a survey of a host of Advanced Placement and National Writing Project teachers about the educational impacts of internet technology in the classroom. The survey revealed that 35% of the eighth-grade students indicated that they were more interested in their teachers' lessons or activities when using their tablets. Teachers also reported that students exceeded teachers' academic expectations when using tablets.

Additionally, Cristol and Gimbert (2013) studied a group of 8th and 10th graders from the Mountainville School District located in the Midwest United States. Cristol and Gimbert used the district's technology coordinator to inform them of teachers who consistently used MLDs inside and outside their classrooms. There were 12 teachers identified and interviewed to discuss their methodologies for incorporating technology in the classroom from this information. Cristol and Gimbert used scores from the state achievement assessment, gathering two years of student data to subdivide students into categories. These categories included (a) those whose teachers encouraged and supported MLDs and (b) those whose teachers did not support and encourage the use or full integration of MLDs.

Cristol and Gimbert (2013) found that those using MLDs showed positive student test scores in all instances. Groups exposed to MLDs scored significantly higher and consistently produced higher scores. The eighth-grade math population noticed the most dramatic increase, scoring an average of 52.34 points above the state assessments, higher than peers unexposed to MLDs. Increases in achievement were noted for reading and science. There was also a positive change throughout the district compared to peers not utilizing MLDs, averaging 25.5 points above peers. After these findings, Cristol and Gimbert supported that using mobile devices as a learning tool could increase student achievement in math, reading, writing, social studies, and science.

According to Couse and Chen (2010), early childhood is from birth through 8 years old, when growth and development happen rapidly. Therefore, Couse and Chen gathered qualitative and quantitative data to assess the viability of mobile devices as a learning tool for preschool children by performing an exploratory study using a mixed-methods approach. Using 41 children between 3 to 6 years old in three preschool classrooms, Couse and Chen distributed a background survey to their parents, soliciting information about demographics and the types of technology used in the home. This survey included 16 items that focused on the types of technology available in the home, the child's usage, and adult facilitation in computer use. Students were paired in a room equipped with tablet computers outside the classroom.

Couse and Chen (2010) investigated how preschool children would acclimate to tablet technology and examined the technology's effectiveness in keeping the child engaged and motivated. Both quantitative and qualitative data were gathered to assess the viability of the tablet as a learning tool for preschool children. The researchers also collected data from the students regarding time spent in each session. Data collection entailed four distinct phases: introductory warm-up sessions, a final self-portrait drawing session, two separate interviews with each child for delayed memory recall, and one focus group interview session with each classroom group of teachers.

Couse and Chen (2010) found that children between the ages of 3 and 6 could quickly learn to use the tablet computer to represent their ideas and learning. However, their home computer use did not influence the ease of becoming acclimated to this new technology. Couse and Chen also found that as students became familiar with the device, they became more independent and asked for less instruction and teacher assistance. Therefore, Couse and Chen concluded that the mobile device was a viable tool to offer young children to represent their ideas in the classroom.

Applications and i-Ready

Mobile devices could be an asset; however, mobile devices are useless without installing or using applications. Briz-Ponce and Juanes-Méndez (2015) explored mobile devices and applications' characteristics and learning potential. The researchers used a cross-sectional survey distributed face-to-face and online to gather data. The face-to-face survey was distributed to the undergraduate students 10 minutes before class. GoogleDocs was used to develop the online survey, and participants received a link to the survey and answered anonymously. The participants completed the survey anonymously. Data were collected from 124 students and teachers in higher education between March 2014 and April 2014.

According to Briz-Ponce and Juanes-Méndez (2015), many participants used their mobile devices daily, and only 9% did not use the device to download apps. This study revealed the essential characteristics that participants looked for when choosing an app to use. These characteristics include (from the most important to the least important) content, usability, recommendation, security/privacy, accessibility, and data connection. Also, the top apps downloaded by the participants were medical apps, training medical apps, and apps used for medical diagnosis (i.e., drug dictionary, medical calculator), which is not surprising considering that the participants are medical students, residents, and medical professionals. The research found that smartphones are the most used for downloading apps and looking up information. Briz-Ponce and Juanes-Méndez also acknowledged that “it is important to notice that if this technology can become a new tool for students to help them learn within the new digital era, the apps must fulfill the requirements and demand of the user” (p. 34).

Kim et al. (2021) performed a meta-analysis of the effects of educational apps on preschool to third-grade children's reading and math skills. Kim et al. (2021) noted over 2,500 educational apps available to school leaders; this does not include apps promising to improve student academic achievement, which boasts 200,000 in 2018. "More recently, the spread of the COVID-19 pandemic has ignited efforts by research and policy organizations to offer free and easy-to-use educational apps as a scalable strategy for helping young children acquire and maintain basic literacy and mathematic skills" (Kim et al., 2021, p. 1).

Kim et al.'s (2021) research followed five criteria: (a) evaluate the effects of interactive educational apps, (b) include outcome measurements of math and reading, (c) provide sufficient empirical information to calculate an effect size, (d) include students from preschool to third-grade (ages 3-9), and (e) exclude studies using single-group pre-posttest designs because they fail to protect against most threats to internal validity (p. 5). There were 306 studies initially identified, and after the screening phase, 36 studies were included in the sample. After coding each study and conducting a robust variance estimation (RVE) to compute the various effect sizes, Kim et al. (2021) found that educational apps positively impact students' math and reading skills. However, the effects are more significant for pre-school-aged kids than those in kindergarten to third grade.

Falloon (2013) studied app design and content influence students' learning pathways utilizing iPads. Falloon (2013) adopted a case study design within an interpretive theoretical framework, and data were collected over six months from 18 students. To carry out this study, the researchers spent 90 minutes in the research classroom on different days and times of the week. There were 45 apps used during this study. Before those apps were selected, the teacher evaluated each app based on the following criteria:

- Professional judgment. How well do the app support teaching and learning goals
- Feedback from the students after using the app
- Online reviews (reported by other teachers)
- Ratings
- Cost of provisioning the app on all devices. (Falloon, 2013, p. 20)

The applications that contained features or designs, including learning concepts, generated more evidence of responses. However, Falloon (2013) found that certain content features were used the most, including video of content being taught, interaction parameters (pressing pause and timed questions), and thoughtful engagement throughout (embedded pedagogy balanced with entertainment but focused on content). Falloon also noted that learning apps provided guidance and structure for children using thoughtfully designed embedded parameters to focus on learning objectives. These parameters included restrictions to predetermined fields, time limits on game components, preset difficulty, and the form in which feedback was provided. According to the researcher, careful attention should be paid to the design and content of applications. The following items should be considered: (a) communicating learning objectives in ways young students can access and understand, (b) providing smooth and distraction-free pathways towards achieving goals, (c) including accessible and understandable instructions and teaching elements, (d) incorporating formative, corrective feedback, (e) combining the appropriate blend of game, practice and learning components, and (f) providing interaction parameters matched to the learning characteristics of the target student group.

i-Ready is one of such programs or applications where students interact to complete various learning activities. In this study, the i-Ready learning program, in conjunction with

Chromebook (the district's chosen mobile device), was the application used to provide additional practice in math and reading. This application allowed students to log in to an online portal to access their learning paths. This application was familiar to many districts within the United States, and the most critical component was that each student had a mobile device assigned to them. Although mobile and seamless learning is the notion that students can learn anytime and anywhere, seamless learning provides instant feedback and exposes new learning content that automatically populates learners. i-Ready allows the district to explore seamless learning, feedback, customized learning tracks, and exposure to the original content.

According to the founders of the i-Ready program, the Curriculum Associates (2019), the "correlation between i-Ready and consortium and state assessment consistently exceed established benchmarks in education" (p. 4). In partnership with the Educational Research Institute of America, research was performed to establish a relationship between the i-Ready exam and the national and state assessments. The National Center on Intensive Intervention (2018a, 2018b) reported that the assessment correlations were above .70, exceeding benchmarks in MA and ELA and across grades. Moreover, analyzing data from more than one million students who took the i-Ready diagnostic from 2017 to 2018, students using the i-Ready instructional program experienced substantial learning gains compared to students who did not experience such gains. The Curriculum Associates (2018) examined the significance of the findings by conducting an ANCOVA analysis and corrected for selection bias using students' prior i-Ready diagnostic scores. However, it limited the data to only those students who had i-Ready scores from the previous academic year. The results of this study were statistically significant, and the significance of the findings provided the support that i-Ready as a program met the criteria for ESSA Level 3: Promising Evidence (Curriculum Associates, 2018).

Moreover, i-Ready research stated that students receiving i-Ready instruction experienced average gains of 38% in mathematics relative to students who did not receive i-Ready instruction and 39% for ELA.

