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Third-Grade Student Literacy: A Quantitative Analysis of Two Concurrent Interventions

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A dissertation presented to the Faculty of the School of Education,

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DEDICATION

I dedicate this to my family, especially my amazing mom, who has never let me be less than the best of what I could become and to my sister for paving the way for others to succeed. I would also like to dedicate my work to beginning readers everywhere, and especially to all the little girls who did not know that “girls could be scientists.”

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ABSTRACT

Third-Grade Student Literacy: A Quantitative Analysis of Two Concurrent Interventions

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The achievement gap is a historic and pervasive issue of social justice in education. the impact of the COVID-19 pandemic has further stalled student achievement in reading and math, amplifying the urgency for accelerating student learning to close the gap. The third grade is a critical year for literacy in education; if students have not mastered grade level literacy skills by then, they are likely to continue to fall behind, which can diminish academic opportunities and significantly reduce their economic potential. This study seeks social justice in education to add to the literature by elucidating strategies to improve third-grade literacy. Grounded in quantitative analysis, this longitudinal study employs a quasi-experimental pretest-posttest design to evaluate the relationship between third-grade student engagement in two concurrent literacy interventions, Smarty Ants and Achieve3000 Literacy, and student reading outcomes. To this end, the analysis of covariance (ANCOVA) was applied with a control for pretest scores while evaluating the relationship between engagement and outcomes. Results of each ANCOVA show statistical significance between student engagement in the literacy interventions and their Lexile outcomes. Despite the small sample size, results of the analyses verify that there is statistical significance in the relationship between student engagement levels in the programs, individually and concurrently, and their Lexile outcomes in Achieve3000 Literacy during the 2020-2021 academic year within the context of the COVID-19 pandemic. Given the strength of correlation results in the ANCOVAs and the *t*-tests, this was especially true for engagement in

Achieve3000 Literacy and more so for combined engagement. The study concludes with a discussion of these findings, an articulation of the significance of the study, as well as recommendations for future practice and study.

CHAPTER 1

INTRODUCTION

The achievement gap is a complex social justice issue in education spanning several decades (Boykin & Noguera, 2011; Paschall et al., 2018; Sanchez, 2008). While there are multiple gaps in student performance across a variety of subject-specific competencies, this study concentrates on literacy to evaluate the impact of a potential solution to close the gap. Specifically, this research sought to understand the relationship between third-grade student engagement in two concurrent literacy interventions and their reading performance during the 2020-2021 school year. To evaluate the longitudinal impact of student engagement within the time constraints of the dissertation process, this quantitative study used a quasi-experimental design to analyze archived student data from the 2020-2021 school year. This study recognized that the 2020-2021 academic year rested in the context of the historical threat posed by the various means of education (site-based, hybrid, and distance) in response to the COVID-19 pandemic (March 2020-ongoing as of time study was completed). This dissertation begins with a statement of positionality, is followed by a background statement of the problem and a review of the literature, then by a description of the methodological process by which data were gathered and analyzed, and concludes with a review of findings, an articulation of the significance of the study, in addition to suggestions for future practice and further research. To provide context for the research, Chapter 1 begins with a broad statement of the problem, providing an overview of the achievement gap and expanding into the historical context of education during the 2020-2021 school year as precipitated by California's response to the COVID-19 pandemic. As this dissertation was based on Catholic elementary schools, this chapter also discusses the context of

Catholic education, technology in Catholic schools, and the efforts of a nonprofit organization partnering with Catholic elementary schools to close the achievement gap.

Positionality Statement

In 1984 an East coast university established a tutoring and mentoring program for the local elementary district experiencing an influx of Salvadorian immigrants due to the civil war in El Salvador. Years later, as a student at the university, I was invited to participate in the program because I spoke Spanish. All volunteers were asked to use literature to connect with the students and support literacy development. I was paired with an eight-year-old girl who had been in the United States for two weeks. In this time, she was reunited with her mother, who had left her seven years prior to find a better life for them in the United States. I remember watching the child's body language and noticing how quiet and timid she was. I thought about how challenging her life must have been at that point in time: not knowing her mother for most of her life, then meeting her as a second grader living alone with this familiar stranger, in new country where she did not understand the culture, speak the dominant language, or know how to navigate the world around her. I wondered what her life trajectory would be if she could not effectively master English or the educational system. My lack of knowledge on literacy acquisition limited my ability to assist, leading me to wonder if the child was destined to become another member of the achievement gap statistic. I look back and remember struggling to connect with her in our brief meetings, thinking: "If I only knew then what I know now."

Since I was a child, I have always wanted to help people. This fundamental desire be a person of service was reinforced through opportunities afforded at my Catholic elementary school. In high school, I furthered my ideal of service to include social justice through the lens of

my studies with the Dominican sisters. This was further refined by my undergraduate and graduate formation at Jesuit universities. After college I served seven years as an elementary Catholic school teacher, followed by another seven as a Catholic school administrator. This experience, particularly my leadership experience, solidified my commitment to social justice in service to children through education.

Nearly eight years after my college experience with the young immigrant mentee, I began my service as an elementary school administrator in an immigrant Latinx community with a clear Salvadorian presence due to migration patterns from the Salvadorian civil war in the 1980s. I worked to realize a vision of using a holistic model of education to ensure true academic excellence and opportunities for every child within the school community. Years later I transitioned to a new role of partnering with a nonprofit working with multiple low-income Catholic schools to close the achievement gap. Over 15 years after our first introduction, the image of the eight-year-old immigrant girl is still with me, pushing me to ensure access to quality educational opportunities and adequate literacy support systems especially for children like her, who may struggle to learn due to a combination of life circumstances—trauma, immigration status, language barriers, poverty, safety, etc. My time with this child as well as my experiences in Catholic education have played a large role in my formation as an individual, a teacher, and a leader committed to enacting social justice in education by closing the achievement gap. Following this passion, my research centers on the achievement gap in literacy. This study is an evaluation of the relationship between concurrent engagement in two literacy interventions and the reading performance Lexile measures of third-grade students in nine Catholic schools.

Background Statement of the Problem

The first publication of The National Assessment of Educational Progress (NAEP) also known as *The Nation's Report Card* in 1969 highlighted the disparities in academic performance between students of low socioeconomic status (SES) and their counterparts, which became known as the achievement gap (Boykin & Noguera, 2011; Rojas-LeBouef & Slate, 2012; Teale et al., 2007). Drawing national attention, the publication heightened federal efforts to engage in the discussion of education and to create support programs and establish financial assistance with accompanying policies to hold schools, districts, and leaders accountable for ensuring the academic success of all students (Klein, 2015; Paschall et al., 2018; U.S. Department of Education, n.d.). A rise in awareness of the various achievement gaps—the variation in performance in such academic subjects as science, reading, writing, and/or mathematics, according to race, gender, national origin, or SES (Boykin & Noguera, 2011; Rojas-LeBouef & Slate, 2012; Teale et al., 2007)—also provoked concerted efforts of state, district, and school leaders to close the gap (Carter, 2018; Jehangir et al., 2015; Johnson, 2002; Paschall et al., 2018; Wenglinsky, 2004). For years researchers have worked to address the injustice, seeking root causes and potential solutions (Amendum et al., 2011; Boykin & Noguera, 2011; Foster & Miller, 2007; Partanen et al., 2019; Wenglinsky, 2004), while curriculum companies and program creators leveraged various educational philosophies to develop instructional resources that attempted to ensure student progress toward expected performance outcomes according to program metrics (Petscher et al., 2020; Snow & Matthews, 2016). The fact remains: the causes of the achievement gap are multifarious, often inextricably interlaced with countless elements from diverse physical, political, social, and socioeconomic contexts impacting children (Jeynes,

2015; Milner, 2013; Muhammad, 2015; Rojas-LeBouef & Slate, 2012; Ryan, 2006; Sanchez, 2008). The achievement gap is a complex and stark representation of inequities in American education, which were further impacted by historic events occurring within the context and timeframe of this research study.

COVID-19

In the fall of 2019, reports from around the world indicated the spread of a coronavirus that became known as COVID-19. By March 2020 the virus had become a pandemic (BBC News, 2020). In March 2020 California Governor Gavin Newsom signed *Executive Order N-33-20* requiring residents to stay home to slow the spread of the virus (Newsom, 2020). The stay-at-home orders precipitated an economic shut down of many site-based services, including education, which doubles as a child-care service in the United States (Dorn et al., 2020a). The shift exacerbated the socioeconomic inequities present in healthcare, economic structures, academic systems, and employment structures, highlighting them for the world to see (Centers for Disease Control and Prevention [CDC], 2021; DeArmond et al., 2021; Dorn et al., 2020b; Employment Development Department [EDD], 2021; Williams et al., 2021). In 2020 COVID-19 was the third leading cause of deaths in the United States (Ahmad et al., 2021). From January 2020 through April 14, 2021, COVID-19 claimed 545,761 U.S. lives (Elflein, 2021). The virus took "an especially heavy toll on Black, Hispanic, and Indigenous communities" (Dorn et al., 2020b, p. 2). In an analysis of risk for COVID-19 infection, hospitalization, and death by race and/or ethnicity, the Centers for Disease Control and Prevention (CDC) reported that Black individuals were 1.1 times more vulnerable, while Indigenous communities were 1.6 times more vulnerable, and Latinx individuals were two times more vulnerable to the risks associated with

COVID-19 than non-Hispanic Whites (CDC, 2021). In addition to the impact of illness and death, the economic shutdowns established to slow the spread of the coronavirus pandemic resulted in an increased unemployment rate in 2020 (EDD, 2021). Job loss between March 2020 and March 2021 was noted in such fields as leisure, government, and education (EDD, 2021).

As a result of the stay-at-home order, schools were forced to close their doors to on-site instruction and abruptly shift to online instruction, referred to as distance learning (Dorn et al., 2020a; Williams et al., 2021). School closures in many areas of California were maintained during the 2020-2021 school year. Throughout this time, the U.S. educational system was significantly disrupted (Lewis et al., 2021) as it "was not built to deal with extended shutdowns like those imposed by the COVID-19 pandemic" (Dorn et al., 2020a, p. 2). Teachers required new technical skills and methods for instructional delivery at a distance (Williams et al., 2021). Inequitable access to learning opportunities (Lambert & Sassone, 2020) as well as the disparity in resources and materials to continue instruction at a distance was readily apparent in limited connectivity and device access, parent support, study space, as well as the quality of instruction, and teacher understanding (Williams et al., 2021). The exacerbation of such preexisting and longstanding educational deficits (DeArmond et al., 2021; Lewis et al., 2021) further intensified the issue of social justice in education. Schools in low SES areas had a reduced capacity to provide technology and connectivity to support students at a distance (Williams et al., 2021). According to Dorn et al. (2020a) the abrupt transition to distance learning resulting from the COVID-19 pandemic was not mitigated by an intentional approach of thoughtful preparation characteristic of high-quality remote instruction. The shift to distance learning not only highlighted the persistence of the existing achievement gap (Dorn et al., 2020a), but also

increased achievement gap in both math and reading (Dorn et al., 2020b; Lewis et al., 2021). Dorn et al. (2020b) anticipated that White students would be four to eight months behind while students of color may be behind their counterparts by six to 12 months. Lewis et al. (2021) found that achievement during the 2020-2021 school year was lower for all groups in their study, but especially for students in high-poverty schools. The decreased levels of learning during the stay-at-home order in response to the COVID-19 pandemic increased dropout rates, resulting in a cohort of students who may "be less skilled and therefore less productive than students" from a different generation, which will further disturb the nation's economy (Dorn et al., 2020a, p. 7). Despite the lack of a thoughtful and deliberate approach to distance learning due to COVID-19 (Dorn et al., 2020a), online education has a substantial history and is historically referred to as e-learning, digital learning, distance education, and online learning (Baggaley, 2019; International Association for K-12 Online Learning [iNACOL], 2013; Moore, 2013).

Distance Education

Online schools have existed since the 1970s (Chih-Yuan Sun & Metros, 2011). In fact, since at least the early 2000s, universities around the world have employed Massive Open Online Courses (MOOCs) to increase educational access (Baturay, 2015). According to the International Association for K-12 Online Learning (iNACOL), now known as the Aurora Institute, 25 U.S. states had virtual schools operating in 2013, while 29 states had full-time online schools (iNACOL, 2013). While California did not have state-supported options for online learning, it had the second highest K-12 student enrollment relative to the state population in 2013 (iNACOL, 2013). In 2019, the *Distance Education* journal celebrated its 40th anniversary with a study on the evolution of distance education in 40 years (Baggaley, 2019). Chih-Yuan Sun and

Metros (2011) argued that while technology has been applied in education since the 1970s, the tools have not become predominant in contemporary education. In the early 2000s, the inequitable access to the Internet or computers was referred to as *the digital divide* (Gorski, 2002). Williams et al. (2021) contended that the divide shifted to greater equity of technology distribution with a disparity in skills required to navigate and use technology effectively. The technology divide has transformed with the use of smart phones and evolved into a split between information consumers and information producers (Williams et al., 2021). Despite efforts to close the digital divide, issues of equity and access to technology persist in education (Cleary et al., 2005). This is especially evident in under-resourced schools such as private and low-income elementary schools.

Catholic Elementary Schools

As Dorn et al. (2020b) keenly noted: "The US education ecosystem is built around an in-class experience" (p. 2) and unequipped to effectively respond to the economic shutdown prompted by the coronavirus pandemic (Dorn et al., 2020a). Catholic schools were no exception. Catholic elementary schools have been site-based institutions since the first formal Catholic schools were established in the late 1700s (Schafer, 2004). In the 1990s, Catholic Schools made a concerted effort to integrate technology as part of the provided curriculum (Curran, 1998; Schuttloffel, 1998). Over time, integration of "current technologies" became an educational trend (Schafer, 2004, p. 248). By 2012, it was an established standard that schools "prepare students to become expert users of technology" (Ozar & Weitzel-O'Neill, 2012, p. 11), which later became a clear expectation for all schools (Richardson et al., 2016). Eventually, the trend of technology integration shifted toward the adoption of one-to-one devices in schools (Cho, 2017).

Despite the progression of online learning, PK-12 Catholic education continued to deliver site-based instruction. Though research on technology integration in Catholic schools is limited (Gibbs et al., 2008; Swallow, 2017), technology has been embedded as a support system for effective instruction rather than as the primary means for delivering instruction or managing student learning (Richardson et al., 2016; Swallow, 2017). Concrete and comprehensive quantitative data regarding student access to the Internet, technology at home, the ratio of devices to students in schools across the Archdiocese of Los Angeles, or the quality of digital technologies available in Catholic elementary schools is presently imprecise, thus making the digital divide across such schools unclear. Amidst challenges with access to digital resources, one nonprofit organization directly supported the use of adaptive curriculum in Catholic elementary schools to help close the achievement gap.

The Nonprofit

This research focused on two concurrent literacy interventions delivered through the work of a nonprofit dedicated to supporting the vision of low-income elementary Catholic school principals. The populations served by each school generally have 70% or more students at the school qualifying for the Federal Free or Reduced Lunch program (FRL; Paschall et al., 2018). The nonprofit has provided funding, training, partnerships, and other resources to meet the academic and social-emotional needs of students in partnering schools. Students' standardized test scores at school sites working with the nonprofit demonstrated academic performance gaps in literacy and math (S. Johnson, personal communication, November 25, 2020). The nonprofit employed a logic model as the theoretical framework from which to develop solutions to student academic underperformance.

Logic models are utilized to explain how and why a specific program or plan meets a specific need, while also explaining how measurement and evaluation appraise the effectiveness of that program or plan (McLaughlin & Jordan, 1999). Jones et al. (2020) referred to these as visual summaries of program activities resulting in program outcomes. The nonprofit designed a five-part logic model to identify the needs of partner schools within the context of the 2020-2021 school year. The model articulated the situation of distance learning resulting from school closures due to COVID-19 as the rationale for change, the desired outcomes, behavioral changes required, the knowledge and skills to be developed, the activities to be conducted, and the resources required to achieve the desired outcomes. To address the specific literacy needs of third-grade students identified in this study, students required, excellent instruction using highly effective curricular materials implemented to fidelity (S. Johnson, personal communication, November 25, 2020). However, the quality of implementation is affected by the degree to which programs are used as intended by their developers (Dusenbury, 2012). Additionally, educators required training and data-driven instructional practices and monitoring to ensure curriculum adoption to fidelity (S. Johnson, personal communication, November 25, 2020). The nonprofit curated a list of research-based programs for literacy, math, science, and social studies that were proven to be valid, efficient, and effective. Programs including professional development for effective implementation were preferred. The nonprofit provided principals with information about each of these programs and site leaders selected program combinations according to their vision, goals, and site needs. Among the literacy combinations for third-grade students were two literacy interventions, Smarty Ants and Achieve3000 Literacy, that were the focus of this research study and are described with greater detail in Chapter 2. In essence, the logic model

created by the nonprofit was the foundation for the implementation of two specific interventions at nine sites for the purpose of addressing the needs of students to close the achievement gap in literacy.

Purpose of the Study

This study was an effort to enact social justice in education by contributing to the research seeking to remediate the achievement gap in literacy. The purpose of this study was to evaluate the relationship between student engagement in concurrent literacy interventions used to close the achievement gap and the reading performance of third-grade students. One intervention, Smarty Ants is a computer-adaptive, gamified, analytic phonics program which targets student mastery of necessary foundational decoding skills for early reading (Achieve3000, n.d.-a, 2017a; MetaMetrics & Achieve3000, n.d.). The other, Achieve3000 Literacy, is a semi-adaptive, cloud-based reading comprehension program targeting student reading growth through teacher-assigned articles at students' individual level using a five-step instructional sequence to promote student literacy development (Achieve3000, 2017a; MetaMetrics, 2021b; MetaMetrics & Achieve3000, n.d.). With these two interventions in mind, this research study responded to the following questions:

1. To what extent does high or low student engagement in Smarty Ants, as defined by the number of levels completed, affect Lexile measures in Achieve3000 Literacy?
2. To what extent does high or low student engagement in Achieve3000 Literacy, as defined by the number of program criteria completed, affect Lexile measures in Achieve3000 Literacy?

3. To what extent does high or low student engagement in both Smarty Ants and Achieve3000 Literacy affect Lexile measures in Achieve3000 Literacy?

Greater detail regarding the criteria for engagement in Smarty Ants and Achieve3000 Literacy is provided in the Chapter 3.

Significance of the Study

Smarty Ants and Achieve3000 Literacy are two widely used literacy interventions with empirical research on their individual effectiveness (Achieve3000, 2017b). However, there is limited research on the concurrent use of both programs. As a result, this study was an opportunity to add to the literature by investigating the impact of concurrent engagement in two literacy interventions. Additionally, research is typically conducted in public education settings, while this research provides an opportunity to collect data from a Catholic context, though the results may not necessarily be limited to the Catholic school experience. The study results demonstrated that concurrent engagement in the two interventions is significant for Lexile outcomes. Results affirmed the importance of foundational literacy in reading as well as the role of student engagement in performance outcomes. The research concludes with recommendations for the integration of both programs as a strategy for improving student literacy in the third grade. On a broader scale this research may provide insight into the benefit of technology-based solutions for increasing student outcomes. In addition to contributing to the literature on Achieve3000, the role of foundational literacy in reading, and the potential of elementary literacy solutions, this study supports advocacy efforts for access to high quality, evidence-based curriculum, especially in high-poverty schools, and informs the decision-making efforts of key stakeholders such as policy makers, district administrators, and educators. Finally, this research

furthers the case for teacher training and school policies that make use of the present-day technology (Schafer, 2004), while also creating the opportunity for education to evolve from 19th century factory model of education (Robinson, 2010) to a system that authentically prepares "students to become expert users of technology" (Ozar & Weitzel-O'Neill, 2012, p. 11).

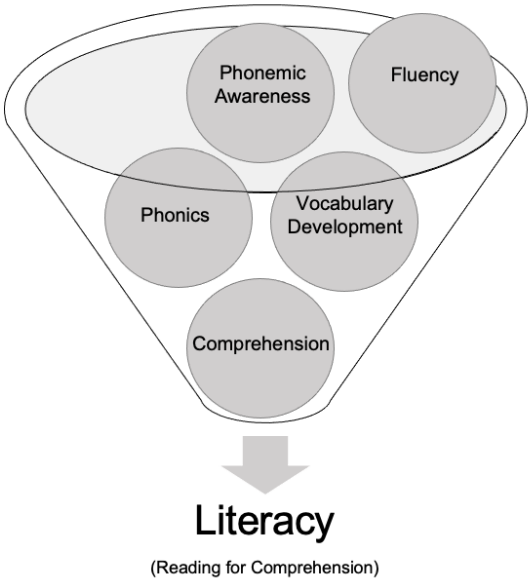
Conceptual Framework

The goal of literacy is reading for comprehension, that is, demonstrating proficient skill in amalgamating relevant prior knowledge and contextual information to understand reading material and use it as author(s) intend (Achieve3000 & MetaMetrics, 2020; Petscher et al., 2020; Reardon et al., 2012; Tompkins, 2017). The five key areas that shape an individual's English literacy development are phonics, phonemic awareness, vocabulary development, fluency, and comprehension (Hattie, 2009; National Institute of Child Health and Human Development [NICHD], 2019; Tompkins, 2017). While phonics is the relationship between symbols and sounds in an alphabetic language such as English, phonemic awareness is the skill of manipulating sounds in spoken words (Achieve3000, n.d.-b; Tompkins, 2017). This skill is particularly helpful in decoding, or breaking down phonemes to read a word, especially when students encounter new words (Tompkins, 2017). Vocabulary development is the skill of assigning appropriate meaning to new or unfamiliar words and is a critical skill to develop in pursuit of understanding of a text (Tompkins, 2017). Fluency is the rate of automaticity that allows a reader to devote greater cognitive capacity to understanding a text rather than decoding it (Tompkins, 2017). Comprehension is an ongoing process that requires combining preexisting knowledge and skill to make sense of a text (Tompkins, 2017). While foundational literacy emphasizes comprehension as result of decoding text to understand words within a context,

advanced literacy requires greater complexity in reading for comprehension (Reardon et al., 2012). Developing a strong foundation in each of these skills contributes to literacy development, ultimately resulting in effective reading for comprehension (Amendum et al., 2011; Hattie, 2009; NICHD, 2019; Tompkins, 2017). Additionally, all five areas are necessary and of equal importance in literacy development (Amendum et al., 2011; Hattie, 2009). Based on these findings, the researcher in this study, created a rudimentary conceptual framework identified in Figure 1. The conceptual framework illustrates the role of the five key areas, each with equal size and importance as ingredients working together to result in literacy, defined as reading for comprehension. This conceptual framework was the foundation undergirding the investigation on the effect of concurrent program engagement on reading outcomes.

Figure 1

Conceptual Framework



Note. This rudimentary framework was created by the researcher in this study based on the following research: "The Effectiveness of a Technologically Facilitated Classroom-Based Early Reading Intervention: The Targeted Reading Intervention" by S. J. Amendum, L. Vernon-Feagans, and M. Ginsberg, 2011, *The Elementary School Journal, 112*(1), 107-131 (JSTOR; https://www.jstor.org/stable/10.1086/660684), copyright 2011 by the University of Chicago; *Visible Learning: A Synthesis of Over 800 Meta-analyses Relating to Achievement* by J. Hattie, 2009, copyright 2009 by John A. C. Hattie; *Literacy for the 21st Century: A Balanced Approach*, 7th ed, by G. E Tompkins, 2017, copyright 2017 by Pearson Education, Inc.

Research Design and Methodology

This research was designed as a quantitative evaluation of the relationship between engagement in two concurrent literacy interventions and third-grade student Lexile measures. Research on literacy acquisition establishes a correlation between developing foundational literacy skills and reading comprehension outcomes (Achieve3000, n.d.-a, n.d.-c; Hattie, 2009; MetaMetrics & Achieve3000, 2015; NICHD, 2019; Tompkins, 2017). The schools selected for this study represented nine nonprofit partner schools who offered both literacy interventions for third-grade students during the 2020-2021 school year. Thus, participants were selected through purposeful convenient sampling and include 241 third graders from nine Catholic elementary schools partnering with the same nonprofit. The rationale for selecting third graders was

threefold. First, in the primary grades (transitional kindergarten through second grade), students are learning to read (Chall, 1983, as cited in Snow & Biancarosa, 2003); by the third grade, students must be reading successfully to independently comprehend increasingly complex texts (Reardon et al., 2012; Snow & Biancarosa, 2003). Second, research on the achievement gap of fourth graders has evidenced a need for earlier intervention (Murphy & Justice, 2019; Paschall et al., 2018; Pfost et al., 2014; Snow & Matthews, 2016; The Nation's Report Card, 2019). According to research, students in high-poverty areas have fallen behind wealthier counterparts in reading scores by the fourth grade (Paschall et al., 2018; Pfost et al., 2014). Within the past three years, students in the third grade have demonstrated the largest literacy gap among the nonprofit network's school sites (S. Johnson, personal communication, November 25, 2020). Third, evidence shows that the achievement gap increased in the context of the coronavirus pandemic (Dorn et al., 2020b).

During the 2020-2021 school year, all third graders registered to use Smarty Ants had a general expectation of actively engaging in the platform for 90 minutes weekly to meet their goal of completing the program before the end of the year. In this study high or low engagement in Smarty Ants was defined by whether students completed the program by the end of the 2020-2021 school year. Data generated in Achieve3000 Literacy included student average and aggregate scores on the reading comprehension activities, the average and aggregate number of articles completed, the monthly Lexile adjustment available for students above a 150L, Lexile growth measures for the school year, and the pretest, interim test, and posttest LevelSet benchmark assessment results. Criteria for student engagement levels in Achieve3000 Literacy were based on the available data and grounded in the literature on Achieve3000 Literacy. Levels

were determined by whether a student met more or less than three criteria. This research defines high engagement as meeting three or more criteria, while low engagement is defined as meeting less than three criteria. Greater detail regarding engagement levels is provided in Chapter 3. This quantitative study followed a quasi-experimental pretest-posttest design. This study evaluated the relationships between student engagement in Smarty Ants and Achieve3000 Literacy and Lexile outcomes, defined as Achieve3000 Literacy posttest Lexile measures and Lexile growth measures. The study employed paired samples tests (*t*-tests) to evaluate statistical significance between the Means of variables used to respond to the research questions and the analysis of covariance (ANCOVA) to evaluate the statistical significance of differences among group scores while controlling for the pretest as the covariate. An *R* squared correlations and *F*-test for Heteroskedasticity were also included in each ANCOVA generated.

Limitations

Campbell and Stanley (1963) identified several internal and external threats to validity. One internal threat to validity that may apply to this dissertation is the historic threat, namely the rise of COVID-19 cases and the subsequent stay at home orders focusing school closures to site-based education beginning in March 2020 and affecting schools and students differently through the 2020-2021 school year. According to Campbell and Stanley (1963) "All those in the same session share the same intrasession history" (p. 14), potentially minimizing the historical validity threat. While all students shifted to remote learning during the pandemic, this study does not account for the impact of the shift on the individual's experience. Although maturation can be a possible threat, all students are within the same grade level, limiting the variation in maturation. In addition, the benchmark assessments for both programs (pretest, interim, and posttest) were

conducted on a predetermined schedule within the school year. Maturation and testing periods can be controlled as they are established equitably across the participant pool (Campbell & Stanley, 1963). Instrumentation threat is controlled as the Achieve3000 Literacy benchmark assessments (pretest, interim test, and posttest), known as the LevelSet assessments, as well as the Smarty Ants benchmark assessments all require students to respond on a fixed cloud-based instrument using a device (Campbell & Stanley, 1963). The data generated from these instruments were automatically documented by the programs, reducing the possibility of human error in recording student scores. While it is possible that testing can be a threat to internal validity (Campbell & Stanley, 1963), Achieve3000 has numerous versions of the LevelSet Assessment which significantly reduce the likelihood that a child will take the same exact version of the test more than once (C. Pileggi personal communication, September 1, 2021). In Smarty Ants, benchmark assessments are computer-adaptive and based on student grade placement and assessment performance (Achieve3000, n.d.-a; MetaMetrics & Achieve3000, n.d.). While these potential threats to validity were relatively controlled, this study had three major limitations. First, Catholic school enrollment is significantly smaller than public school enrollment for a variety of reasons. As the research conducted centers on use of specific programs in the third grade at nine Catholic elementary schools, the sample size was small and limits the generalizability of the results. The sample size was further reduced by the results of data showing that 241 students received the Achieve3000 Literacy treatment, while only 192 received the Smarty Ants treatment. Second, this study does not attempt to account for the impact of the coronavirus pandemic on individual schools or students. According to Lewis et al. (2021), “data alone cannot paint a complete picture of how young people fared this past year” (p.

9). During the 2020-2021 school year, the schools highlighted in this study may have had different formats for instructional delivery including distance learning, site-based instruction, and/or a hybrid of the two modalities. This may have impacted the role of the teacher, degree of access to instructional support, internet connectivity, access to devices, variation in student learning environments, and other potential factors influencing student engagement and performance. Thus, while all students were affected by school closures and the context of the COVID-19 pandemic, this study does not account for their individual experience and the factors influencing their engagement in the two programs. Lastly, while closing the achievement gap requires a multidimensional approach (Carter, 2018), this study did not account for other elements of the multidimensional approach to closing the gap. As this study was quantitative, it did not address the role of elements impacting student engagement, such as: student home culture; student individual learning needs or special education qualifications; students' English language development or immigration status, family size, and parent educational levels; or the role of the teacher regarding professional development, teacher expectations, program implementation, or instructional methodology.