With i-Ready being a relatively new topic, only a few studies had been performed outside of the Curriculum Associates to illustrate the effect of the i-Ready program. Federico (2016) collected data by observing her class of nine students to answer how students interacted with the education program i-Ready. The researcher collected and analyzed data, such as on-task and off-task behaviors and positive and negative experiences. The researcher found that 44% of student experience was rated positive, and 46% was rated negatively. Positive experiences included completing a lesson, enjoying using computers, using the touch screen feature, and passing lessons. Negative experiences included becoming overwhelmed by i-Ready, boredom, and academically inappropriate lessons.

Regarding on-task and off-task behaviors, 45% of behavior noticed was on task, and 55% was off-task behavior. According to Federico (2016), students had more negative experiences than positive ones. Students were more off-task than on-task when using the i-Ready program. Additionally, positive experiences did not lead to on-task behaviors. The i-Ready program did not provide opportunities for student choice, nor did the i-Ready program support development of 21st-century skills.

Finch (2015) also investigated the impact of i-Ready on students' reading achievements in an urban classroom. Finch used 24 students from two 6th-grade ELA classes and 37 teachers from fifth through eighth grade in the study. Finch collected data through the 2013-2014 and 2014-2015 school years to determine if a correlation existed between the digital intervention tool (i-Ready) and academic performance. Finch divided students into two groups for this study. Both were administered a pretest and posttest via i-Ready. The research found no significant difference between the year's beginning, middle, and end variables. However, a significant main effect was on the benchmark's overall scores. Finch concluded that the results were inconclusive and could not be used to determine if i-Ready was an effective intervention.

Silva (2016) also examined if i-Ready could increase students' reading achievement. Silva used 80 first-grade students for the study during the 2014-2015 academic year. These students were divided into two groups: the treatment group participated in an i-Ready and an ELA program, while the control group participated only in the ELA program. Silva found a significant difference in overall reading achievement between the treatment and control groups. However, there were no differences in reading fluency between those participating in i-Ready and those who did not participate. Silva concluded that using a supplemental CAI program was not always effective in boosting student achievement.

Conversly, Pruznak (2021) researched the effectiveness of i-Ready on student growth. The researcher specifically sought to determine if the time spent, the total lessons completed, and the total lesson passed on i-Ready instruction for reading and math would determine end-of-year growth in those areas. The research collected archival data for kindergarten through fourth grade during the 2018-2019 school year. The sample demographics were 92% white, with a median household income of $73,108 and only 5.7% below the poverty line. The researcher used an ex post facto correlational design and multiple regression, and the research found that reading growth could be significantly predicted for the first, second, and third grades. However, the time spent reading and reading lessons passed were only significant for second and third grade. Total time spent was negatively correlated with the end-of-year math growth for all grades except the fourth grade. Also, math growth could be predicted for kindergarten, second, and third grade.

However, only the math lessons passed were significant in determining end-of-year growth. The total math time spent was negatively correlated with the end-of-year math growth for all grades except the first grade. For second and third grades, both variables were significant.

Forsman (2018) sought to study the impacts of i-Ready on mathmatic and language art growth for special needs students. The data used for the study was based on the test and intervention results of students in Grades 6 through 8, for a total of 66 special needs students during the 2016-2017 school year. The student disabilities included Emotionally Disabled, Intellectual Disability, Multiple disabilities, Language/Speech Impaired, Specific Learning Disabled in one or all subjects, Autism, and Other health impaired. There were 15 females and 51 males; 63 of the students were Caucasian. Forsman (2018) found a significant difference in the students' scores for pretest and post-tests, implying that post-test scores were higher than the pretest scores for language arts. There were no significant differences between the pre and post-test scores for mathematics. The results indicated that the posttest scores were lower than the pretest scores. The researcher also found that implementing the i-Ready program could significantly improve the inclusion student's language art growth. A significant difference was found in pre and post-test conditions for inclusion students in language arts. The inclusion i-Ready for inclusion students in mathematics also revealed a significant difference in scores for pre and post-test conditions. Therefore, the researcher concluded that i-Ready does affect the academic growth of special needs students in an inclusion setting in both mathematics and language arts.

Lewis (2018) performed a study to evaluate the influence on student assessment scores and teacher evaluation scores with implementation of the i-Ready mathematics program. There were 4 third grade, 4 fourth grade, 4 fifth grade, and 1 retained third-grade class used, for a total of 477 students included in this study. Of the students, 90% were African American, and 9% were Hispanic. The researcher compared the students' 2015-2016 FSA scores to the 2016-2017 i-Ready diagnostic scores. Teacher evaluation scores for the Technology Needs Assessment for 2015-2016 were compared to the 2016-2017 evaluation results. Lewis (2018) found that no significant difference existed between student math performance and the implementation of i-Ready for grades three and five. However, a relationship did exist between i-Ready implementation and student performance on the Florida Standards Assessment (FSA) exam. Lastly, no difference was found between teacher evaluation scores, and therefore, it could not be determined if the evaluation scores affected the implementation of the i-Ready mathematics program.

Moreover, Jones (2013) studied 108 third-grade students from a small, rural elementary school in Southern Ohio. Of the 108 students, 91 were in mainstream classes, and 17 special education. Jones used correlation to find a significant relationship between the variables (i-Ready diagnostic and the Ohio Acheivement Assessment reading portion). The results of this study produced two significant findings. First, a strong correlation was found between the i-Ready Diagnostic and the OAA reading portion, indicating that i-Ready scores showed what the student would make on the OAA reading portion. Second, using linear regression, Jones predicted that if students scored between 445 and 509, the students would be in the range necessary to pass the OAA reading portion.

Moreover, gender has also been said to play a part in student performance. Reardon et al. (2018) stated that “studies of gender achievement gaps in the United States show that on average, females outperform males on reading/ELA tests and males outperform females on math tests” (p. 284). Cimpian et al. (2020) completed a study to understand the persistent gender gap in STEM (science, technology, engineering, and mathematics). The researchers followed a host of students from the ninth grade through the first few college years. The final dataset included 5,960 students. Cimpian et al. (2020) found that the gender gaps differ at the top versus the bottom; for example, students attending a four-year college consisted of 23.8% of men and 5.5% of women who pursued a PECS (physics, engineering, and computer science) major. Men majored in PECS at a higher rate at every point in the STEM achievement distribution. Overall, citing a 4-to-1 male-to-female ratio in PECS implicates the importance of assessing the gender balance in PECS throughout the achievement distribution.

Schwabe et al. (2014) found similar results to Reardon et al. (2018) and Cimpian et al. (2020) while examining the influences of item format and intrinsic reading motivation on reading achievement. The researchers gathered pre-existing data from two large-scale reading tests to systematically investigate the relationships between gender, item format, and intrinsic reading motivation. Data for 4,000 students were gathered from the 2011 Progress in International Reading Literacy Study (PIRLS) and 4,979 from the 2009 Program of International Student Assessment (PISA). The students were ages 10 and 15. They used a ”jackknife” procedure, a resampling technique useful for variance and bias estimations, *t*-tests for preliminary data analyses, and Cohen’s *d* to interpret mean differences. Schwabe et al. (2014) found that on both the PISA and the PIRLS, girls outperformed boys in reading achievement and showed higher levels of intrinsic reading motivation. However, when performing analysis to test the interaction of gender and item format, the researchers found no statistically significant effect of gender on reading achievement but a significantly positive interaction between gender and item format. Essentially, the ten-year-old girls did significantly better on constructed-response items when compared with equally skilled boys. The 15-year-old girls' findings were the same, thus leading the researchers to conclude that ten and 15-year-old female students showed a specific advantage in constructed-response reading items.

Conclusion of Literature Review

According to Cristol and Gimbert (2013), technology is recognized in government legislation and national educational associations as essential in all learning environments. The ISTE (2019) set standards for using technology in educational settings. Beginning in the early 2000s, the No Child Left Behind Act (2002), Individuals with Disabilities Education Act (2004), National Council of Teachers of Mathematics (2000), National Science Teachers Association (2001), and National Council for the Social Studies (2006) expected that every student receives access to age-appropriate curricula through essential technological tools. The ESSA (2015) concurred with this expectation. More than half of the U.S. population owns a cellphone, with children being fast-growing mobile technology users. With the growing community of children using mobile devices, it is only natural for this usage to spill over to the classroom environment (Cavus et al., 2008).

Although research has found many advantages of using mobile devices in the classroom as a learning tool or a learning aid, there are also significant disadvantages. The device's ability to provide anywhere, anytime connectivity, collaboration, and communication are benefits. Students have an information portal and learning device at their fingertips. However, the disadvantages of such devices include connectivity, usability/adaptability, affordance, and design flaws. These disadvantages may cause adverse learning effects, such as encouraging distracting behavior or offering irrelevant materials during learning periods. Careful planning and design are essential for teachers, educational leaders, or specialists to integrate mobile device use smoothly. As briefly discussed in the above sections, proper training and handling of a teacher's perception of technology is critical in a smooth transition. Researchers such as Domingo and Garganté (2016) and Hill 2011, would agree that a direct correlation between a teacher's view of technology and the effect that it will have on their experiences in the classroom. If the teacher’s view is negative, their student will also have a negative learning experience. However, when insights are positive and the teacher feels confident in his/her skills, research has shown that the student will have a positive learning experience. Despite the disadvantages and negative perceptions, mobile devices have managed to propel forward and offer some positive implications that these devices may be a beneficial learning and teaching tool in various subject matters. These devices also appear to implicate that they are helpful in various facets of education regarding the subject.