Delimitations

For optimal focus and manageability of data within the data collection timeline, this research study did not include a qualitative component. As a result, this study did not explore elements affecting teacher implementation of programs, the pandemic's impact on student experience, or the factors affecting student engagement in each program. Some examples include, but are not limited to: connectivity, access to devices, availability or accessibility of technical support, capacity to troubleshoot issues, or other technological issues; conditions,

quality, and type of learning environment; expectations of school leadership, teachers, and caregivers as well as how those were communicated, understood, and met by the students; the reason(s) for and degree to which students were motivated to engage in the programs or make progress; the role of supervision, monitoring, or communication within the school and between the home and school; the role of attendance and truancy; the role of instruction, the format for instructional delivery, instructional time frames; the role of teacher-student relationships, or the type, quality, and degree of instructional support. Similarly, this study did not include an analysis of the potential factors influencing the achievement gap, including, but not limited to: teacher capacity and understanding of program expectations and implementation; quality and role of teacher training; the perceptions of students, teachers, and leaders during the academic year; class or school culture; student home culture; student individual learning needs or special education qualifications, or students' English language development or immigration status, family size, and parent educational levels.

Assumptions

Based on the research citing a correlation between the five key foundational elements of literacy and reading comprehension, which was the foundation for the conceptual framework in this study (Achieve3000, n.d.-a; Hattie, 2009; NICHD, 2019; Tompkins, 2017), it was assumed that a relationship exists between student completion of Smarty Ants and student Lexile growth in Achieve3000 Literacy. In addition, research by MetaMetrics and Achieve3000 Literacy (n.d.) asserted that student completion of 40 lessons with a score of 75% or above within one school year will result in one year of growth as measured by Lexile scores. Based on these findings, it

was assumed that if students complete 80 activities with a score of 75% or higher, they should demonstrate two years of Lexile growth.

Conclusion

Being an engaged, informed, and productive citizen, in addition to choosing one's career path requires successful and competent navigation of text-based information (Pfost et al., 2014) and yet, "the descendants of those subjected to slavery, genocide, and conquest remain wedged at the bottom of the contemporary socioeconomic ladder" (Carter, 2018, p. 3). The educational failure to ensure that all elementary students have mastered grade level literacy for future academic and career success is a clear issue of social justice in education as it results in increased dropout rates (Dorn et al., 2020b; Papay et al., 2013; Partanen et al., 2019), contributing to the school-to-prison pipeline (Annamma et al., 2014), reduced employment opportunities for people of color with limited skills (Reardon et al., 2012), and the loss of economic potential for the nation (Dorn et al., 2020b). For years, federal, district, school and classroom-based efforts have been made to close the gap (Carter, 2018; Jehangir et al., 2015; Johnson, 2002; Paschall et al., 2018; Wenglinsky, 2004). According to Pfost et al. (2014), the development pattern of Matthew effects in reading result in strong readers increasing their skills while less skilled readers show only minimal gains. Matthew effects give evidence to the need for intervention to ensure equity and justice in education through literacy.

In 2020, the social, emotional, economic, and academic situation of working class and low-income communities of color was intensified by the COVID-19 Pandemic (Cookson, 2020; Fensterwald, 2020; Gardner, 2020; Kotkin, 2020). The forced economic shut down and school closures to slow the spread of the virus expanded the technology divide and reduced access to

quality education for children of color in low-income areas (Dorn et al., 2020a; Williams et al., 2021). The subsequent widening of the achievement gap (Dorn et al., 2020a) renewed the sense of urgency for a resolution to this blatant educational injustice. Whether it is public or private education, the problem persists, especially in low-income areas. This context presented a unique opportunity to lean into an authentic and effective integration of technology for increased student outcomes. While time is of the essence, potential solutions to close the achievement gap in the current context require research, planning, and intention (Dorn et al., 2020a). The nonprofit is an organization applying such criteria while working to close the achievement gap. The nonprofit partners with low-income Catholic elementary school leaders to close the achievement gap by delivering support to meet the academic and social-emotional needs of students in partnering schools. In this work, the nonprofit applied theory of change to shape a long-range plan to deliver high quality whole child curriculum, professional development, and support to close the achievement gap in partnering low-income Catholic schools (S. Johnson, personal communication, November 25, 2020). Among the programming delivered by this nonprofit are two literacy interventions, Smarty Ants and Achieve3000 Literacy.

This research addressed this issue of social justice in education by investigating relationship between third-grade student engagement in the two concurrent interventions and their literacy performance over the course of one academic year. Participants were selected through purposeful convenient sampling, given the site leader's commitment to using both programs in the third grade and the accessibility of archived data due to the researcher's role working with the nonprofit. This quantitative analysis applied a quasi-experimental pretest-posttest design to evaluate the relationship between third-grade student engagement in the

literacy interventions and student Lexile measures from archived data documenting student progress during the 2020-2021 school year. One major limitation of the study was the sample size due to the demographic in question, which may limit generalizability. In addition, this study was limited as a quantitative analysis that did not investigate qualitative elements such as the impact of the COVID-19 pandemic on student learning and engagement. Furthermore, as this research did not evaluate factors influencing the literacy gap in context, elements potentially impacting student engagement and progress in either or both programs, and the perspective of students, teachers, and school leaders, which may be areas for further research discussed in Chapter 5. Following are definitions to support the reader in understanding key terminology associated with this research.

Definition of Terms

a. *Achieve3000 Literacy*: A cloud-based, semi adaptive literacy intervention using predominantly nonfiction leveled texts to target third- through 12th-grade student comprehension skills, measured by Lexile assessments within the program (MetaMetrics & Achieve3000, n.d.).

b. *Federal Free or Reduced Lunch* (FRL): The National School Lunch Program serves as an indicator for family income levels; those with low family income are eligible (Paschall et al., 2018).

c. *Literacy*: In this study, the term was defined as the ability to read, comprehend, and use a text for the intended purpose (Achieve3000 & MetaMetrics, 2020; Petscher et

al., 2020; Pilgrim & Martinez, 2013; Reardon et al., 2012; Tompkins, 2017; Venezky, 2016).

d. *Literacy gap*: While the achievement gap can be defined as the variation between the performance outcomes of students of color as compared to their White counterparts (Boykin & Noguera, 2011; Rojas-LeBouef & Slate, 2012; Teale et al., 20007), there was no racial or ethnic demographic data for participants in this study to allow a comparative performance gap according to these characteristics. As a result, the literacy gap addressed in this study referred to the difference between students' actual and expected reading performance according to grade level Lexile measures.

e. *Lexile Framework for Reading*: A reading metric designed by MetaMetrics, grounded in over 20 years of research, and recognized as "the most widely used reading metric" (MetaMetrics & Achieve3000, 2015, p. 7). The framework "is a scientific approach to reading and text measurement . . . that measures both text complexity and reader ability using the same scale" meaning "that the ability to comprehend and the material being comprehended are evaluated using the same criteria" (Achieve3000, 2017b, p. 6). Thus, the framework accounts for both the Lexile text measures and Lexile reader measures (Copeland & Liben, 2013).

f. *Lexile measure*: A numerical value followed by an "L" that indicates a text's level of difficulty or readability as well as a reader's comprehension skill (MetaMetrics & Achieve3000, n.d.; Reardon et al., 2012).

g. *Smarty Ants*: A computer adaptive and gamified program focused on delivering analytic phonics instruction, progressively challenging activities, feedback, scaffolding, support, and assessment to build transitional kindergarten through second grade foundational literacy skills (MetaMetrics & Achieve3000, n.d.).

h. *Reading for comprehension*: Defined by Reardon et al. (2017) as having developed the knowledge-based competencies to effectively integrate "background knowledge and contextual information to make sense of a text" (p. 17).

Organization of the Dissertation

Chapter 1 provided a broad statement of the problem introducing the achievement gap, the context of the study, the role of COVID-19 and its impact on Catholic education, as well as the need for technology, and the role of a nonprofit supporting low-income Catholic elementary schools in closing the achievement gap. In addition, Chapter 1 included the conceptual framework underpinning this research as well as the limitations and delimitations of this study. The review of the literature in Chapter 2 provides greater detail on the general achievement gap as well as the achievement gap in literacy, and the two interventions addressed in this study. The methodology discussed in Chapter 3 includes an explanation of participant selection as well as the process for data collection and analysis. The results of the quantitative analysis are discussed in Chapter 4. The study concludes with a discussion of the findings and implications for the significance of the study, recommendations for the field and further areas for study in Chapter 5.

CHAPTER 2

REVIEW OF THE LITERATURE

This study emphasized one segment of the larger achievement gap, the literacy gap, which was defined in this research as the difference between students' actual and expected reading performance according to grade level Lexile measures. The purpose of this study was to evaluate the relationship between third-grade student engagement in two concurrent literacy interventions, Smarty Ants and Achieve3000 Literacy, and their reading performance outcomes. This review of the literature provides an overview of the achievement gap, various aspects of literacy, relevant interventions, and the inclusion of technology. The chapter concludes with information about the two literacy interventions in this study.

The Achievement Gap

In 1969 a report of the academic progress of fourth-, eighth- and twelfth-grade students known as *The Nation's Report Card* was first published, clearly demonstrating poor student academic achievement, particularly among low socioeconomic (SES) populations and people of color (Boykin & Noguera, 2011; Jeynes, 2015; The Nation's Report Card, 2019; Wenglinsky, 2004). As a clear issue of injustice in the academic field, the disparity became known as the achievement gap (Boykin & Noguera, 2011; Rojas-LeBouef & Slate, 2012; Teale et al., 2007). *The Nation's Report Card* became the standard metric by which to evaluate magnitude of academic performance disparities across the nation (Boykin & Noguera, 2011; Jeynes, 2015; Wenglinsky, 2004). According to Boykin and Noguera (2011), there are three major achievement gaps in the United States: the variation in performance between American children as compared to children around the world; the difference between American children's

educational preparation and college career readiness expectations, and the disparity between the performance of White children as compared to children of color, particularly Black, Latinx, and Native American children. While the Black-White gap has been studied extensively, research regarding the Latinx-White gap continues to be limited (Paschall et al., 2018). Research notes a variance in performance among subgroups of Latinx populations (Reardon et al., 2012) in addition to variations in SES within Black or Latinx populations (Paschall et al., 2018). Although the most common definition of the achievement gap in education refers to the variation between performance outcomes of students of color as compared to their White counterparts (Boykin & Noguera, 2011; Rojas-LeBouef & Slate, 2012; Teale et al., 2007), this research focused on the gap in literacy, referring to the difference in actual and expected student performance according to grade level measures indicated by the MetaMetrics (2021b) Lexile Framework for Reading. Just as research has made efforts to understand the achievement gap, much research has been devoted to understanding the factors contributing to the gap.

Contributing Factors

Research commonly cites SES as a factor impacting student achievement (Boykin & Noguera, 2011; Dietrichson et al., 2017; García & Weiss, 2017; Johnson, 2002; Snow & Biancarosa, 2003; Wenglinsky, 2004). According to Rojas-LeBouef and Slate (2012), a family's status as high SES is linked to academic success in education. Perry and McConney (2010) asserted that low SES students perform lower on standardized academic assessments than their higher SES counterparts. Similarly, García and Weiss (2017) noted a significant difference in reading and math performance of students from high SES backgrounds as compared to students from low SES backgrounds. Crouzevialle and Darnon (2019) found that the disparity between

students of low SES and their counterparts was highly evident on standardized assessment, where the former "are at a disadvantage and experience lower efficiency when in an achievement context that requires them to outperform others" (p. 9). Crouzevialle and Darnon (2019) credited the differences in SES for the increased achievement gap since 2003, yet Johnson (2002) argued that the disparities are present in the performance outcomes of people of color regardless of SES. Research has shown that SES is entwined with other factors (Waldfogel, 2012), including, but not limited to race and/or ethnicity, religious background, language, geography, history, as well as economic and sociopolitical aspects (Duke & Cartwright, 2021; Milner, 2013; Rojas-LeBouef & Slate, 2012; Ryan, 2006).

Efforts to understand causes of the achievement gap have resulted in a myriad of intersecting factors that can be framed by the layers of a child's ecosystem from birth to their upbringing, and educational experiences. In addition to SES, the child's home environment can include such elements as parent educational attainment or immigration status (Waldfogel, 2012), English language proficiency (Borrero & Bird, 2009; Johnson, 2002; Waldfogel, 2012), cultural expectations and experiences (Duke & Cartwright, 2021; Petscher et al., 2020; Waldfogel, 2012), trauma (Sanchez, 2008), or adverse childhood experiences (ACEs; Harris, 2015). Early educational opportunities such as access to literature in the home, foundational learning, and access to quality preschool programming are also potential influences affecting the achievement gap (Waldfogel, 2012; Wenglinsky, 2004). Success in formal academic settings may be impacted by students existing content knowledge and cultural experience (Duke & Cartwright, 2021). In the absence of effective intervention, the Matthew effects in reading explain that struggling students make little progress as compared to literate peers who make significant gains (Pfost et

al., 2014). During formal years of schooling, the achievement gap might also be influenced by special education qualifications or placement (Annamma et al., 2014), seasonal breaks from school (Pfost et al., 2014), school policies and practices (Wenglinsky, 2004), asset or deficit-based approaches to learning (Moll et al., 1992), school climate and teacher-student relationships (Sanchez, 2008), and teacher quality, professional development, and expertise (Amendum et al., 2011).

While there is no clear formula for understanding how achievement gaps are created, research has been clear that the problem is multifaceted and complex (Jeynes, 2015; Muhammad, 2015) and likely the result of a convergence of factors (Sanchez, 2008). While Crouzevialle and Darnon (2019) described the disadvantage and limited proficiency that students from a lower SES face, Carter (2018) portrayed the student experience as if "[walking] up 16 flights of broken stairs to college graduation [while] others have the opportunity to take elevators going at bullet-train speed or a combination of escalators and speedy elevators" (p. 9). This description was an articulation of the educational injustice that children of low SES and children color continue to experience, which results in a variety of negative consequences for both the individual and society at large.

Consequences of the Achievement Gap

According to researchers, the achievement gap begins in the early years of children's education and increases over time, resulting in life-long consequences, especially for children from lower SES backgrounds (Burroughs-Lange & Douëtil, 2007; García & Weiss, 2017; Jehangir et al., 2015; Palumbo & Sanacore, 2009; Paschall et al., 2018). Furthermore, "income-related gaps . . . reflect difference in skills and behaviors that emerge early in students'

educational careers" (Papay et al., 2013, p. 4). Academic performance affects the educational attainment of students from low SES backgrounds who have lower assessment scores, rates of educational attainment, and eighth grade, high school, and college graduation rates when compared to their higher SES counterparts (Crouzevialle & Darnon, 2019; Milner, 2013; Papay et al., 2013; Rojas-LeBouef & Slate, 2012). According to Smith (2014b), high school graduation does not equate postsecondary preparation, as graduates entering post-secondary education required remediation in mathematics, reading and writing. Moreover, research has specifically demonstrated that students of color from low SES backgrounds are disproportionately unprepared for high school literacy opportunities, entering "with average literacy skills three years behind those of White and Asian students" (Reardon et al., 2012, p. 17), reducing opportunities to successfully navigate increasingly complex courses (Muhammad, 2015). Consequently, people of color tend to be underrepresented in higher level courses (Dorn et al., 2020a). This leads to the question of whether the preparation and rigor students receive in the PK-12 continuum effectively integrates text complexity toward postsecondary requirements (Smith, 2014b). Failure to adequately prepare students for future learning, especially those from lower SES backgrounds, has resulted in a reduced self-efficacy, self-esteem, and achievement expectancies (Crouzevialle & Darnon, 2019). Student academic failure has also resulted in low engagement and motivation (Ryan & Deci, 2000), retention and attendance problems (Hattie, 2009), and increased rates of students dropping out of the educational system (Dorn et al., 2020a; Papay et al., 2013; Partanen et al., 2019), further limiting career potential (Partanen et al., 2019; Reardon et al., 2012). In addition, the nation's economic growth within a few decades expanded to focus on employment opportunities that require higher skill in literacy (Reardon et al., 2012).

As a direct consequence of the achievement gap, the nation has experienced reduced economic power (Dorn, 2020a). Recognizing that the achievement gap is a persistent issue of social justice in education with grave lifelong consequences, the federal government increased its level of involvement, thereby emphasizing the urgency for remediating the issue.

Federal Efforts to Close the Gap

Efforts to close the achievement gap have been predominantly government or school based (Jeynes, 2015). In 1964 President Johnson addressed low SES through the War on Poverty (Paschall et al., 2018). The following year President Johnson signed *Public Law 89-10*, *Elementary and Secondary Education Act of 1965* (ESEA) into law (*Elementary and Secondary Education Act* of 1965, 1965). *ESEA* 1965 established the federal government's role in educational policy, creating Title I, offering more than one billion dollars in annual aid to high need K-12 public schools, and establishing the Head Start program (Klein, 2015; Paschall et al., 2018; U.S. Department of Education, n.d.). In 1975, Congress passed *Public Law 94-142*, also known as the *Education for All Handicapped Children Act* of 1975 or the *EHA*, to protect and meet the needs of children with disabilities and their families (*Education for All Handicapped Children Act*, 1975; IDEA: Individuals with Disabilities Education Act, 2020). In 1990 *Public Law 101-476* reauthorized the *Education for All Handicapped Children Act of 1975* as the *Individuals with Disabilities Education Act* (IDEA) (*Individuals with Disabilities Education Act*, 1990). *Public Law 108-446* reauthorized *IDEA* in 2004 (*Individuals with Disabilities Education Improvement Act*, 2004). On January 8, 2002, *Public Law 107-110* was signed as an update to *ESEA* known as *No Child Left Behind* (*NCLB*) (*No Child Left Behind Act of 2001*, 2002). The law further expanded the federal government's role in education and increased state

accountability for improving student performance outcomes on state-selected assessments; states choosing not to comply with the new requirements risked losing Title I funds (Klein, 2015). Under this legislation, schools were required to ensure that all teachers and paraprofessionals hired through Title I funds were *highly qualified*, meaning that teachers possessed the minimum qualification of a bachelor's degree in the subject area they taught as well as state certification while paraprofessionals possessed an Associate degree, completed two years of college, or passed an assessment evaluating teaching knowledge and ability (Klein, 2015). In addition, schools were required to administer reading and math assessments to all third through eighth grade students and once to high school students (Klein 2015). Schools were then required to report results for the entire student body as well as for specified groups such as English language learners, special education students, low-income students, and racial minorities (Klein, 2015). On December 10, 2015, President Barak Obama signed *Public Law 114-95*, reauthorizing the *Elementary and Secondary Education Act of 1965* as *Every Student Succeeds Act* (*ESSA; Every Student Succeeds Act* [ESSA], 2015; U.S. Department of Education, n.d.). Schools continued to be measured for adequate yearly progress (AYP) and are subject to consequences when requirements are not consistently met for more than two years (Klein, 2015; U.S. Department of Education, n.d.). While policy efforts in the 1970s and the 1980s slightly reduced the gap, it continued to widen in time (Boykin & Noguera, 2011; Carter, 2018; Hansen et al., 2018 Jeynes, 2015; Johnson, 2002; Paschall et al., 2018; Wenglinsky, 2004).

A Widening Gap

Since 1969, the biennial National Assessment of Educational Progress (NAEP), commonly known as *The Nation's Report Card*, has been used as the measure for determining

the educational progress of students at specific grades, thus indicating the extent of the achievement gap (Boykin & Noguera, 2011; Jeynes, 2015; The Nation's Report Card, 2019; Wenglinsky, 2004). According to Paschall et al. (2018), from 2003 through 2015 the NAEP report identified significantly lower scores for fourth graders eligible for Free and Reduced Lunch (FRL) as compared to those who were ineligible for it. Similarly, the 2015 performance gap for eighth graders eligible for FRL had increased since 2005 (Paschall et al., 2018). While federal efforts have made minimal progress in closing the achievement gap, five states reduced the Black-White achievement gap between 1998 and 2007, while the Latino-White achievement gap persisted (Boykin & Noguera, 2011). In a descriptive analysis of reading and math assessments from 1986 to 2004, Paschall et al. (2018) found that while the reading achievement scores of five-to-six-year-old non-poor White children were stable over time, the rank of their non-poor Black counterparts declined over time. In addition, the performance gap between poor and non-poor 13-14-year-old Black student scores increased during the 18-year period (Paschall et al., 2018). In California, the gap has increased between 2003 and 2017 (Hansen et al., 2018). According to NAEP, reading scores for fourth and eighth grades were lower in 2019 than in 2017 (The Nation's Report Card, 2019). In addition, fourth grade scores have only improved by four points, while eighth grade scores had improved by three points since 1992 (The Nation's Report Card, 2019). Boykin and Noguera (2011) concluded that policy has not effectively addressed equity. While such policies emphasized teacher quality, they fail to address opportunity gaps in education (Carter, 2018).

The Achievement Gap in Literacy

While a general discussion on the achievement gap predominantly emphasizes reading and math, this study attends on the achievement gap in literacy. This section further explores an operationalization of literacy, a brief description of the evolution of reading theories, the critical nature of literacy in the third grade, and literacy interventions including the two interventions at the center of this study, Smarty Ants and Achieve3000 Literacy.

Defining Literacy

In his time, Marcus Tullius Cicero used the Latin term *literatus* to mean a learned person who could read, write, and speak Latin (Venezky, 2016). While the modern terms *literate* and *illiterate* originated from this Latin word, *literacy* was not established in the English lexicon until the end of the 19th century (Venezky, 2016). Today, literacy is a multidimensional skill that "plays a key role in social mobility, economic growth, and democratic participation" (Reardon et al., 2012, p. 18). As an empowering skill, literacy affords the opportunity to acquire new privilege or maintain a position of privilege (Venezky, 2016). To some degree, literacy in the late 20th century was traditionally used to refer to "students' ability to read words," though it is now described as using the tools of reading and writing "for participating more fully" in society (Tompkins, 2017, p. 17). According to the International Literacy Association (ILA), literacy is "The ability to identify, understand, interpret, create, compute, and communicate using visual, audible, and digital materials across disciplines and in any context" (International Literacy Association [ILA], n.d.). Reardon et al. (2012) portrayed literacy as "the ability to access, evaluate, and integrate information from a wide range of textual sources" (p. 18). A fundamental definition offered by Pilgrim and Martinez (2013) suggested that literacy is "reading and writing

effectively in a variety of contexts" (p. 60). Petscher et al. (2020) articulated that "The ultimate goal of reading is to extract and construct meaning form text for a purpose" (S270). Smith (2014b) suggested that "the ability to read and comprehend complex texts" is essential among college readiness criteria (p. 6). To become literate as a reader, one must acquire a solid foundation in reading skills to effectively read and comprehend a text (Amendum et al., 2011; Hattie, 2009; NICHD, 2019; Tompkins, 2017). This research study considered these examples to focus on reading alone and provide a basic definition of literacy as the ability to read, comprehend, and use a text for the intended purpose (Achieve3000 & MetaMetrics, 2020; Petscher et al., 2020; Pilgrim & Martinez, 2013; Reardon et al., 2012; Tompkins, 2017; Venezky, 2016). The changing definition of literacy over time has influenced an evolution of methods for instruction of literacy (Taylor et al., 2020).

Reading Wars: Theories of Literacy Development Over Time

The reading wars is a term assigned to the 100-year debate on how to best teach reading (Petscher et al., 2020). Reading itself is a "complex process of understanding written text" (Tompkins, 2017, p. 16). Since the 1960s debates about the best way to teach reading have dominated literacy discourse (Jeynes, 2008). While educators in the 1960s placed an emphasis on phonics due to the logic behind the phonetic construction of the English Language (Jeynes, 2008), in the 1970s the focus was reading aloud (Coltheart, 2005). As research attempted to explain role of decoding, Gough and Tunmer (1986) offered the simple view of reading, which could be applied to the general population, but not to students with reading difficulties (Cervetti et al., 2020). This model organized the elements necessary for reading instruction (Petscher et al., 2020) by expressing reading skill as a product of the relationship between decoding and

comprehension, i.e., $R = D \times C$ (Gough & Tunmer, 1986). The terms *reading* and *reading skill* in the simple view of reading were intended to "mean comprehension of written text," while the original terms of *decode* and *comprehension* have now expanded "to *word recognition* and *language (linguistic) comprehension*" (Duke & Cartwright, 2021, p. S26). In 2020 the simple view of reading was reaffirmed as research emphasized a direct correlation between skill in decoding and language comprehension and reading skill (Hoover & Tunmer, 2020, as cited in Duke & Cartwright, 2021). Since it was first published, the simple view of reading has been the most widely used model for explaining reading development to practitioners, yet it does not sufficiently account for the factors impacting reading skills, nor does it prepare educators to meet the needs of students who struggle with decoding and comprehension (Duke & Cartwright, 2021). Given this contention Duke and Cartwright (2021) suggested augmenting the simple view of reading to include the roles of fluency, vocabulary, and morphological awareness as factors influencing word recognition and language comprehension in reading development.

In 1999, the National Reading panel was convened to review over 100,000 published reading studies to "determine the most effective evidence-based methods for teaching children to read" (NICHD, 2019). The panel found "that the best approach to reading instruction is one that incorporates: explicit instruction in phonemic awareness, systematic phonics instruction, methods to improve fluency and ways to enhance comprehension" (NICHD, 2019). Furthermore, the panel determined that a combination of techniques for effectively teaching children to read included phonemic awareness, phonics, fluency, guided oral reading, teaching vocabulary words, and reading comprehension (NICHD, 2019). Research has since determined that effective reading instruction includes phonemic awareness, phonics, fluency, vocabulary, and

comprehension (Hattie, 2009; Tompkins, 2017), as noted in the conceptual framework predicating this research study (see Figure 1). Additionally, readers need regular opportunities to develop their accuracy, fluency, and comprehension through connected texts (Petscher et al., 2020). According to Hattie (2009), "Successful reading requires the development of decoding skills, the development of vocabulary and comprehension, and the learning of specific strategies and processes" (pp. 129-130). Duke and Cartwright (2021) explained vocabulary as a contributor to word recognition and language comprehension, and fluency as a bridge between the two. However, research has demonstrated that a focus on one of these areas such as phonics or fluency, over the others is ineffective in meeting desired outcomes (Amendum et al., 2011). Hattie (2009) asserted that programs based on specific strategies are most successful and that a combination of the "five pillars of good reading instruction" are more effective than programs that prioritize one area over another (p.140). Consequently, research has promoted a balanced approach to reading instruction (Amendum et al., 2011; Tompkins, 2017). This comprehensive view of literacy "combines explicit instruction, guided practice, collaborative learning, and independent reading and writing" (Tompkins, 2017, p. 17).

In recent years, researchers have contributed to literacy pedagogy by using science to map the brain processes involved in learning to read (Snowling & Hulme, 2005). Such scientific investigations have revealed that while the human brain evolved to include structures for verbal speech millions of years ago, the brain structures for learning to read are just about 6,000 years old (Dehaene, 2009, as cited in Fisher et al., 2016). Mapping how the brain learns to read provided greater insight for developing literacy pedagogy and programs as well as responding to neurodiversity to ensure greater success in student literacy acquisition (Wolf, 2007). As an

example, empirical research has shown that the English language is challenging for early readers as it does not have a one-to-one sound-letter correspondence and vowels have multiple pronunciations, consequently, "students learning to read in English are slower to acquire decoding skill" (Petscher et al., 2020, p. S270). The amalgamation of literature on the development of reading as well as practices for effectively teaching reading became termed *the science of reading* (Petscher et al., 2020). Studies within the science of reading have used multiple research approaches subjected to arduous experimental analysis to reach a degree of unanimity regarding typical reading development and the impact of individual differences (Petscher et al., 2020). While a comprehensive analysis of literacy is important, this study attends to literacy in the third grade as a critical hinge point for academic and career success.

Third Grade: A Critical Year for Literacy

Research has delineated the differences between early literacy and subsequent literacy development, arguing that students in the early grades are learning to read, while students in the third grade and beyond are applying their reading ability to learn (Chall, 1983, as cited in Snow & Biancarosa, 2015). One reason is the shift of emphasis from developing foundational skills to application of skills for comprehension of increasingly complex texts. Early literacy depends on decoding for reading comprehension, which decreases and shifts to an emphasis on linguistic comprehension over time (Petscher et al., 2020). Moreover, while early literacy includes comprehension of words within a context and using textual cues to create inferences, third through eighth grade literacy skills focus on "knowledge-based literacy competencies," such as developing inferences by combining prior knowledge and text cues, understanding style, drawing connections between the text and one's own life, and critical evaluation with increased text

complexity (Reardon et al., 2012, p. 20). Research on literacy acquisition has dominated the early years of reading and documented limited reading growth in the upper elementary years (Hattie, 2009). Young children who struggle to read effectively also tend to fall behind in other academic areas as compared to their peers (Amendum et al., 2011). In 2010 children entering kindergarten "were not all equally prepared for school" (García & Weiss, 2017, p. 2). Moreover, Murphy and Justice (2019) noted that "in 2015 63% of 4th graders performed at basic or below basic levels in reading comprehension" (p. 1). According to Reardon et al. (2012), 2/3rds of eighth graders did not have knowledge-based competencies of reading for comprehension. In 2004 70% of secondary students required literacy remediation (Edmonds et al., 2009). Smith (2014b) reported that 20% of first-year students at a four-year university and 42% of first-year students at community colleges were enrolled "in at least one remedial course" (p. 6), which evidenced a significant difference between instruction, expectations, and text complexity at the secondary level as compared to postsecondary education (Smith, 2014a, 2014b). Murphy and Justice (2019) found that "about 16% of children who do not read proficiently in the third grade will fail to graduate from high school" (p. 1). This was further affirmed by Snow and Matthews (2016) who determined that "children who don't develop age-appropriate literacy skills by the end of third grade are at high risk of school failure" (p. 56). Thus, third graders' literacy performance is an established predictor of later success. Despite the unadulterated injustice present in education and the limited impact of federal policy, research has identified school practices that can improve student outcomes.