CHAPTER III

METHODOLOGY

Weitzel (2019) stated, "A mobile world is here and will only continue to grow. In education, however, the mobile revolution has not yet reached its tipping point" (p. 1). There is a limited amount of literature investigating the impact of mobile devices paired with instructional programs, such as i-Ready, and their effects on students' academic achievements. Therefore, this study aimed to examine the relationships between the use of mobile devices and student performance in MA and ELA. This chapter consists of the research and analysis methodologies used to investigate mobile devices on the students' math and ELA scores. This chapter is divided into the following sections: (a) research questions, (b) research design, (c) population and sample, (d) instrumentation, (e) data collection, and (d) data analysis.

Research Questions

The following research questions were used to guide this study:

1. Is there a significant statistical difference between the MAAP mathematics scores for District A (technology district) and District B (non-technology district)?
2. Is there a significant statistical difference between the MAAP English language arts (reading) scores for District A and B?
3. Is there a relationship between i-Ready scores and MAAP scores for District A in math and ELA?

4. Is there a relationship between the students' gender and the student scores in mathematics and English language art for Districts A and B on the MAAP exam?

Research Design

Based on a quantitative research approach, this research was a causal-comparative study to compare student MAAP scores based on the district's technology standing (technology/non-technology). Inferential analysis was conducted using the MAAP scores for math and ELA to generalize the population's results. Additionally, a descriptive analysis was conducted for the MAAP scores for Districts A and B. A causal-comparative approach to this research was taken to find a relationship between MA and ELA scores after an action or event (in this case, a tool, the mobile device) has occurred or been introduced.

Population and Sample

The target population for this study was fourth-grade students in Districts A and B. District A served approximately 5,000 students, with 51% male and 49% female. Of this population, 400 of those students were fourth-grade students. District B served approximately 20,000 students, 51% male, and 49% female. Of District B's population, 2,000 were fourth-grade students. The students did not have to partake in this study; only pre-existing data (MAAP scores in ELA and math) were collected for the fourth-grade students in District A and District B for the 2018-2019 school term. After the data were cleansed of outliers and duplicate data, 396 students were used for District A, and 396 were randomly selected from District B's population. This random sample was created within SPSS by using the select cases feature. Within this feature, the researcher is given the option to randomly sample cases and choose the "exactly" function.

Within this function, the researcher chose to randomly sample 396 cases from District B's 2000 cases to match District A's 396.

Instrumentation

School improvement and data specialists provided pre-existing datasets for Districts A and B for the 2018 to 2019 school year. These pre-existing datasets consisted of the students MAAP scores for ELA and mathematics. The i-Ready diagnostic scores for District A served as a support instrument for explaining any differences between the two school districts. District B did not utilize the i-Ready platform as a supplementary learning platform. All data was provided to the research through digital file storage methods, such as Dropbox by the designated contact within Districts A and B.

Mississippi Academic Assessment Program

The purpose of the MAAP was to evaluate student performance relative to the Mississippi College and Career Readiness Standards (MDE, 2017). The MAAP was also designed to provide valid and reliable results that guide instruction through data-driven education. The design included an accountability system to improve student achievement, increase accountability for school districts and individual schools, and aid state-level decisions. The MAAP exam encompassed ELA and math and English II and Algebra I for Grades 3 to 8. Fundamental groups and organizations involved in developing and administering the MAAP included the MDE Office of Student Assessment, Questar Assessment Inc., the Council for the Aid to Education, Mississippi educators, and the Mississippi Technical Advisory Committee. During the 2018 to 2019 school term, the Mississippi State Board of Education "waived passing score requirements and the Governor issued an executive order granting the Board the ability to suspend or amend state laws and policies if necessary to cope with the effects of the coronavirus" (Royals, 2021, p. 1). MAAP testing and accountability resumed during the 2021-2022 academic school term.

Validity

MDE (2017) stated,

> Validity evidence is gathered throughout the entire test lifecycle, from the item and test development to scoring and reporting. Validity evidence is provided in multiple ways for the 2016-2017 MAAP: (a) Content validity, (b) Internal structure, and (c) Differential item functioning (DIF). (p. 118)

The validity of MAAP depended on establishing a link between each piece of the assessment and what students should know and do, as described in the Mississippi College and Career Readiness Standards. Several standards developed by Questar (MDE, 2017) and MDE presented evidence of validity related to testing content, such as the following:

- Webb's (1999) Depth of Knowledge (DOK) ensured that MAAP items aligned with the Mississippi College and Career Readiness Standards for content and cognitive levels.
- MDE/Questar (MDE, 2017) selected qualified item writers and provided training to ensure high-quality items were written.
- A bias, fairness, and sensitivity committee reviewed items related to diversity, gender, and other factors.
- Several statistical analyses were conducted before items were selected for operational use, including classical item analysis, distractor analysis, and DIF.

The correlation between exams indicated moderate to solid relationships, with ELA assessment scores of .51 and .61 for math.

Reliability

During the 2016 to 2017 school year, the scores of districts across Mississippi were compiled by Questar (MDE, 2017). These data, after analysis, served as a technical report to ensure that the MAAP exam was clear and accessible to a wide range of educators. Questar played a part in developing content for the MAAP exam and performed assessments to ensure that items aligned with standards and specific MAAP specifications like rigor (MDE, 2017). According to the MDE (2017),

> Reliability can be estimated via the correlation of scores on forms assumed to be parallel (equivalence reliability), form test-retest data (stability reliability), or from a single test administration (internal consistency reliability) using any of a variety of techniques. Reliability evidence for the 2016-2017 MAAP exam includes the following: (a) Internal consistency (coefficient alpha), (b) Standard error of measurement (SEM), Conditional standard error to measurement (CSEM) for scale scores, (c) Classification accuracy and classification consistency, and (d) Rater agreement for hand-scored items (p. 109).

According to the MDE (2017), the following steps were taken to reduce measurement error during item development, administration, and scoring: (a) Items were written with the same set of standards and item specifications using blueprints and test construction specifications; (b) test administrators were instructed to follow testing directions and attend training; and (c) the ELA writing prompts were hand scored, making them susceptible to scoring error due to the difference among scorers and ambiguity in the scoring rubric. Scorers received extensive training and were monitored throughout the scoring process to minimize error (MDE, 2017). Reliability evidence was demonstrated using internal consistency measures. The fourth-grade coefficient was .82 in ELA and .92 in math. State summative assessments measured reliability from the mid .80s to the low .90s, meeting the internal consistency protocol. For the SEM, reliability scores close to 0 illustrated increased accuracy. The calculations for SEM delivered a range of 3.33 for ELA and 3.18 for math.

Moreover, a CSEM was conducted to measure relatability at different points along the ability scale. The CSEMs characterized measurement precision regarding score levels and determined a cut score to gauge student proficiency on an assessment. These scores for the fourth-grade student included 450 to 465 for ELA and the same for math. According to the Mississippi Performance Standards: Performance Levels, these scores fall on the PL3/Proficient.

i-Ready Diagnostic Assessment

The i-Ready diagnostic assessment scores were used as a support instrument for explaining the differences (if any) between District A (the technology district with a supplementary learning platform) and District B (the non-technology district with no supplementary platform). This assessment was designed to provide teachers with insight into their students' needs—the i-Ready diagnostic measured their performance and growth. The assessment also adapted to the students' responses, pinpointed their ability level, identified specific skills students needed to learn to accelerate their growth, and charted a personalized learning path for each student. In District A, the i-Ready diagnostic assessments evaluated students’ math and ELA skills. Individual scores were given at the end of the evaluation in both subject areas.

Validity

The i-Ready diagnostic assessment was aligned with the MAAP's and Smarter Balanced Assessment Consortium's testing standards. The Curriculum Associates (2019) chose correlation. The Curriculum Associates collected data across the country to study the relationship between the i-Ready, national, and state assessments because it was the commonly used and widely accepted form of validity evidence. According to the National Center on Intensive Intervention (2019), the internal structure of the i-Ready diagnostic exam was supported by the construct maps and the order of skills addressed at different stages on the map. Additionally, the distribution of indicator difficulties by grade level provided further evidence of internal structure. The difficulty of an indicator corresponded to a 67% probability of passing on the indicator characteristic curve aggregated across all items aligned to the indicator. The average standard deviation for indicator difficulty was 21.10.

Regarding validity for the performance level score (e.g., concurrent or predictive), the average correlation between the scores was 0.80 (predictive) and 0.82 (concurrent), meaning this correlation demonstrated similarities across exams or assessments. A high correlation between the two assessments showed that the two assessments measured similar constructs. The analysis conducted by the National Center on Intensive Intervention (2019) confirmed that the i-Ready diagnostic assessment was a helpful tool.

Reliability

Moreover, the i-Ready diagnostic provided two types of reliability estimates: item response theory's reliability measures, such as marginal reliability and standard error of measurement, and test-retest reliability coefficients. Due to the i-Ready diagnostic being a computer-adaptive assessment that did not have a fixed norm, traditional reliability estimates, such as Cronbach’s alpha, were inappropriate for quantifying consistency or inconsistency in student performance. The item response theory’s reliability (marginal reliability) operated on the variance of the theta scores and averages of the expected error variance. The marginal reliability for performance level scores’ internal consistency was .96, marking reliability (National Center on Intensive Intervention, 2019). Given the adaptive nature of i-Ready and the wide difficulty range in the item bank, the SEM was expected to be low and close to the theoretical minimum for the test of the given length. For mathematics, the minimum Standard Error of Mean (SEM) for overall scores was 6.0. The test-retest served as a reliability estimate, as appropriate for providing stability estimates for the same students who took two diagnostic tests. According to the National Center on Intensive Intervention (2019), the test-retest reliability used Pearson’s correlation coefficients to obtain scores for two diagnostic tests. The average test-retest coefficient was 0.87. With these tools combined, the i-Ready diagnostic was a reliable instrument for gauging student performance in reading and math.

Data Collection

Districts A and B were chosen by selecting all low-performing school districts reported in Mississippi; therefore, all districts with a grade of D or lower. Once all low-performing districts were identified, each district was compared for similarities in demographics and performance scores in MA and ELA. After being compared and eliminated, each school district's superintendent/curriculum director was contacted and asked a series of questions, for example, does your district utilize i-Ready, does your district utilize mobile devices, how and if not, what do you currently use. This process narrowed the selections more, these districts were compared, and the selection was made. After the district selections were made, a description of the study and the data requirements was sent to the district superintendent and review board for review and approval for conducting this research. Second, an Institutional Review Board (IRB) application was submitted to the IRB for review and approval. Once granted permission to conduct the study by the IRB (See Appendix A), a copy of the approval documentation was presented to the superintendent and the review board. A description of the study and the data requirements was disseminated to the district superintendent and review board for review and approval for conducting this research.

District A and District B had established contact persons, which the researcher contacted, to provide datasets. After approval documentation was presented to the districts, these designated persons were contacted and asked to provide student MAAP scores in ELA and mathematics during the 2018-2019 academic school year. In addition to these scores, District A was asked to provide i-Ready scores for the same academic year. The i-Ready scores were utilized to determine if student MAAP scores or performance in MA and ELA could be estimated.

District A emailed the data in the form of Excel worksheets. District B utilized Dropbox to provide their data. Once the data were presented to the researcher, the researcher prepared the data for analysis. This preparation began by cleaning or checking the data for duplications and missing information, such as reading and math scores and gender. No identifiers were collected for the students. After the cleaning process, the data yielded 396 students for District A, and 396 students were randomly selected from District B’s pool of 2000 after the data had been cleaned.

Data Analysis

The following methods were used to conduct this study: descriptive statistics, paired-sample *t*-test, and multiple regression analysis. Research Question 1 (RQ1) was: Is there a significant statistical difference between the MAAP Mathematic scores for District A (technology district) and District B (non-technology district)? Each MA score was identified for each student. An analysis of variance (ANOVA) was used to assess both outcomes simultaneously while controlling for the other score for the first research question. Descriptive analysis was also conducted for each district's students' MAAP scores.

Research Question 2 (RQ2) was: Is there a significant statistical difference between the MAAP English language arts (reading) scores for District A and B? The same method used for RQ1 was used for RQ2. Each ELA score was identified for each student. An ANOVA was used to assess both outcomes simultaneously while controlling for the other score. Descriptive analysis was also conducted for each district's students' MAAP scores.

Research Question 3 (RQ3) was: Is there a relationship between i-Ready scores for District A in math and ELA? The i-Ready data were used as support data to analyze if there is any relationship between the district scores. This analysis consisted of descriptive analysis and an independent *t*-test.

Research Question 4 (RQ4) was: Is there a relationship between the students' gender and the student scores in mathematics and English language arts for Districts A and B on the MAPP exams? A multiple regression analysis was used to determine a relationship between the student's performance scores and gender to evaluate RQ4.

CHAPTER IV

RESEARCH FINDINGS

This study aimed to examine whether a significant difference existed in MA and ELA scores for students in a technology district versus those in a non-technology district. The researcher investigated students' MA and ELA scores during the 2018-2019 academic school year. The results of this study may provide leaders of the school district and various educators with information related to the before and after use of mobile devices to complete the criteria for the district's supplementary learning program. This chapter provides the results of the data analysis, including descriptive statistics and assumptions testing for each research question.

Research Questions

The following research questions were used to guide this study:

1. Is there a significant statistical difference between the MAAP mathematics scores for District A (technology district) and District B (non-technology district)?
2. Is there a significant statistical difference between the MAAP English language arts (reading) scores for District A and B?
3. Is there a relationship between i-Ready scores and MAAP scores for District A in math and ELA?
4. Is there a relationship between the students' gender and the student scores in mathematics and English language art for Districts A and B on the MAAP exam?

Descriptive Statistics

The target population for this study was fourth-grade students in Districts A and B. District A served 400 fourth-grade students, and District B served 2,000 fourth-grade students. Pre-existing data (MAAP scores in ELA and MA) were collected for the fourth-grade students in Districts A and B for the 2018-2019 school term. There were 396 students used for District A, and 396 were randomly selected from District B's population. Combined the total sample was 792 students. Of the 792 combined, 386 (48.7%) were males and 406 (51.3%) were females, as shown in Table 2.

Table 2

Gender Demographics – Districts A and B

	District A	District B	N	%
Male	195	191	386	48.7
Female	201	205	406	51.3
Total	396	396	792	

The mean MA score for District A and District B combined was M = 454.09. The mean ELA score for the two districts combined was M = 451.76. Table 3 provides the combined descriptive statistics for the two dependent variables included in this study: MAAP MA scores and MAAP ELA scores.

Table 3

Descriptive Statistics for ELA and MA (combined)

			Statistic	Std. error
ELA Scale score	Mean		451.76	.68
	95% confidence interval	Lower bound	450.41	
	for mean	Upper bound	453.11	
	5% trimmed mean		451.32	
	Median		450.00	
	Variance		371.93	
	Std. deviation		19.29	
	Minimum		401.00	
	Maximum		499.00	
	Range		98.00	
	Interquartile range		27.00	
	Skewness		.31	.09
	Kurtosis		-.41	.17
MA Scale score	Mean		454.09	.58
	95% confidence interval	Lower bound	452.96	
	for mean	Upper bound	455.23	
	5% trimmed mean		453.62	
	Median		452.00	
	Variance		265.59	
	Std. deviation		16.30	
	Minimum		414.00	
	Maximum		499.00	
	Range		85.00	
	Interquartile range		23.00	
	Skewness		.37	.09
	Kurtosis		-.37	.17

Table 4 provides the descriptive statistics for the females and males in this study. This table provides the mean, max, min, and standard deviation between the MAAP performance scores for the female and male students.

Table 4

Descriptive Statistics for Gender (combined)

FEMALES	N	Minimum	Maximum	Mean	Std. Deviation
ELA Scale score	406	401.00	499.00	453.17	18.68
MA Scale score	406	414.00	499.00	454.72	15.97
Valid N (listwise)	406				
MALES					
ELA Scale score	386	401.00	499.00	450.28	19.81
MA Scale score	386	414.00	499.00	453.44	16.63
Valid N (listwise)	386				

Table 5 provides the descriptive statistics for District A and District B. This table provides the students' mean, max, min, and Standard deviation for MA and ELA in District A and B.

Table 5

Descriptive Statistics for Districts A & B

District A	N	Minimum	Maximum	Mean	Std. Deviation
ELA Scale score	396	401.00	499.00	451.41	19.71
MA Scale score	396	414.00	499.00	456.27	16.71
Valid N (listwise)	396				
District B					
ELA Scale score	396	401.00	499.00	452.11	18.87
MA Scale score	396	414.00	499.00	451.92	15.60
Valid N (listwise)	396				

Assumptions Testing

Several procedures were used to determine whether data met the assumptions of parametric testing: normality, homogeneity of variance, linearity, homoscedasticity, independence of residuals, outliers, and multicollinearity. Normality was assessed using the Kolmogorov-Smirnov test. According to the Kolmogorov-Smirnov statistic, data for the dependent variables (MAAP MA and ELA scores) did not meet the assumption of normality (see Table 6).

Table 6

Test for Normality

	Statistic	*df*	Sig.
ELA Scale score	.071	792	<.001
MA Scale score	.068	792	<.001

The data were transformed; however, the transformations did not lead to a normal distribution. However, the histograms' results contradict the Kolmogorov-Smirnov test results, indicating normal data. The assumption of homogeneity of variances was assessed using Levene’s Test. The test results revealed that MA and ELA scores met the assumption of homogeneity of variances ($p > .05$; see Table 7).