School-based Opportunities to Address the Gap

For years, educators, school leaders, policymakers, and researchers alike have investigated opportunities and invested time and resources in the hope of finding effective solutions to closing the gap (Boykin & Noguera, 2011; Muhammad, 2015; Sanchez, 2008). Pfost et al. (2014) argued that schools can create an "equalizing effect" in the achievement gap (p. 207). Research has also contended that specific practices and factors can effectively reduce the gap (Jehangir et al., 2015; Jeynes, 2015). Access to resources alone is insufficient to enhance student outcomes; there exist macro and meso levels impacting the gap requiring a multidimensional approach (Carter, 2018). Jeynes (2015) also asserted that the achievement gap cannot be closed with attention to one element and advocated instead for an "interdisciplinary approach" (p. 547). School-based priorities should include positive teacher-student relationships, school climate, and safety (Sanchez, 2008). These elements can be developed through funds of knowledge in teaching (Moll et al., 1992) or assets-based classroom instructional practices (Borrero & Bird, 2009; Boykin & Noguera, 2011). Engagement is also increased though motivation. Articulated by Ryan and Deci (2000) as Self-Determination Theory, this approach to motivation addresses the needs for competence, relatedness, and autonomy. Boykin and Noguera (2011) argued that change requires concerted efforts to provide resources and quality instructional time. Sanchez (2008) advocated for the Resiliency Education Program (REP), "a training model focused on the brain-based strategies of repetition, chunking, music, symbols, movement, and senses" (p. 24). Additionally, routines, appropriate guiding, opportunities for practice, and high student engagement on academic tasks improve student outcomes (Boykin & Noguera, 2011; Hattie, 2009; Sanchez, 2008). Among suggestions to address the literacy gap

offered by Smith (2014a) are the exposure to increased text complexity, the use of benchmarks to measure progress, targeted intensive practice with feedback, and the integration of technology for individualization. In response to the urgency of addressing gaps in student literacy development, educators, textbook publishers, and researchers alike developed and implemented various literacy interventions.

Literacy Interventions

Despite the knowledge gained over the past several years, many students do not possess grade level literacy skills (Petscher et al., 2020). However, schools can take measures "that are more influential than prior achievement effect" (Hattie, 2009, p. 42). Research argued that early targeted intervention can help reduce achievement gaps (Amendum et al., 2011; Foster & Miller, 2007; Partanen et al., 2019). In fact, "research has also shown that targeted support for students with poor phonics (Stage 1) skills significantly improves performance" (Foster & Miller, 2007, p. 174). According to Hattie (2009), prior achievement has an impact on later learning at all stages of education and "will lead to gains in achievement on 48 percent of the occasions" (p. 42). Snow and Matthews (2016) indicated that there have been a variety of literacy interventions developed that rely on different elements of school life such as professional development, targeting students, and targeting specific skills. However, while "reading curricula developed by textbook publishers are widely used" there has been little evidence to suggest that they are effective in developing student literacy (Snow & Matthews, 2016, p. 63). Petscher et al. (2020) advocated for reading interventions and practices that are evaluated through rigorous empirical studies, though researchers note that only two of the five most popular nationwide programs had

studies that meet the rigorous standards of What Works Clearinghouse, (https://ies.ed.gov/ncee/wwc/) a digital library of meticulously evaluated research in education.

One major intervention rising from federal funding directed at closing the achievement gap was Reading First. Beginning in 2002, the Federal government provided one billion dollars annually to institute this program which emphasized decoding and fluency, though it was not a comprehensive literacy program (Snow & Matthews, 2016). Success for All was another popular program emerging from federal policy. This program "is a comprehensive school-improvement program with a strong emphasis in its literacy component on phonological awareness and structured phonics" (Snow & Matthews, 2016, p. 63). Other popular early literacy interventions included Early Steps, Voyager Passport, and Targeted Reading Intervention (Amendum et al., 2011). One challenge to effective literacy instruction noted by Hattie (2009) was that "teachers do not have a common conception of progress in learning to read during those years; most curricula do not attend to reading professions; and there is so much emphasis placed on early learning to read that we have not built a perceived need to then continue to develop excellent programs to build on this early start" (p. 141). Moreover, Petscher et al. (2020) emphasized: "to make meaningful gains, intervention for reading comprehension likely requires addressing multiple components of language and teaching content knowledge" (p. S272). This research has built the case for effective curriculum that aligns with teacher capacity. Research also demonstrated that pull out instruction or additional supports outside the classroom can disrupt the continuity of instruction in the classroom setting, and thus, support should be built into the classroom model (Amendum et al., 2011). While such supports are not effective for increasing

student literacy, empirical research indicated the potential of applying technology to positively impact education outcomes (Pierce & Cleary, 2016; Smith, 2014a).

Opportunity for Technology

According to Taylor et al. (2020), the use of technology increases the ability to teach differently. In a blended learning model, for example, Wilkes et al. (2020) indicated that "students spend time working independently with online activities and receive instruction tailored to their own skill levels" (p. 596). Teachers then monitor student progress through corresponding program dashboards (Wilkes et al., 2020). Such models are selected for their "flexibility of implementation" (Wilkes et al., 2020, p. 596). Effectiveness is contingent upon making informed decisions when using technology (Taylor et al., 2020). Additionally, the quality of implementation is affected by the degree to which programs are used as indented by their developers (Dusenbury, 2012). Moreover, educators and policymakers emphasize a focus on teacher practices, yet research has found that some strategies are effective in certain contexts but not necessarily effective in others (Wenglinsky, 2004). Based on research, the field has produced a variety of software programs to support literacy development (Achieve3000, n.d.-b). The reading intervention Success for All is one example of an intervention that had greater outcomes when paired with digital technologies (Wilkes et al., 2020). The shift to distance learning due to COVID-19 in the 2020 school year heightened the need for software by which to deliver instruction at a distance.

In the context distance learning due to COVID-19, a nonprofit working with low-income elementary Catholic schools employed a logic model to propose the use of research-based computer adaptative software as a potential solution to student academic underperformance (S.

Johnson, personal communication, November 25, 2020). For the nonprofit to support any interventions, all potential solutions proposed must be effective, efficient, and socially valid, meaning they must work for the population using it in their context (S. Johnson, personal communication, November 25, 2020). Among the web-based literacy programs delivered by the nonprofit for the third grade were a foundational reading program, a reading comprehension program, a literature-based reading program, and a writing program. Each site leader selected a combination of programs that suited their school's needs and capacity. Nine leaders adopted two literacy interventions for concurrent implementation in the third grade. These two programs, Smarty Ants and Achieve3000 Literacy, became the focus of this research study.

Smarty Ants

Operated by Achieve3000, Smarty Ants is a computer-adaptive analytic phonics instruction program designed "under the advisement of a core team of educators from Stanford University and the University of California, Berkeley" (Achieve3000, n.d.-a., p. 2). The program is based on the foundational skills of phonemic awareness, phonics, fluency, vocabulary development and reading comprehension delivered through explicit instruction (Achieve3000, n.d.-a). Smarty Ants targets prekindergarten through second grade students employing gamification to deliver explicit instruction, feedback, and assessment on phonics to build students' decoding skills through a progression of 97 interactive lessons within 18 levels of activities and rewards to motivate children (Achieve3000, n.d.-a). Each of the 97 lessons corresponds to one of 18 levels organized from prekindergarten to second grade, which is visually represented in Table 1. Students participate in three Smarty Ants benchmark

assessments referred to in this research as the pretest, interim test, and posttest. These assessments are an opportunity for students to demonstrate mastery of foundational skills.

Table 1

Smarty Ants Program Levels and Lessons by Grade

Prekindergarten	Kindergarten	First Grade	Second Grade
Levels 1 to 2	Levels 3 to 6	Levels 7 to 11	Levels 12 to 18
Lessons 1 to 2	Lessons 3 to 39	Lessons 40 to 69	Lessons 70 to 97

At the beginning of the school year the teacher sets the academic goal for all students which is either the end of their grade level or one year of academic progress (Achieve3000, n.d.-a). When students first log into the program they complete the initial assessment that begins at their assigned grade level and increases with difficulty as the student proves his or her mastery of foundational skills (Achieve3000, n.d.-a). Based on their performance, students are placed in a lesson corresponding to one of the 18 program levels. The program also utilizes the benchmark assessments to set a weekly time goal for each child to meet his/her annual goal. If students actively engage in the program according to their weekly time goal, they will meet the academic goal, set at the end of the grade level or one year's growth. Based on Smarty Ants research for making progress toward the end of year goal (Achieve3000, 2017a), the nonprofit set a standard expectation for all students of 90 minutes of engagement in the program each week. Smarty Ants can be used with developing or at-risk readers to achieve the end goal of reading comprehension, "the ability to make meaning from print" (Achieve3000, n.d.-a. p.3). While Smarty Ants focuses on establishing strong foundational literacy for primary students, Achieve3000 Literacy was designed to support second through 12th grade students in building their reading competence to a Lexile level at or above grade level (Achieve3000, n.d.-c).

Achieve3000 Literacy

Achieve3000 Literacy is a cloud-based, semi-adaptive reading comprehension program directed at accelerating the reading skills of students in grades second through 12 through differentiation (Achieve3000, n.d.-c). To this end the program is designed to prioritize assessment and growth. Achieve3000 uses the proprietary software designed by MetaMetrics, the Lexile Framework for Reading (MetaMetrics, 2021b), to assess student reading comprehension and measure individual growth over time (Achieve3000, n.d.-c). The Lexile Framework for Reading is grounded in over 20 years of research (MetaMetrics & Achieve3000, 2015) and "is recognized as the most widely-used reading metric" (Achieve3000, n.d.-c, p. 7). The framework uses a modification of a scientific approach known as the Rasch model (Stenner et al., 2006) to evaluate a reader's comprehension skill and the complexity of a text on the same scale (Achieve3000, 2017; Copeland & Liben, 2013; Smith, 2014b). According to Stenner (1996), the Rasch model evaluates the interaction of item calibrations and number of correct items in a probability model to establish a score, in this case, a Lexile measure. The Lexile measure is denoted by a scaled number adjacent to the capital form of the alphanumeric letter "L" (MetaMetrics & Achieve3000, n.d.). According to Stenner et al. (2006), "Lexile text measures are an order of magnitude more accurate than those produced by older technologies" (p. 320). Smith (2014c) further emphasized that Lexile measures are ubiquitous, used by publishers and educators, and "available for more than 150,000 books from more than 200 publishers" (p. 81). MetaMetrics's Lexile analyzer calculates the Lexile measure of a text using a linguistic algorithm designed to evaluate semantic and syntactic text features (Copeland & Liben, 2013). Similarly, a Lexile reader measure is assigned to a student to indicate their skill in

reading comprehension, which matches them with a text measured within their zone of proximal development (Smith et al., 2014). As the Lexile Reading Measure is a vertical and developmental scale accounting for both student reading ability and text readability, it drives the Achieve3000 Literacy assessment known as the LevelSet (Achieve3000, 2017b; Copeland & Liben, 2013; MetaMetrics & Achieve3000, 2015).

The LevelSet assessment is a fixed-form, cloud-based, multiple-choice assessment with three alternate forms that are randomly assigned to students at each grade level (Achieve3000, 2021). It formally evaluates students' comprehension of expository texts with increased complexity (MetaMetrics, n.d., p. 2) and is administered at three points during the year, each referred to in this study as the Achieve3000 Literacy pretest, interim test, and posttest (Achieve3000, 2017b). The dates for testing windows are assigned by administrators prior to each academic year. The initial LevelSet assessment (pretest) is conducted when students first log into their program accounts (Achieve3000, n.d.-c). The pretest provides a baseline assessment of students reading skill to determine their "just-right reading ability" (Achieve3000, n.d.-c, p. 4). The interim assessment is generally scheduled for January and is intended to evaluate progress and provide a recalibration of student Lexile while the posttest is scheduled for May and measures summative progress (C. Pileggi, personal communication, January 21, 2022). All students, regardless of their initial Lexile score have an opportunity to adjust their Lexile Level score through their performance on the Achieve3000 Literacy interim and posttest assessments (Achieve3000, 2021). The LevelSet assessments generate a Lexile reader measure that is indicative of the student's individual reading ability (MetaMetrics & Achieve3000, n.d.).

A Lexile measure assigned to a text for its readability has limited error as compared to reader ability (Stenner et al., 2006). According to Stenner et al. (2006), "text readability can be measured with high accuracy" and error in expected comprehension rate is not attributed to errors in the Lexile text measures but rather variation in reader ability (p. 320). The disparity between a Lexile reader measure and a Lexile text measure is evaluated through comprehension assessments; "If the reader measure is greater than the text measure, the comprehension rate will exceed 75%. If the reader measure is less than the text measure, the comprehension rate will be less than 75%" (Stenner et al., 2006, p. 312). A difference of 250L between text difficulty and reader ability can result in a 50% comprehension rate, which can cause "confusion, frustration and feelings of inadequacy in most readers" (Smith, 2014b, p. 8). In contrast, "A reader with a measure of 600L who is given a text measured at 600L is expected to have a 75% comprehension rate" (Stenner et al., 2006, p. 311). Thus, a 75% comprehension rate is an indicator that a reader's ability, indicated by Lexile reader measure, aligns with the level of a text, i.e., the Lexile text measure (Stenner et al., 2006). Based on their work with Lexile measures, MetaMetrics (2021b) developed four-leveled performance standards in the Lexile metric for grades one through 12, referred to as College and Career Readiness Proficiency Ranges (CCR) by Achieve3000 and MetaMetrics (2020). Table 2 identifies Lexile measures by grade, categorized by levels according to "far below," "approaches," "meets," and "exceeds" (MetaMetrics, 2020). Students with a Lexile level of 0L or below are developing readers or beginning readers (BR) who require greater support to reach grade level expectations (MetaMetrics, 2021b).