Table 7

Test for Homogeneity of Variances

	Statistic	*df1*	*df2*	Sig.
ELA Scale score	1.68	1	790	.195
Math Scale score	1.99	1	790	.158

Linearity was an assumption of multiple regression analysis. A visual inspection of the Q-Q plots produced from the descriptive statistical analyses showed that the dependent variables met the assumption for linearity. Figures 1 and 2 include the Q-Q plots for both districts' MA and ELA scale scores.

Figure 1

Q-Q Plot for English Language Arts Scale Score

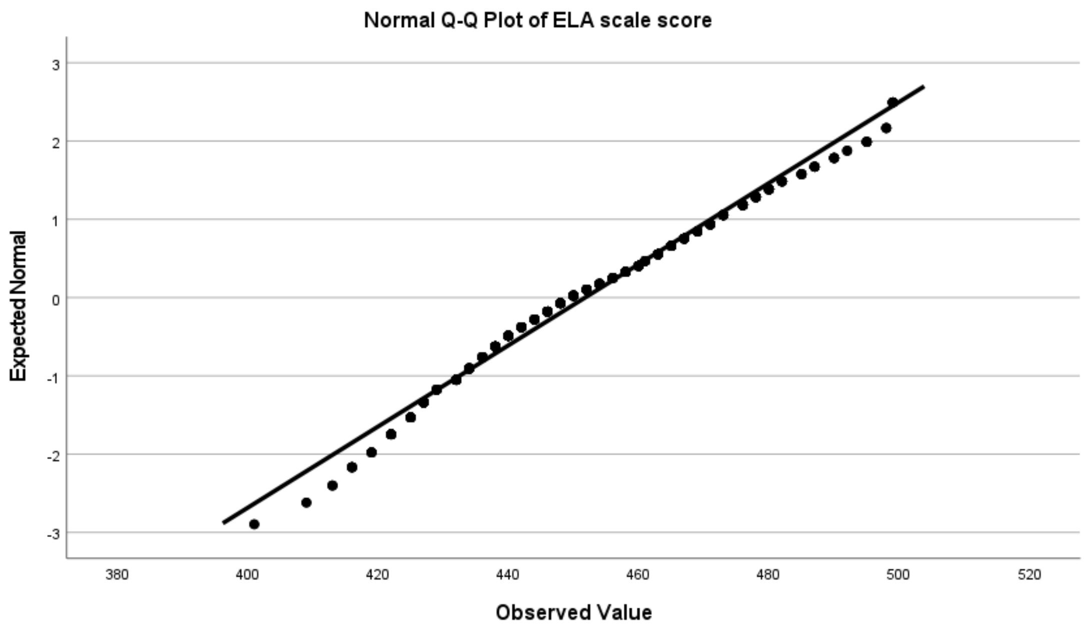
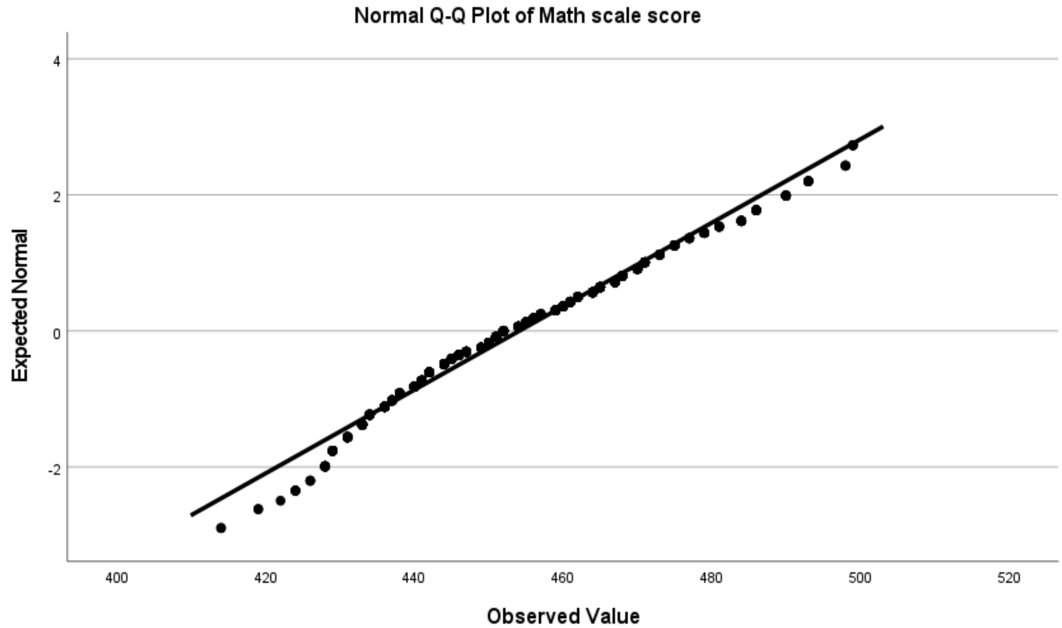


Figure 2

Q-Q Plot for MA Scale Score



Figures 3 and 4 include the Q-Q plots for MA and ELA scale scores for District A.

Figure 3

Q-Q Plot for District A ELA Scale Score

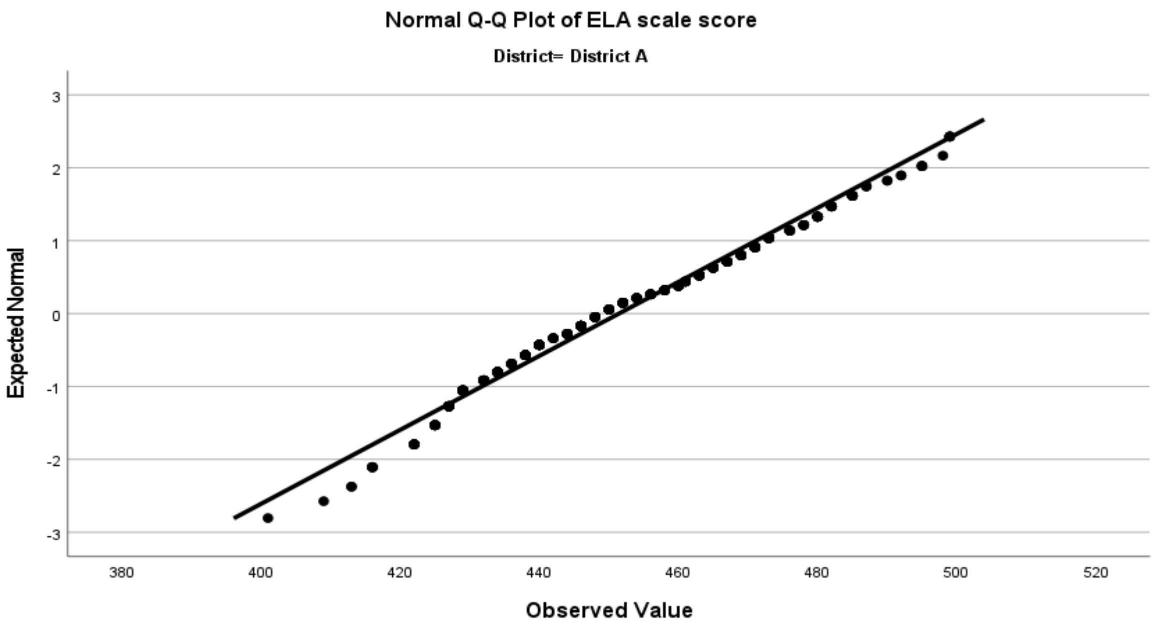
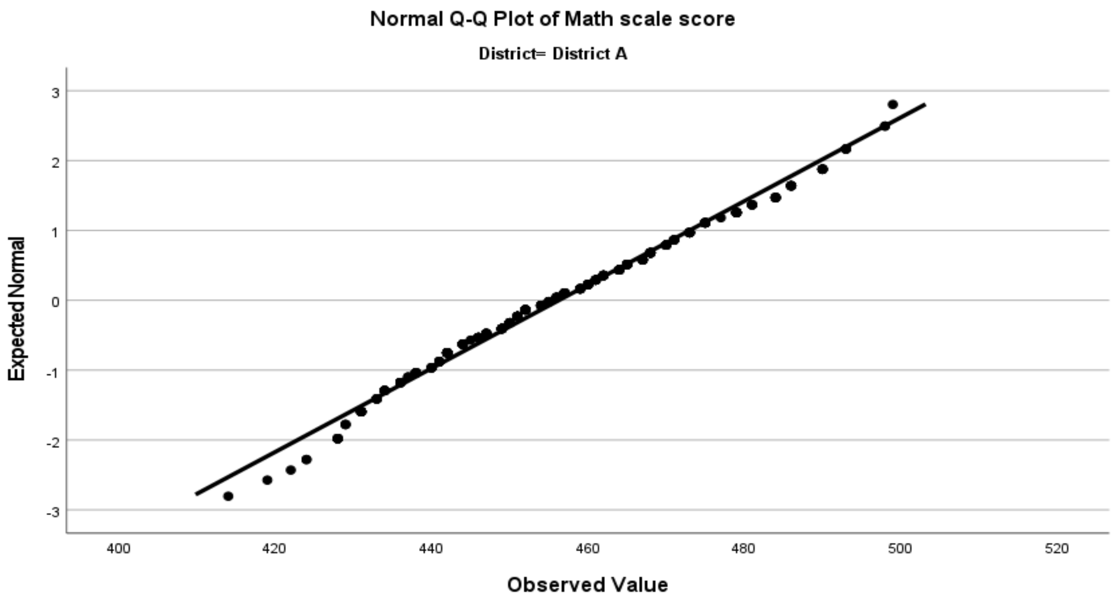


Figure 4

Q-Q Plot for District A MA Scale Score



Figures 5 and 6 include the Q-Q plots for MA and ELA scale scores for District B. The assumption of independence of residuals was assessed using the Durbin-Watson test, which showed acceptable ranges between 1.5 to 2.5 (see Table 8).

Figure 5

Q-Q Plot for District B ELA Scale Score

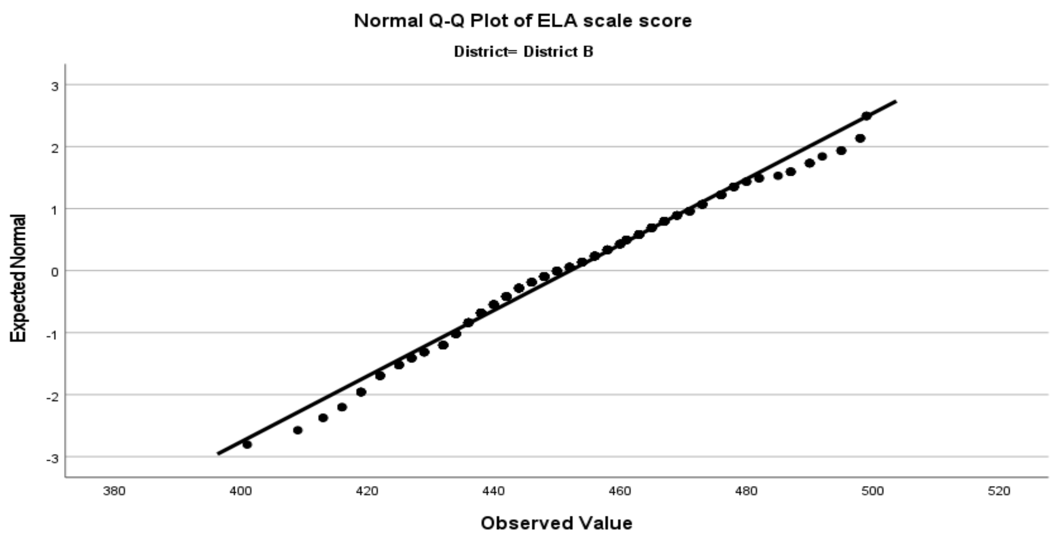


Figure 6

Q-Q Plot for District B MA Scale Score

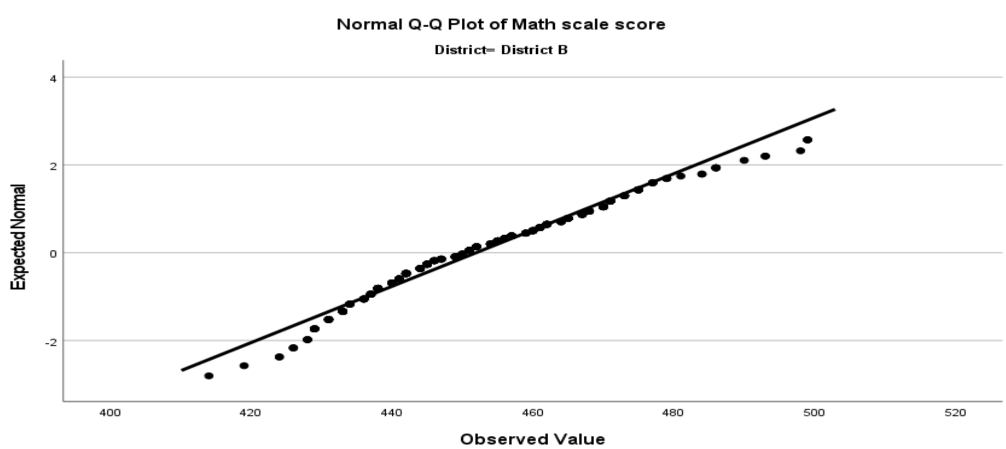


Table 8

Durbin-Watson Test for Independence of Residuals

Model	*R*	*R* square	Adjusted *R* square	Std. error of the estimate	Durbin-Watson
ELA Scale score	.075	.006	.004	19.24	1.72
MA Scale score	.039	.002	.000	16.29	1.65

Regarding the assumption of homoscedasticity, a visual analysis of scatterplots showed that the data were patterned in a line rather than clustered in a rectangular shape, signifying that the assumption of homoscedasticity was violated (see Figures 7 and 8).

Figure 7

Scatterplot for ELA Scale Score

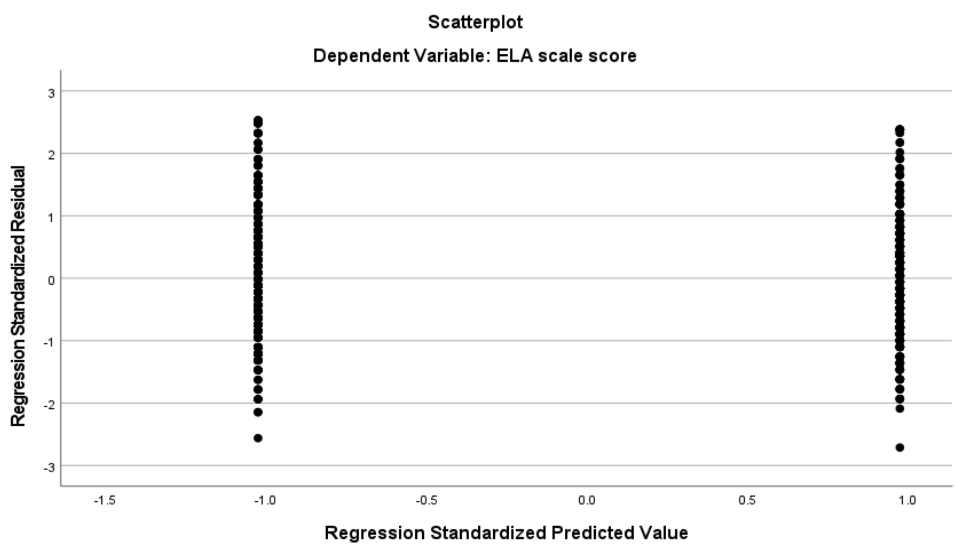
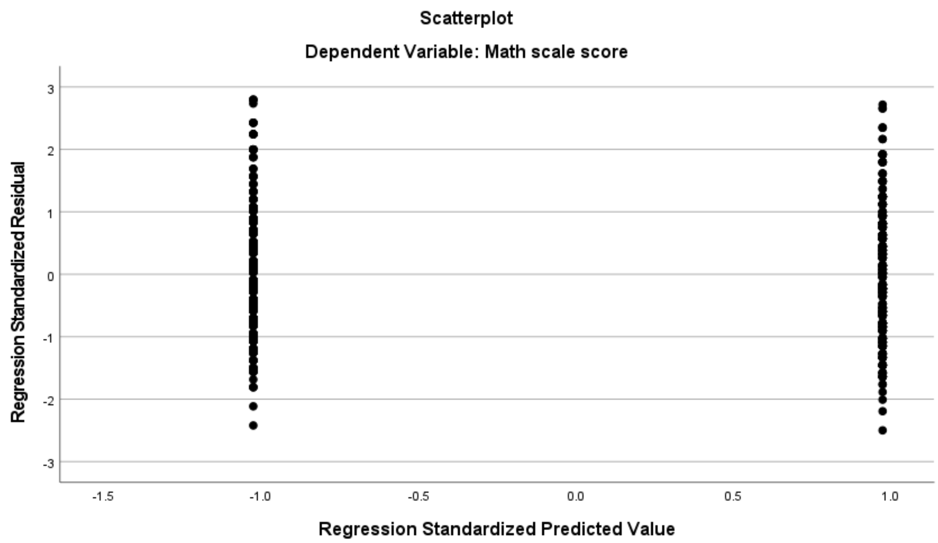


Figure 8

Scatterplot for MA Scale Score



The assumption of outliers was also assessed using scatterplots, which confirmed the absence of outliers because all data points were within the 3.3 and -3.3 range. Finally, as shown in Table 9, the variance inflation factors for the dependent variables were less than 10, indicating acceptable levels of multicollinearity.