Table 2

Four-level Performance Standards in the Lexile Metric (also Referred to as College and Career Readiness Proficiency Ranges)

	Not On Track		On Track	
Grade	Falls Far Below	Approaches	Meets	Exceeds
1	BR115 and Below	BR — 185L	190L — 530L	535L and Above
2	150L and Below	155L — 415L	420L – 650L	655L and Above
3	265L and Below	270L – 515L	520L – 820L	825L and Above
4	385L and Below	390L – 735L	740L – 940L	945L and Above
5	500L and Below	505L – 825L	830L – 1010L	1015L and Above
6	555L and Below	560L – 920L	925L – 1070L	1075L and Above
7	625L and Below	630L – 965L	970L – 1120L	1125L and Above
8	660L and Below	665L – 1005L	1010L – 1185L	1190L and Above
9	775L and Below	780L – 1045L	1050L – 1260L	1265L and Above
10	830L and Below	835L – 1075L	1080L – 1335L	1340L and Above
11/12	950L and Below	955L – 1180L	1185L – 1385L	1390L and Above

Note. Adapted from "Table 37: Revised A3K 4-Level Performance Standards in the Lexile Metric, Revised June 2012," by MetaMetrics, 2021b, September, 2021, *Achieve3000 LevelSet (Version 2): Development and Technical Guide* (5th ed.), p. 79, MetaMetrics, Inc; copyright 2021 by MetaMetrics, Inc.

According to Achieve3000 (2017c), sustained activity scores above 75% over time result in an increase to student Lexile measures. Consequently, "Achieve3000 recommends that students complete 40 or more reading activities per semester for the greatest Lexile growth" (MetaMetrics & Achieve3000, n.d., p. 1). Prior to August 2021, a Bayesian scoring algorithm was used to evaluate the monthly performance of students above 150L with at least four activities scores to determine if their performance merits a monthly Lexile adjustment (Achieve3000, 2017c). During the 2020-2021 school year, developing readers were not eligible for this monthly adjustment until they had attained 150L on any of the LevelSet assessments (Achieve3000, 2021). The monthly Lexile adjustment results are available in the platform on the first of each month from September through June of each school year. Due to the system's design and summer maintenance, in July through August, students are not eligible for the monthly Lexile adjustment (C. Pileggi, personal communication, May 28, 2021).

Petscher et al. (2020) stressed the importance of simultaneously teaching reading and content. Articles in Achieve3000 Literacy are predominantly nonfiction and cover a range of topics and subjects, offering the prospect of frequent reading opportunities and explicit instruction as suggested by Petscher et al. (2020). They can be sorted into article only, article and discussion, article and activity, or five-step articles. Articles with the five-steps include the before reading poll (a question to encourage activation of relevant prior knowledge), the article (provided at the students Lexile level for independent reading), the activity (comprehension multiple-choice assessment automatically graded by the system), the thought question (an open-ended essay question to be graded by the teacher) and the after reading poll (MetaMetrics, 2021b). Once students take the Achieve3000 Literacy pretest, the articles that teachers assign to their class is provided to students in platform at their individual Lexile level. Teachers were expected to provide a degree of direct instruction, feedback, scaffolding, and support. Achieve3000 offered one full day of professional development for each site that ordered Achieve3000 Literacy. Professional development included a variety of topics such as preparing for and responding to LevelSet data, planning for the five-step literacy routine, instructional strategies, motivating students, vocabulary development, close reading strategies, evidence-based writing, and Social and Emotional Learning and Literacy, to name a few. During the 2020-2021 school year, the nonprofit negotiated that the professional development hours from all sites using Achieve3000 Literacy be combined and spread out over the course of the year (S. Johnson, personal communication, June 1, 2020). Professional development was conducted via a video conferencing application for hosting meetings and webinars called Zoom (www.zoom.us) and all Achieve3000 Literacy teachers and principals were invited to attend the sessions. Table 3

provides a complete list of the professional development workshop topics offered to all Achieve3000 Literacy teachers within the nonprofit network during the 2020-2021 school year, though the role of these workshops was not evaluated in this study.

Table 3

List of Achieve3000 Literacy Professional Development Workshops Offered During the 2020-2021 School Year

#	Date	Workshop Title
1	8/12/20	Achieve Launch - Day 1
2	8/14/20	Achieve Launch - Day 2
3	8/19/20	Achieve for returning T.
4	8/21/20	Achieve for returning T.
5	8/26/20	Selecting Lessons in achieve
6	8/28/20	Selecting Lessons in achieve
7	9/5/20	Before, During and After: Interactive Strategies
8	9/8/20	Before, During and After: Interactive Strategies
9	9/11/20	Literacy across the content areas
10	9/18/20	Literacy across the content areas
11	9/23/20	Instructional Fidelity with Achieve 3000 Literacy 2020-2021
12	9/25/20	Instructional Fidelity with Achieve 3000 Literacy 2020-2021
#	Date	Workshop Title
13	10/2/20	Q&A
14	10/9/20	Planning the 5-step Literacy routine
15	10/16/20	Planning the 5-step Literacy routine
16	10/21/20	Motivation
17	10/23/20	Motivation
18	10/30/20	Accountability
19	11/6/20	Data 1.0
20	11/13/20	Data 2.0
21	11/18/20	Hosting Student Data Conversations & Connecting Parents in Achieve 3000 Literacy
22	12/4/20	Back to Basics (for newer staff)
23	12/11/20	Collaborative Conversations
24	1/13/21	Reading LevelSet Data (P1)
25	1/22/21	Responding to LevelSet Data (P2)

Table 3 (continued)

List of Achieve3000 Literacy Professional Development Workshops Offered During the 2020-2021 School Year

#	Date	Workshop Title
25	1/22/21	Responding to LevelSet Data (P2)
26	1/29/21	Strategic Solutions Part 1
27	2/5/21	Strategic Solutions Part 2
28	2/9/21	Using Prediction to Increase Student Engagement and Comprehension
29	2/19/21	Using Prediction to Increase Student Engagement and Comprehension
30	3/5/21	Close Reading using Point of Use Webb's DOK Questions
31	3/18/21	Evidence Based Writing
32	3/23/21	How to Create Meaningful Interactions with new Vocabulary Words
33	4/16/21	Social and Emotional Learning and Literacy
34	4/20/21	Preparing for LevelSet
35	4/30/21	Summer Advantage
36	5/7/21	Understanding Posttest LevelSet Data
37	5/28/21	Reflection, Evaluation and Plan for Moving Forward

Conclusion

The achievement gap first came to national attention with the publishing of *The Nation's Report Card* in 1969 (Boykin & Noguera, 2011; Jeynes, 2015; Wenglinsky, 2004). Determined to be a multifaceted and complex issue (Borrero & Bird, 2009; Johnson, 2002; Sanchez, 2008; Waldfogel, 2012; Wenglinsky, 2004), the gap has lifelong consequences, especially for children of low-income backgrounds (Burroughs-Lange & Douëtil, 2007; Jehangir et al., 2015; Palumbo & Sanacore, 2009; Paschall et al., 2018). While the federal government made efforts to close the gap through policy and funding (Klein, 2015; Paschall et al., 2018), it has continued to widen since the 1980s (Boykin & Noguera, 2011; Carter, 2018; Jeynes, 2015; Johnson, 2002; Paschall et al., 2018; Wenglinsky, 2004), and was further exacerbated in the context of COVID-19 (Dorn et al., 2020a).The severity and consequences of the achievement gap in literacy have been well

documented (Amendum et al., 2011; Edmonds et al., 2009; Murphy & Justice, 2019; Reardon et al., 2012; Smith, 2014a; Snow & Biancarosa, 2015; Snow & Matthews, 2016). Despite various literacy interventions, the gap has yet to be remedied (Amendum et al., 2011; Foster & Miller, 2007; Muhammad, 2015; Sanchez, 2008; Snow & Matthews, 2016). The case for technology as a vital instructional resource (Pierce & Cleary, 2016), a tool for differentiation (Taylor et al., 2020; Wilkes et al., 2020), and a solution for acceleration (Smith, 2014a) brought to the forefront two technology-based literacy interventions, Smarty Ants and Achieve3000 Literacy, used in nine Catholic schools partnering with a nonprofit to close the achievement gap. While Smarty Ants was utilized to enhance students' foundational literacy skills (Achieve3000, n.d.-a), Achieve3000 Literacy was adopted to strengthen student reading comprehension skill at or above grade level (Achieve3000, n.d.-c). The conceptual framework guiding this investigation into the relationship between student engagement in these programs and their reading outcomes was grounded in foundational literacy research. As research has contended, effective reading instruction is established through the development of robust foundational literacy skills, including phonemic awareness, phonics, fluency, vocabulary, and comprehension (Hattie, 2009; NICHD, 2019; Tompkins, 2017). Such a foundation augments the reader's ability to comprehend increasingly complex texts (Hattie, 2009; Tompkins, 2017). Providing student-centered opportunities to work with texts of increased complexity further enhances students' literacy competence (Smith, 2014a). The purpose of this study was to evaluate the relationship between student engagement in each of these programs and their reading performance outcomes, defined as posttest Lexile measures and Lexile growth measures in Achieve3000 Literacy. In doing so, this research adds to the literature, provide recommendations for future practice and study, and offers a potential

solution to illiteracy in the third grade that is built into the classroom model (Amendum et al., 2011) and integrates technology to accelerate literacy development beyond the third grade using increased text complexity, measurement, and benchmarks (Smith, 2014a).

CHAPTER 3

METHODOLOGY

Since the growing achievement gap between the academic performance outcomes of children of color as compared to their White counterparts first came into public view, efforts have been made on the part of federal, state, district, and school leaders as well as educators to remedy, if not resolve the achievement gap (Carter, 2018; Jehangir et al., 2015; Johnson, 2002; Paschall et al., 2018; Sanchez, 2008; Wenglinsky, 2004). The problem is highly complex and persists as an issue of fundamental justice and equity that has consequences for both individual children and entire communities, as well as the nation (Dorn et al., 2020b, Jeynes, 2015; Milner, 2013; Muhammad, 2015; Rojas-LeBouef & Slate, 2012; Ryan, 2006; Sanchez, 2008). While research on the achievement gap includes a variety of subjects, this study centered on the literacy gap in education. A review of the literature demonstrated a consensus that providing instruction in key elements of decoding skills, vocabulary and comprehension are pertinent to reading success (Hattie, 2009; Tompkins, 2017). Additionally, use of high-quality technology has ameliorated the challenge of tailoring instructional opportunities to the individualized needs of students to effectively address academic areas for growth (Wilkes et al., 2020). Of the two interventions in this study, one aimed to establish student mastery of foundational literacy skills, while the other emphasized reading comprehension to enhance students' literacy competence. The purpose of this research was to evaluate the relationship between engagement in two literacy interventions and the reading performance of third-grade students at multiple low-income Catholic schools according to student Lexile measures from the 2020-2021 school year. This research employed a quasi-experimental group pretest-posttest design, which controls for

individual differences on the assessments (Mills & Gay, 2019). Several analyses of covariance (ANCOVAs) were used to evaluate the relationship between engagement in the interventions and student reading performance according to Lexile measures from the 2020-2021 academic year. The conceptual framework guiding this study (see Figure 1) was rooted in the research establishing that strong foundational literacy skills enhances a student's capacity for reading comprehension of varied texts with increasing complexity (Amendum et al., 2011; Hattie, 2009; Smith, 2014a, 2014b; Tompkins, 2017). Thus, it would follow that ensuring student mastery of these skills while also receiving continuous opportunities to enhance their reading comprehension skills would increase reading capacity and performance. Based on these findings, the researcher presumed a correlation between mastery of foundational literacy skills, reading comprehension, and literacy advancement evaluated according to student Lexile measures. This research study responded to the following questions:

1. To what extent does high or low student engagement in Smarty Ants, as defined by the number of levels completed, affect Lexile measures in Achieve3000 Literacy?
2. To what extent does high or low student engagement in Achieve3000 Literacy, as defined by the number of program criteria completed, affect Lexile measures in Achieve3000 Literacy?
3. To what extent does high or low student engagement in both Smarty Ants and Achieve3000 Literacy affect Lexile measures in Achieve3000 Literacy?

Methodology

The purpose of this study was to evaluate the degree to which third-grade student Lexile measures are affected by their engagement in Smarty Ants and Achieve3000 Literacy

during the 2020-2021 school year. The focal population for this study was identified through purposeful convenient sampling and included the archived performance records of 241 third-grade students from nine Catholic elementary schools partnering with the same nonprofit. Leaders at the nine sites chose to use Smarty Ants and Achieve3000 Literacy as the literacy interventions for third graders during the 2020-2021 school year. As both Smarty Ants and Achieve3000 Literacy provide initial, midpoint, and final benchmark assessments, this quantitative study employed a research design known as the one-group pretest-posttest design. In a pretest-posttest control group design participants are randomized and only one group receives a treatment (Mills & Gay, 2019). This study was not a control group design; it was quasi-experimental in nature as subjects were not randomly assigned (Leavy, 2017). The pretest-posttest design controls for individual assessment differences as gains are relative to individual performance (Mills & Gay, 2019). According to Leavy (2017), differences between the pretest and posttest in the one-group pretest-posttest design are credited to the intervention. The Achieve3000 Literacy pretest was administered to students at each site as well as the treatment (engagement in Smarty Ants and Achieve3000 Literacy), followed by the Achieve3000 Literacy posttest. Archived data for third-grade students from nine schools who participated in the two literacy interventions during the 2020-2021 school year were used in this research. None of the data for Smarty Ants or Achieve3000 Literacy were manually entered by teachers. Rather, both programs gathered student performance data based on their participation in the program. This reduced any human error associated with manual reporting. The metrics available in each of the literacy interventions discussed provided ratio and interval data used for quantitative analysis in this research.

This study engaged statistical analysis to understand the relationship between student engagement in Smarty Ants and summative Lexile measures from Achieve30000 Literacy, in addition to the relationship between student engagement in Achieve30000 Literacy and summative Lexile measures as well as the relationship between combined student engagement and summative Lexile measures from Achieve30000 Literacy. Paired samples tests (*t*-tests) were used to determine if the Means of variables used to respond to each research question were statistically significant at an alpha level of 0.05. As a casual-comparative technique was required, such a technique needed to ensure control for any variation resulting from the initial assessment scores (Mills & Gay, 2019). While the analysis of variance (ANOVA) investigates "significant differences among the scores" of multiple groups, the analysis of covariance (ANCOVA) controls for "initial group differences on variables used" (Mills & Gay, 2019, p. 255). Thus, the ANCOVA was used in this study to further control for the initial group differences on the pretest. The Lexile measures generated from the Achieve3000 Literacy pretest were established as the covariate in this study to remove any advantage high performing students may have had over lower performing students on the initial performance assessment. Student Achieve3000 Literacy posttest Lexile measures as well as Lexile growth measures served as dependent variables in the analysis. For each ANCOVA, the null hypothesis was tested with the standard measurement of error at an alpha level of 0.05. In situations where the treatment effect, engagement in either or both programs (Smarty Ants and Achieve3000 Literacy), was significant, the null hypothesis was rejected (Becker, 2000). An *R* squared correlation and an *F*-tests for Heteroskedasticity were included in each ANCOVA conducted.