Table 9

Variance Inflation Factor for Multicollinearity

	Collinearity statistics	
	Tolerance	Variance inflation factors
ELA Scale score	1.00	1.00
MA Scale score	1.00	1.00

Research Question 1

RQ1 was: Is there a significant statistical difference between the MAAP MA scores for District A (technology district) and District B (non-technology district)? One-way between-groups ANOVA was conducted to answer RQ1. As illustrated in Table 5, the mean scores found for District A in MA were M= 456.27 and M=451.92 for District B. The results of the analysis revealed a statistically significant difference at the $p < .05$ level in MA scores for District A and District B; F (1, 790) = 14.32, p = .00 (see Table 10). District A’s MA scores were significantly higher than District B’s MA scores. Therefore, the district with technology performed better than the non-technology district.

Table 10

ANOVA for MA

	Sum of squares	*df*	Mean square	*F*	Sig.
Between groups	3739.698	1	3739.698	14.32	.000
Within groups	206342.199	790	261.193		
Total	210081.898	791			

Research Question 2

RQ2 was: Is there a significant statistical difference between the MAAP English language arts (reading) scores for District A and B? District A had a mean score of M=451.41 and M=451.92 for District B, as illustrated in Table 5. A one-way between-groups ANOVA was conducted to answer RQ2. The results of the analysis produced $F(1, 790) = .25$, $p = .61$, meaning that there was no statistically significant difference at the $p < .05$ level in ELA scores for District A and District B, as shown in Table 11.

Table 11

ANOVA for English Language Arts

	Sum of squares	*df*	Mean square	*F*	Sig.
Between groups	94.793	1	94.793	.25	.61
Within groups	294105.626	790	372.286		
Total	294200.419	791			

Research Question 3

RQ3 was: Is there a relationship between i-Ready scores and MAAP scores for District A in MA and ELA? Two Spearman's rho correlations were conducted to answer RQ3: one to determine the relationship between i-Ready scores and MAAP scores in math and one to show the relationship between i-Ready scores and MAAP scores in ELA. A Kolmogorov-Smirnov test of normality was conducted to assess the assumption of normality for i-Ready scores in MA and ELA (see Table 12).

Table 12

Test for Normality of i-Ready Scores

	Kolmogorov-Smirnov		
	Statistic	*df*	Sig.
i-Ready ELA overall score	.056	395	.005
i-Ready MA overall score	.078	395	<.001

Neither the MAAP scale scores in MA and ELA (see Table 3) nor the i-Ready overall scores for MA and ELA were normally distributed. Because of the violation of this assumption, the non-parametric Spearman's rho correlation analysis was conducted in place of the parametric Pearson's correlation. For ELA, the analysis produced *rho* = .781, $p < .001$, meaning a strong, statistically significant association between MAAP scale scores and i-Ready overall scores in ELA. For MA, the analysis produced *rho* = .864, $p < .001$, meaning a strong, statistically significant association between MAAP scale scores and i-Ready overall scores in MA (see Table 13). These results indicate that teachers or administrators can use i-Ready scores to predict the students' performance on the MAAP exam in MA and ELA.

Table 13

Correlations Between Mississippi Academic Assessment Program Scale Scores and i-Ready Overall Scores in MA and English Language Arts

				MAAP Scale	i-Ready overall
Spearman's rho	ELA	MAAP Scale	rho	1.000	.781
			Sig. (2-tailed)	-	< .001
		i-Ready Overall	rho	.781	1.000
			Sig. (2-tailed)	< .001	-
	MA	MAAP Scale	rho	1.000	.864
			Sig. (2-tailed)	-	< .001
		i-Ready Overall	rho	.864	1.000
			Sig. (2-tailed)	< .001	-

Research Question 4

RQ4 was: Is there a relationship between the students' gender and the student scores in mathematics and English language art for Districts A and B on the MAAP exam? Two linear regression analyses were conducted to answer RQ4: one was to determine the impact of gender on MA scores, and one was to determine the impact of gender on ELA scores. Although data did not meet the assumption of normality and homoscedasticity, the linear regression analyses were still conducted because a non-parametric alternative was unavailable.

The regression model for math produced $R^2 = .002$, $F(1, 790) = 1.21$, $p = .27$ (see Tables 14 and 15), indicating that gender explained .2% of the variance in math scores. Because the significance level was greater than .05, the result was insignificant. The regression model for ELA produced $R^2 = .006$, $F(1, 790) = 4.46$, $p = .03$ (see Tables 16 and 17), indicating that gender explained .6% of the variance in ELA scores, therefore producing a significant difference.

Table 14

Model Summary for MA

Model	*R*	*R* square	Adjusted *R* square	Std. error of the estimate	Durbin-Watson
1	.039	.002	.000	16.29	1.65

Table 15

ANOVA for MA and Gender

Model		Sum of squares	*df*	Mean square	*F*	Sig.
1	Regression	322.34	1	322.34	1.21	.27
	Residual	209759.56	790	265.52		
Total		210081.90	791			

Table 16

Model Summary for English Language Arts – Overall

Model	*R*	*R* square	Adjusted *R* square	Std. error of the estimate	Durbin-Watson
1	.075	.006	.004	19.24	1.72

Table 17

ANOVA for English Language Arts and Gender – Overall

Model		Sum of squares	*df*	Mean square	*F*	Sig.
1	Regression	1650.03	1	1650.03	4.46	.03
	Residual	292550.39	790	370.32		
Total		294200.42	791			

Additional regression analyses were conducted to determine whether gender impacts MA and ELA scores in each district separately. The data did not meet the assumption of normality and homoscedasticity, the linear regression analyses were still conducted because a non-parametric alternative was unavailable.

The regression model for MA in District A (technology district) produced $R^2 = .006$, $F(1, 394) = 2.52$, $p = .11$ (see Tables 18 and 19), indicating that gender explained .6% of the variance in math scores. Because the significance level was greater than .05, the result was insignificant. The regression model for MA in District B (non-technology district) produced $R^2 = .000$, $F(1, 394) = .01$, $p = .92$ (see Tables 18 and 19), indicating that gender explained 0% of the variance in math scores. Because the significance level was greater than .05, the result was insignificant.

Table 18

Model Summary for MA – by District

District	Model	*R*	*R* square	Adjusted *R* square	Std. error of the estimate	Durbin-Watson
A	1	.080	.006	.004	16.67	1.89
B	1	.005	.000	-.003	15.62	1.43

Table 19

ANOVA for MA and Gender – by District

District	Model		Sum of squares	*df*	Mean square	*F*	Sig.
A	1	Regression	700.12	1	700.12	2.52	.11
		Residual	109545.51	394	278.03		
	Total		110245.63	395			
B	1	Regression	2.39	1	2.39	.01	.92
		Residual	96094.18	394	243.89		
	Total		96096.57	395			

The regression model for ELA in District A (technology district) produced $R^2 = .011$, $F(1, 394) = 4.55$, $p = .03$ (see Tables 20 and 21), indicating that gender explained 1.1% of the variance in ELA scores. Because the significance level was smaller than .05, the result was significant. The regression model for ELA in District B (non-technology district) produced $R^2 = .002$, $F(1, 394) = .65$, $p = .42$ (see Tables 20 and 21), indicating that gender explained .2% of the variance in ELA scores. Because the significance level was larger than .05, the result was insignificant.

Table 20

Model Summary for English Language Arts – by District

District	Model	*R*	*R* square	Adjusted *R* square	Std. error of the estimate	Durbin-Watson
A	1	.107	.011	.009	19.62	1.85
B	1	.040	.002	-.001	18.88	1.59

Table 21

ANOVA for English Language Arts and Gender – by District

District	Model		Sum of squares	*df*	Mean square	*F*	Sig.
A	1	Regression	1751.57	1	1751.57	4.55	.03
		Residual	151650.51	394	384.90		
	Total		153402.08	395			
B	1	Regression	230.52	1	230.52	.65	.42
		Residual	140473.03	394	356.53		
	Total		140703.55	395			

Conclusion

This study examined whether a significant difference existed in MA and ELA scores for students in a technology district versus those in a non-technology district. These scores were taken from District A analyses were conducted to compare MAAP scores for students in MA and ELA across a technology district (District A, where 1:1 computing had been implemented) and a non-technology district (District B, where 1:1 computing had not been implemented). This study also examined the impacts of gender on MA and ELA scores in these districts. An ANOVA analysis was used to answer the first research question, indicating significantly higher MAAP MA scores for students in the technology district than students in the non-technology district. An ANOVA analysis for the second research question revealed no significant differences in MAAP

ELA scores for students in the two districts. Regarding gender (using the combined district scores), linear regression analysis revealed that gender significantly influenced MAAP ELA scores for the districts combined and for District A alone, but not MA scores in the two districts, separately or combined.