The three benchmark assessment results for Smarty Ants were used to determine the students' engagement level in the program. This nominal data was used as an independent variable in the analysis. Similarly, the Achieve3000 Literacy data was used to establish criteria for the engagement level (nominal data) assigned to each user. The statistical analysis software program designed by IBM, SPSS Statistical Software version 27 (SPSS), was used to generate descriptive data, create *Z* scores, and conduct the statistical analysis required to answer the research questions. Further details on this process are discussed in the data collection and data analysis sections of this chapter.

Participants

The third-grade level was specifically selected as the focus of this study for three reasons. First, the instructional design of American education has designated that the primary grades of preschool through second grade focus teaching children to read through the development of foundational literacy skills, while the curriculum in third grade and beyond is directed toward advanced comprehension of text (Chall, 1983, as cited in Snow & Biancarosa, 2003; Petscher et al., 2020; Reardon et al., 2012). Second, by the third grade, students must independently read material at their grade level with success as students in high-poverty areas tend to fall behind their wealthier counterparts in their reading scores by the fourth grade (Pfost et al., 2014). Thus, research has suggested that third-grade academic performance is a predictor of later success (Murphy & Justice, 2019; Snow & Matthews, 2016). Lastly, students in the third grade have demonstrated the largest literacy gap at the participant school sites within the past three years (S. Johnson, personal communication, June 1, 2020).

During this study, the researcher was a consultant working with a nonprofit committed to supporting the vision of low-income Catholic elementary school principals in providing a high-quality whole child education to close the achievement gap. To this end, the nonprofit supported schools in curriculum adoption of such literacy interventions as Smarty Ants and Achieve3000 Literacy. The researcher supported schools with program implementation through consultation, coaching in data analysis, and management of cloud-based programs. Thus, as the researcher had access to programmatic data of all in-network school partners, participants were selected from the pool of partner schools through purposeful convenient sampling. In the spring school principals in the nonprofit network selected the programs to implement at their site based on their vision, goals, and staff capacity. Of the school sites partnering with the nonprofit during the 2020-2021 school year, the site leaders of nine schools chose to use both Smarty Ants and Achieve3000 Literacy in the third grade. As these sites all had the combined intervention tools, they were selected as the focus of this study. The combined third-grade enrollment for each of these nine schools was 241. Though class demographic information on race, socioeconomic status (SES), special education status, or English learner status were not available for this study, the nonprofit collected school-wide percentages of students receiving Free and Reduced Lunch (FRL). Table 4 provides the FRL population by school. While most schools in this study served populations with a minimum of 75% FRL, one school included in the study was unique among sites as it had a population of only 39% FRL. This school was still included due to the small sample size. In addition to the schoolwide information, the gender demographic of students was available by school (see Table 5).

Table 4

2020-2021 Percentage of Free and Reduced Lunch by School

School A	School B	School C	School D	School E	School F	School G	School H	School I
84%	75%	85%	89%	89%	87%	39%	75%	81%

Table 5

*2020-2021 Third-Grade Enrollment and Gender Demographics by School (*N = *241)*

	School A	School B	School C	School D	School E	School F	School G	School H	School I	Total
Male	17	12	10	10	11	7	23	9	12	111
Female	13	11	15	11	17	13	22	19	9	130
Total	30	22	25	21	28	20	45	28	21	241

Data Collection

Data for both Smarty Ants and Achieve3000 Literacy targeted student progress over the course of one year, allowing the researcher to analyze multiple data points in third-grade student results from the 2020-2021 school year. The data generated from these instruments were automatically documented by the programs as both are cloud-based. The data from programs were downloaded stored as Microsoft Excel files in the nonprofit's archives. As the owner of these archives the nonprofit granted the researcher permission to download the archived performance data corresponding to third-grade students in both programs from August 2020 to June 2021 for the purpose of this study. Information from various spreadsheets was consolidated onto one file. To remove identifying information and ensure confidentiality, the letters A through I were randomly assigned to each school in place of the school's name and used to display demographic information in Table 4 and Table 5. The personal identifying information in the data included student names, unique student identification (UID), and gender. Student names

were removed and unique student identifiers from the nonprofit's system were used to ensure that data sets aligned for each participant as they were consolidated into one file. Once completed, a unique code was assigned to each individual data set to maintain the integrity of individual data sets and maintain confidentiality, then all student UIDs were deleted. The file was saved on a password-protected external drive only accessible to the researcher. An additional tab in the file was created with the key variables for the statistical analysis, which was imported into SPSS and saved as an SPSS statistics data file.

The Smarty Ants data gathered for the purpose of this research included four measures for all schools: lesson placement at the end of the academic year, pretest placement level (fall of 2020), interim test placement level (January 2020), and posttest placement level (May 2020). The Smarty Ants program levels range from 1 to 18 (Achieve3000, n.d.-a). Student data generated on placement levels were treated as ordinal data. Some cells in the data did not have numerical values, but specific terms of "in progress," "no data," or "not yet started" (found within the three columns for each of the assessments), and "completed" (present in all four columns). The number 19 was assigned as a code for "completed" while the remaining terms were removed, and their corresponding cells left empty since a 0 would indicate a measure of data when there was no data to measure. Two participant sites had no data available for Smarty Ants, indicating that while the sites had third-grade students rostered in the program, it was not used during the 2020-2021 school year. In the archived data file one site only had the students current lesson level, which included the code for completion, but no assessment data for any of the benchmark assessment windows.

Engagement levels in Smarty Ants were required to answer the first research question. As there was no formal quantifiable data or report on evaluating student engagement, the researcher selected two categories (high engagement and low engagement) and assigned a categorical score for each. To determine the criteria for engagement, the researcher considered three things: the program's purpose, the student goal in the program, and the critical nature of literacy in the third grade communicated in the literature. Smarty Ants was designed to foster skill development in foundational literacy for prekindergarten through second grade students (Achieve3000, n.d.-a). The goal set for all third graders during the 2020-2021 school year was end of academic year, meaning that students were expected to complete the program by then. The researcher also considered the literature on foundational literacy development as an expectation prior to the third grade (Snow & Biancarosa, 2003), research on the impact of illiteracy in the third grade on the achievement gap (Murphy & Justice, 2019; Paschall et al., 2018; Pfost et al., 2014), and the urgency for addressing this issue of social justice in education (Burroughs-Lange & Douëtil, 2007; Jehangir et al., 2015; Muhammad, 2015; Palumbo & Sanacore, 2009; Paschall et al., 2018). As a result, engagement in Smarty Ants was evaluated according to program completion; a high engagement level (a categorical value of 1) was assigned to each student who completed the program at any point during the school year, while a low engagement level (a categorical value of 0) was set for each student who did not complete the program by the end of the year. The results of data collection and greater detail regarding assigned engagement levels in Smarty Ants are presented in Chapter 4.

Engagement levels in Achieve3000 Literacy were required to answer the second research question. Data were evaluated to determine criteria for engagement. The Achieve3000 Literacy

data retrieved included benchmark assessment data (pretest, interim test, and posttest Lexile measures), monthly Lexile adjustment results; monthly and aggregate number of (reading comprehension) activities completed; monthly and aggregate number of (reading comprehension) activities with a score at or above 75%; monthly and aggregate number of (reading comprehension) activities with a score below 75%; monthly and summative average (reading comprehension) activity score, and Lexile growth measures. Using this information and research on Achieve3000 Literacy, the researcher established six criteria for categorizing student engagement, identified in Table 6. Since MetaMetrics and Achieve3000 Literacy (n.d.) asserted that students who completed 40 lessons with a score of 75% or above in one school year demonstrate one year of growth in reading, this was set as a baseline criterion. Based on these findings, it was assumed that if students double the number of activities with a score of 75% or higher, they should demonstrate twice the Lexile growth. Consequently, 80 or more total activities within a year was established as the second criterion in Table 6 as a measure of student reading engagement in the program. Criterion number three was determined to be an average activity score of 66%, intended to include scores just above and below the 75% comprehension rate. If students above a 150L complete four activities with a first try score of 75% or higher within a month they could quality for a monthly Lexile adjustment calculated through a Bayesian algorithm (Achieve3000, 2017c). Students demonstrating any degree of increase in their monthly Lexile adjustment over time were considered to demonstrate a "Lexile increase over time" as established in criterion number four. Criterion number five was set to designate student growth from the Achieve3000 Literacy pretest to the interim assessment and/or the posttest as an indicator of engagement. Finally, according to MetaMetrics (2021b), the "on track" Lexile

range for the third grade is between 520L and 820L. As a result, a 520L was used as a minimum benchmark for the third-grade reading level in this study. Participant data demonstrating three or more of the six criteria were assigned a high engagement level (a categorical value of 1), while student data with less than three criteria were assigned a low engagement level (a categorical value of 0). The results of this review and subsequent assignment of Achieve3000 Literacy engagement levels are presented in Chapter 4.

Table 6

Criteria and Engagement Levels for Achieve3000 Literacy

Achive3000 Literacy Data	Engagement Criteria
1. Number of activities at above 75%	40 or more
2. Total number of activities completed	80 or more
3. Average activity score	At or above 66%
4. Monthly Lexile adjustment	Lexile increase over time
5. Pretest, interim test, and posttest Lexile measures	Lexile increase in 50% of the results
6. Posttest Lexile within College and Career Readiness range	At or above 520L

Note. High engagement was assigned to students who met three or more criteria and low engagement to those who met less than three criteria.

According to Becker (2000), individual pretest differences are controlled with a gain score because the calculation is a relative measure of the individual's scores. For the first two questions, the researcher utilized Lexile growth as an outcome (DV) rather than calculating a gain score, defined as an evaluation of differences in scores (Becker, 2000). While a gain score was simply calculated by subtracting students' pretest Lexile measures from their posttest Lexile measures, doing so yielded different results than the growth score generated in Achieve3000 Literacy. Lexile growth in Achieve3000 Literacy is calculation of the student's progress from the pretest to the final Lexile reader measure of the year, i.e., the Lexile from the last available benchmark assessment or the last monthly Lexile adjustment (Achieve3000, n.d.-c). Based on

the student data, some Lexile measures were adjusted in the month after the Achieve3000 Literacy posttest, while some students did not complete this posttest. For this reason, the Lexile growth measure was a more accurate calculation of actual participant growth as compared to a manual gain score calculation of the difference between Achieve3000 Literacy pretest and posttest scores. Posttest Lexile measures and Lexile growth measures were identified as dependent variables by which to evaluate progress in response to the first two questions. The third question addressed the effect of combined engagement in both Smarty Ants and Achieve3000 Literacy on reading comprehension. As a result, a gain score was calculated for this question, in addition to a combined posttest score, and a combined engagement score. The details of these calculations are presented in the following section along with the processes by which data were analyzed in this study.

Data Analysis

A Microsoft Excel file containing several variables was imported to SPSS. Included were the student code set as string data, in addition to student gender, the only demographic data available for students set as categorical data of numeric type with a nominal measure. These variables were not used in the statistical analysis. The Smarty Ants data uploaded to SPSS included engagement levels (categorical values assigned a numeric type and an input role) as well as pretest, interim, and posttest placement levels (scale data assigned a numeric type and an input role). The benchmark data for Smarty Ants was used to generate frequency data in SPSS, though they were not used in the statistical analysis conducted in response to the research questions. The Achieve3000 Literacy data imported to SPSS included engagement levels, Lexile growth measures, and pretest, interim, and posttest Lexile measures. Each of these variables

were set as scale data and assigned a numeric type in SPSS. A measure of nominal and an input role were assigned to the variables for both Smarty Ants and Achieve3000 Literacy engagement levels. The Achieve3000 Literacy pretest, posttest, and growth variables were identified as scale data with an input role. As the dependent variables in this study, the Achieve3000 Literacy posttest Lexile measures and Lexile growth measures were assigned the target role. To evaluate the distribution of data, histograms were generated on each of the continuous (scale) variables. The results of these frequency distributions for pretest, posttest and Lexile growth are presented in Chapter 4.

Descriptive statistics were generated on the Achieve3000 Literacy pretest, interim test, posttest, and Lexile growth variables and the new variables were saved to standardize the scores by creating a *Z* score. *Z* scores were useful as they allow comparisons between tests (Kurpius & Stafford, 2006). The Achieve3000 Literacy interim test was not used in the analysis as the research was directed by a pretest-posttest design. The file was split by Smarty Ants engagement levels then according to Achieve3000 Literacy engagement levels. Each time, descriptive statistics of the *Z* scores for the Achieve3000 Literacy pretest, posttest, and Lexile growth variables were generated to review differences among the engagement level groups. The file split was then removed to analyze all cases for the next step of evaluation. A description of the statistical analyses conducted for each research question is provided by question in the ensuing section.

Overview of Statistical Analysis by Research Question

The first research question investigated the relationship between Smarty Ants engagement and Lexile outcomes, defined as Achieve3000 Literacy posttest Lexile measures and

Lexile growth measures. To first assess the relationship between Smarty Ants engagement and Lexile measures, the SPSS file was split by Smarty Ants engagement levels and paired samples tests (*t*-tests) were conducted to determine if the Means of each set of variables used to respond to the research question were statistically significant at an alpha level of 0.05. The first set of variables compared were the *Z* scores for the Achieve3000 Literacy pretest and posttest. The second set of variables compared were the *Z* scores for the Achieve3000 Literacy pretest and Lexile growth measures. Following the *t*-tests, an ANCOVA was generated with the Smarty Ants engagement level as the independent variable, the *Z* score for Achieve3000 Literacy posttest Lexile measures as the dependent variable, and the *Z* score for the Achieve3000 Literacy pretest Lexile measures as the covariate. To evaluate the relationship between Smarty Ants engagement and Lexile growth, another ANCOVA was conducted with same covariate and independent variable used in the previous analysis, while the *Z* score for Achieve3000 Literacy posttest Lexile measures was removed as the dependent variable and replaced with the *Z* score for Achieve3000 Literacy Lexile growth measures. An *R* squared correlation and an *F*-test for Heteroskedasticity were also included in each ANCOVA.

The second research question investigated the relationship between Achieve3000 Literacy engagement and Lexile outcomes, defined as posttest Lexile measures and Lexile growth measures. As with the previous research question, the statistical analysis began with an assessment of the relationships between each pair of variables. The SPSS file was split by Achieve3000 Literacy engagement levels and paired samples tests (*t*-tests) were conducted on the *Z* scores for Achieve3000 Literacy pretest and posttests, followed by the *Z* scores for Achieve3000 Literacy pretest and Lexile growth measures. To evaluate the relationship between

Achieve3000 Literacy engagement and Achieve3000 Literacy posttest Lexile measures, an ANCOVA was generated with the Achieve3000 Literacy engagement levels as the independent variable, the *Z* score for Achieve3000 Literacy posttest Lexile measures as the dependent variable, and the *Z* score for the Achieve3000 Literacy pretest Lexile measures as the covariate. To evaluate the relationship between Achieve3000 Literacy engagement and Achieve3000 Literacy Lexile growth, a similar ANCOVA was conducted with the same independent variable and covariate, however, the *Z* score for Achieve3000 Literacy posttest Lexile measures was exchanged for the *Z* score for Achieve3000 Literacy Lexile growth as the dependent variable. Each ANCOVA also included an *R* squared correlation and an *F*-test for Heteroskedasticity.