The results revealed that students in the technology district performed better on the MA assessment than in the non-technology district; however, students in District B performed better in ELA than those in the technology district. Also, District A could use the student's performance on the i-Ready assessment to predict student performance on the MAAP exam. Lastly, the results reveled that gender influenced students ELA scores but not MA scores.

CHAPTER V

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

This chapter will summarize the findings of this study, provide a discussion regarding how the findings relate to the literature, including conclusions and implications about how the findings can be applied to practice, and offer recommendations for future mobile learning research.

Summary of the Study

School Districts Studied

Two districts were chosen and compared to determine if using mobile devices (Chromebooks) as a learning tool would impact student learning. District A was a technology-driven district. This district adopted a 1:1 Technology Initiative in 2015 and completed the project, with all students assigned devices, by the fall of 2018. District A students were assigned Chromebooks to be used throughout the day in class and to access their i-Ready portal for additional practice with MA and ELA. Students logged in and practiced each subject for at least 45 minutes per week. District B, however, was a non-technology district. Students were taught subject matter using traditional teaching methods, lectures and activities, and practice. District A yielded 396 students for the study, and a random sample of 396 students was selected from District B to match the sample size obtained from District A. Of the students' chosen for the study, 48.7 % were male, and 51.3% were female.

The Data

Pre-existing data was used for this study. Both Districts A and B utilized the MAAP to evaluate student performance in MA and ELA. The 2018-2019 scores for the MAAP were used for the study. At the time of data collection, this data set was the last academic year that the MAAP exam was given prior to the global outbreak of the Coronavirus. During the academic 2019-2020 year, the state legislature and the state educational board suspended testing for that academic year, as students could not be in the classroom due to the mandated shutdowns. For example, high school students are not required to take assessments to graduate. Instead, all students will need to pass district and state requirements.

The data for this study were processed through a series of tests to ensure they did not violate the assumptions of parametric testing. This included testing for normality, homogeneity of variance, linearity, homoscedasticity, independence of residuals, outliers, and multicollinearity. The data were normally distributed, and the MA and ELA scores met the assumption of homogeneity of variance. The dependent variables met the assumption of linearity, and the independence of residuals showed acceptable ranges between 1.5 and 2.5. The data did not include outliers, and there were acceptable levels of multicollinearity. After testing the data, data analysis began.

The Results

The study results revealed that the MAAP MA scores in District A (M = 456.27) were significantly higher than those of District B (M = 451.92). Based on the results, students who use the Chromebooks in the classroom perform better on the MAAP MA exam than students who do not use the device in the classroom. However, the study did not find any significant difference in

MAAP ELA scores for students in the two districts. Therefore, the results indicate that mobile technology in the classroom may not help students perform better in ELA.

The study also found a statistically significant relationship between MAAP scale scores and i-Ready overall scores for MA and ELA. This result indicates that the i-Ready score can indicate how the student will perform on the MAAP MA and ELA exams. Finally, the results revealed that gender significantly influenced MAAP ELA scores, both overall and in District A alone, but did not significantly influence MAAP MA scores among students in either district.

Discussion of the Findings

The results revealed that students in the technology district performed better on the math assessment than in the non-technology district, which aligns with previous research findings found in the literature, such as Kim et al. (2021), Gardner (2013), and Rich (2013). Kim et al. (2021) found that mobile learning technology positively affected students' math skills. Similarly, Fabian et al. (2018) and Zhang et al. (2015) found that mobile math applications enhanced students learning experience in mathematics. However, Tetzlaff (2017) and Hossein-Mohand et al. (2021) found no difference in math performance among students who used mobile technology compared to those who learned using traditional math instruction.

Research question two asked whether there was a significant statistical difference between the MAAP ELA scores for District A (technology district) and District B (a non-technology district). The results revealed that students in the technology district did not perform better on the ELA assessment than in the non-technology district. Some researchers indicated that mobile technology could improve MA skills but not ELA skills because the indicated way students learn these two subjects differ substantially (Gardner, 2013; Rich, 2013). For example, math skills are considered constrained skills that are improved through simple drills and practice, while ELA skills are considered unconstrained skills that are improved through extensive experience (Kim et al., 2021). According to Kim et al. (2021), mobile technology can be helpful for the acquisition and maintenance of math skills.

The study results showed that MAAP scale scores were strongly and significantly associated with i-Ready overall scores for Math and ELA. These results aligned with the research results found by the Curriculum Associates (2019), which found that after comparing students' diagnostic scores for i-Ready, data showed that fourth-grade students improved their scores by 11 points in MA and 7 points in ELA (Curriculum Associates, 2019). Based on these findings, the Curriculum Associates (2019) suggested that i-Ready diagnostic scores forecast students' performance on Math and ELA MAAP exams. These results are also consistent with Silva (2016), who examined the i-Ready impact on students' achievement, finding a significant difference in overall reading achievement.

While studying the impacts of gender on MA and ELA scores, the results revealed that gender significantly influenced MAAP ELA scores overall and in District A, but did not significantly influence MAAP MA scores among students in either district. This finding aligns with previous research. For example, according to Reardon et al. (2018), gender influences ELA scores. Female students have a more substantial advantage on constructed-response items in ELA than males. Similarly, Torres (2019) examined the influence of gender on MAP (Measures of Academic Progress) Reading and Math assessments and found that gender influenced students' MAAP Reading assessment scores but not MAAP Math scores. In another study, Cimpian (2020) found a gender gap in reading but not in math assessments. Like Reardon et al. (2018), Cimpian (2020) found that females performed better on reading assessments than males.

Reardon et al. (2018) suggested that male and female students may differ in ELA achievement because of gender stereotypes that children learn at a young age, such as reading being feminine.

Conclusion

Based on the results of this study, the following conclusions can be made:

1. Mobile devices as a learning tool have an impact on students' performance in math, but not in reading.
2. i-Ready diagnostic scores can forecast students' performance in math and reading on the MAAP assessments.
3. Gender impacts student performance in reading, but not in math.

Recommendations for Future Research

Based on the findings of this study, the following recommendations are for future research:

1. This study revealed that using a mobile device as a learning tool did not influence students' performance in ELA. Therefore, more research is recommended to study the impact of mobile devices on ELA. Perhaps a larger sample size can shed light on the impact of the mobile device on student performance in ELA.
2. A larger sample is needed to study the impacts of gender on reading.
3. Future research should be conducted on other age groups to determine the influence of i-Ready on student achievement in MAAP math and reading.
4. Further research is recommended to understand the relationship between time spent on the device and student performance.

5. This study did not explore other demographic variables influencing MAAP math and reading assessment scores, such as race and socioeconomic status. More research is needed to explore the different demographic variables influencing MAAP scores.
6. More research is recommended to better understand the students' and teachers' perceptions of mobile technology use in the classroom as a learning tool for math, reading, and other subjects.
7. Finally, more research is needed to identify other technologies and their impacts on student performance.

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APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL EMAIL

Protocol ID: IRB-21-095
Principal Investigator: Chien Yu
Protocol Title: Mobile Learning: Using mobile devices to promote students' reading and mathematic skills
Review Type: EXEMPT
Approval Date: March 25, 2021
Expiration Date:March 24, 2026

This is a system-generated email. Please DO NOT REPLY to this email. If you have questions, please contact your HRPP administrator directly.

The above referenced study has been approved. *For Expedited and Full Board approved studies, you are REQUIRED to use the current, stamped versions of your approved consent, assent, parental permission and recruitment documents.*

To access your approval documents, log into myProtocol and click on the protocol number to open the approved study. Your official approval letter can be found under the Event History section. All stamped documents (e.g., consent, recruitment) can be found in the Attachment section and are labeled accordingly.

If you have any questions that the HRPP can assist you in answering, please do not hesitate to contact us at irb@research.msstate.edu or 662.325.3994.

Please take a minute to tell us about your experience in the survey below. When logging in, please use your MSU email (ex: abc123@msstate.edu) and login credentials:
https://forms.office.com/Pages/ResponsePage.aspx?id=sNtR7YavokWcl3P7OTXfF9uShqNaQAdClfXwiCnibYZURUtWVDRRN1pRMEhHUzBCT1RGUFRZRkdLSy4u

Protocol ID: IRB-21-095
Review Type: EXEMPT
Principal Investigator: Chien Yu

You are receiving this inactivation notification for one of the two following reasons:

1) Exempt Determinations:

This protocol is has been granted an exemption determination. Based on this exemption, and in accordance with Federal Regulations which can also be found in the MSU HRPP Operations Manual, your research does not require futher oversight by the HRPP.

Therefore, this study has been inactivated in our system. This means that recruitment, enrollment, data collection, and/or data analysis can continue, yet personnel and procedural amendments to this study are no longer required. If at any point, however, the risk to participants increases, you must contact the HRPP immediately.

2) Non-Exempt Approvals (Expedited or Full Board):

A request to inactivate (with the submission of a final report) your non-Exempt protocol was submitted and approved. If this is the case, there should be no further data collection or data analysis conducted under this protocol.

For additional questions pertaining to this study, please contact the HRPP at irb@research.msstate.edu.