The third research question examined the combined effect of engagement in Smarty Ants and Achive3000 Literacy on Lexile outcomes. To account for the relationship between both Smarty Ants and Achieve3000 Literacy and the overall outcomes of both programs, new variables were required. A combined engagement variable was established for students with high engagement in both Smarty Ants and Achieve3000 Literacy and for students with high engagement in either program. A posttest variable was calculated a by adding the Smarty Ants posttest placement levels to the Achieve3000 Literacy posttest Lexile measures. Rather than subtracting the pretest from the posttest to calculate a gain score (Becker, 2000), the calculated gain score was generated for each participant by adding the Achieve3000 Literacy pretest and posttest Lexile measures and dividing the results by two. Each variable was calculated in Microsoft Excel to ensure the accuracy of calculations and that data aligned by participant. The file was then transferred to SPSS. Greater detail about the creation of variables is discussed in Chapter 4. To conduct the analysis in response to the third research question, descriptive

statistics were generated on each variable and saved to create a *Z* score. The *Z* score standardized the data to allow comparisons between variables (Kurpius & Stafford, 2006). As with the previous questions, the file was split by combined engagement level and paired samples tests (*t*-tests) were created to determine if the Means of the Achieve3000 Literacy pretest and combined posttest scores, and the Means of the Achieve3000 Literacy pretest and calculated gain scores were statistically significant at an alpha level of 0.05. An ANCOVA was then conducted using the combined engagement levels as the independent variable, the *Z* score for combined posttest scores as the dependent variable, and the *Z* score for Achieve3000 Literacy pretest Lexile measures as the covariate. A subsequent ANCOVA was generated using the same independent variable and covariate, while the *Z* score for the calculated gain score was identified as the dependent variable. Again, an *R* squared correlation and an *F*-test for Heteroskedasticity were included with each ANCOVA.

Conclusion

The achievement gap in education has proven multifaceted, persistent, and complex (Dorn et al., 2020b; Jeynes, 2015; Muhammad, 2015; Rojas-LeBouef & Slate, 2012; Sanchez, 2008). The third grade has been established as a critical year for student literacy (Snow & Matthews, 2016). By the third grade, students must effectively read for comprehension (Reardon et al., 2012) or risk falling behind their counter parts (Murphy & Justice, 2019; Paschall et al., 2018; Pfost et al., 2014; The Nation's Report Card, 2019), which has resulted in grave, life-long consequences, especially for children of low SES backgrounds (Burroughs-Lange & Douëtil, 2007; Jehangir et al., 2015; Palumbo & Sanacore, 2009; Paschall et al., 2018), as well as for the larger society (Dorn et al., 2020a; Partanen et al., 2019; Reardon et al., 2012).

This research evoked social justice by investigating a potential solution to the achievement gap in literacy. This study sought to understand the extent to which engagement in two concurrent literacy interventions impacts literacy development, as evaluated by the Lexile measures of third-grade students at nine low-income Catholic schools. Research accentuated the role of five areas of literacy, which are equally important in reading development (Amendum et al., 2011; Hattie, 2009; NICHD, 2019; Tompkins, 2017). Drawing from this literature, the conceptual framework in this study (see Figure 1) was developed to guide this examination of early literacy and reading comprehension by evaluating the relationship between student engagement in literacy interventions and reading performance. Participants were gathered through purposeful convenient sampling. Archived 2020-2021 student performance data from Smarty Ants and Achieve3000 Literacy were gathered, coded, and statistically analyzed to identify the relationship between student engagement and performance outcomes.

The maturation, testing, and instrumentation threats to internal validity were fairly controlled as participants were in the same grade level, and assessed with cloud-based, fixed instruments within the same time frames. While the historic threat to validity was controlled to the extent that all students experienced a shift due to a state-wide response to the pandemic, this study did not account for the individual experiences or the factors impacting student engagement due to the historic event. As a result, this research identified three major limitations: the small sample size, the impact of the learning context during the 2021-2022 school year, and the role of the teacher on student engagement. In addition, the research included qualitative delimitations regarding the scope of research focusing on quantitative aspects rather than including the voice of students or teachers, or the elements impacting student engagement and the achievement gap,

such as role of the teacher, teacher capacity, and program implementation and training. As literacy research clearly articulated a connection between foundational literacy skills and reding comprehension (see Figure 1), the researcher assumed that a relationship existed between engagement in the interventions and performance data. The findings of this research are discussed in Chapter 4.

CHAPTER 4

RESULTS

The achievement gap in education is often defined as the variation between performance outcomes of students of color as compared to their White counterparts (Boykin & Noguera, 2011; Rojas-LeBouef & Slate, 2012; Teale et al., 2007). Researchers have attempted to determine sources of the gap to conclude that the problem is multifaceted and likely resulting from a convergence of factors (Jeynes, 2015; Muhammad, 2015; Sanchez, 2008.). Efforts to close the achievement gap have been predominantly government or school based (Jeynes, 2015). Despite such determinations, the gap has persisted through the decades (Boykin & Noguera, 2011; Carter, 2018; Jeynes, 2015; Johnson, 2002; Paschall et al., 2018; Wenglinsky, 2004) and has been further exacerbated by the impact of COVID-19 (Dorn et al., 2020a, 2020b). While the literature characterized the achievement gap according to race and/or SES, this study concentrated on the achievement gap in literacy as the disparity between students' actual and expected reading performance (Lexile measures) according to MetaMetrics (2021b) Lexile Framework for Reading. Grounded in the literature and the conceptual framework established to illustrate the role of foundational literacy in reading development, this study evaluated the relationship between student engagement in two literacy interventions, Smarty Ants and Achieve3000 Literacy, and reading outcomes, defined as posttest Lexile measures and Lexile growth measures. To this end, this study addressed the following research questions:

1. To what extent does high or low student engagement in Smarty Ants, as defined by the number of levels completed, affect Lexile measures in Achieve3000 Literacy?

2. To what extent does high or low student engagement in Achieve3000 Literacy, as defined by the number of program criteria completed, affect Lexile measures in Achieve3000 Literacy?
3. To what extent does high or low student engagement in both Smarty Ants and Achieve3000 Literacy affect Lexile measures in Achieve3000 Literacy?

In response to these questions, this quantitative study employed a quasi-experimental pretest-posttest design. This chapter provides the results of the data collection and subsequent statistical procedures in this study. Included are an explanation of the data gathered, the distribution of data used to establish engagement levels for Smarty Ants and Achieve3000 literacy, as well as the descriptive statistics for each set of data. The results of statistical analyses conducted in the research process are organized in this chapter according to each research question in this study. The findings of each *t*-test and ANCOVA conducted demonstrated statistical significance in the relationship between engagement in the literacy interventions and reading outcomes and are further discussed in Chapter 5.

Engagement Levels in Smarty Ants and Achieve3000 Literacy

With permission from the nonprofit, the archived 2020-2021Smarty Ants and Achieve3000 Literacy data of 241 third-grade students across nine Catholic elementary schools were downloaded and consolidated into a Microsoft Excel spreadsheet. To answer the first two research questions, the data were evaluated, and tabulated before Smarty Ants and Achieve3000 Literacy engagement levels were assigned to each participant's data set. Of the 241 students in this study, only 79.7% (n =192) had any type of data for Smarty Ants, indicating that 20.3% of students (n = 49) did not receive this treatment. As this study did not investigate qualitative

aspects of student engagement, there was no information to clarify why students did not receive the treatment. Data generated from Smarty Ants records included students' lesson and level placement at the end of the year, in addition to pretest, interim, and posttest placement levels. Smarty Ants program levels are grouped by grade level from prekindergarten to second grade (Achieve3000, n.d.-c). Table 7 displays the results of student Smarty Ants placement levels within each assessment period. Benchmark assessment data were missing for some students (n = 45) due to an error in the nonprofit's archived file. Another group of students (n =10) did not have any benchmark assessment data in their data set, though their peers at the same site did. Due to the quantitative nature of this study, information was not gathered to explain why these 10 students were missing data. Despite missing Smarty Ants benchmark assessment data, lesson progress data were available for these students (n = 55). As they were missing benchmark assessment data, these students along with the 45 students who did not receive the treatment (n = 104) are not accounted for in Table 7. Hence, although there were 192 students who used Smarty Ants during the 2020-2021 school year, 104 students were missing all Smarty Ants benchmark assessment data, and only 137 students were accounted for in Table 7. In addition, of the students who had benchmark assessment data, some students only completed one or two of the three benchmark assessments, as indicated in Table 7.

Table 7

Student Placement Levels on the Smarty Ants Benchmark Assessments (N = *137)*

	Pretest (*n = 135)*		Interim Test (*n* = 106)		Posttest (*n* = 115)	
Grade (Placement Levels)	*n*	%	*n*	%	*n*	%
PK (Levels 1 & 2)	0	0%	0	0%	0	0%
K (Levels 3-6)	3	2.2%	1	0.9%	0	0%
1 (Levels 7-11)	83	61.5%	25	23.6%	23	20.0%
2 (Levels 12-18)	49	36.3%	24	22.6%	33	28.7%
Completed the Program	0	0	56	52.8%	59	51.3%
Missing Assessment Data [a]	2	1.5%	31	29.2%	22	19.1%

Note. Of the students included in this study (*N = 241)*, some were missing benchmark assessment data (*n* = 104). According to the data, some students did not receive the treatment (*n* = 49), some did not have the data though their classmates did (*n* = 10), and some did not have data due to an error in recordkeeping (*n* = 45). Percentages do not add to 100 due to rounding.

[a] Accounts for students who only had data for one or two of the benchmark assessments.

Of the students with assessment data represented in Table 7 (*n* =137), the majority placed at a first (61.5%, *n* = 83) or second-grade level (36.3%, *n* = 49) on the Smarty Ants initial benchmark assessment. Although fewer students completed the interim assessment (77.4%, *n* = 106), 52.8% of the students assessed (*n* = 56) concluded the program by this benchmark in January 2021. Of the students who completed the Smarty Ants posttest, the number of students who finished the program by the final benchmark increased by three (51.3 %, *n* = 59), this suggested minimal change. In addition, 28.7% (*n* = 33) ended the school year at a second-grade level, as compared to 20.0% (*n* = 23) who placed at first grade level. While more students completed the Smarty Ants posttest benchmark assessment, 16.1% of students (*n* = 22) with benchmark assessment data were missing posttest data. Despite the missing posttest data, results showed overall performance improvement from the Smarty Ants pretest to the posttest.

The goal for all third-grade students in Smarty Ants was to complete the program by the end of the 2020-2021 school year. Engagement levels were determined by whether students had

met this goal. The placement data from the Smarty Ants benchmark assessments were used to evaluate the engagement level for students with this data (n = 137). The data identifying students' current lesson placement at the end of the year were reviewed for students who received the treatment and were missing all benchmark assessment data (n = 55) to determine whether they completed the program. This information was used to assign a Smarty Ants engagement level to these students. Of the 192 students with Smarty Ants data, 38.5% (n = 74) qualified for high engagement as they completed Smarty Ants, while 61.5% of students (n = 118) did not complete the program and received a low engagement level. The engagement levels for Smarty Ants are presented with the engagement levels for Achieve3000 Literacy in Table 8.

Table 8

*Engagement Level Results for Smarty Ants and Achieve3000 Literacy by Program (*N = *241)*

Engagement Levels	Smarty Ants		Achieve3000 Literacy	
	Criteria	*n*	Criteria	*n*
High engagement	Completed Smarty Ants	74	Met 3 or more criteria	84
Low engagement	Did not complete Smarty Ants	118	Met less than 3 criteria	157
No engagement level	No data available to establish engagement level	49	n/a	0

Note. See Table 6 for Achieve3000 Literacy engagement criteria.

Levels of engagement for Achieve3000 Literacy were evaluated based on six criteria rooted in Achieve3000 research and available data retrieved from the archived files (see Table 6). High engagement was assigned to students who met three of the six criteria, while low engagement was assigned to students who met less than three criteria. The details of this process are explained in Chapter 3. The results of engagement level assignment provided in Table 9 show that 32.0% of students (n = 76) met one criterion, while 24.1% met two criteria (n = 58). In

addition, the number of students meeting an increased number of criteria decreased as the number of criteria increased. The assignment of engagement levels for Achieve3000 Literacy, represented in Table 8, indicate that 34.9% of students attained a high engagement level (n = 84) and the data for 65.1% of students merited a low engagement level (n = 157).

Table 9

*Results of Evaluating Students Data Against Criteria to Assign Engagement Levels in Achieve3000 Literacy (*N = *241)*

	Number of Achieve3000 Literacy Engagement Criteria Met						
	0	1	2	3	4	5	6
n	24	76	58	25	21	20	17
%	10.0%	32.0%	24.1%	10.4%	9.0%	8.3%	7.1%

Note. Percentages do not add to 100 due to rounding.

The third research question asked about the relationship between engagement in both literacy programs and Lexile outcomes. A review of individual student data revealed that not all students with high engagement in Smarty Ants had a corresponding high engagement level in Achieve3000 Literacy. The distribution of student engagement levels for each program as well as the engagement levels for both programs are available in Table 10. According to this distribution, 15.4% of students (n = 37) were assigned high engagement levels in both Smarty Ants and Achieve3000 Literacy, and 34.4% of students (n = 83) received high engagement levels for one of the two programs. In addition, 34.0% of students (n = 82) merited a low engagement level for both Smarty Ants and Achieve3000 Literacy, while 16.2% of students (n = 39) demonstrated low engagement in Achieve3000 Literacy alone. Of the 241 students, 20.3% (n = 49) did not have data for Smarty Ants and could not be assigned a corresponding engagement level. Of these students, 10 merited high engagement in Achieve3000 Literacy and were

included in that category. The individual groups resulting from this analysis were too small and too many to warrant effective statistical analysis, so additional procedures were required for further analysis. Further detail regarding these procedures is provided in the section Results for Research Question 3.

Table 10

*Distribution of Combined and Individual Program Engagement Levels for Smarty Ants and Achieve3000 Literacy (*N = *241)*

Engagement Level by Program	*n*
High engagement in both Smarty Ants and Achieve3000 Literacy	37
High engagement in Smarty Ants only	36
High engagement in Achieve3000 Literacy only [a]	47
Low engagement in both Smarty Ants and Achieve3000 Literacy	82
Low engagement in Achieve3000 Literacy [b]	39

Note. 49 students did not have Smarty Ants data and could not be assigned an engagement level.
[a] Includes the 10 students who did not have a Smarty Ants engagement level and had a high engagement level in Achieve3000 Literacy.
[b] Accounts for the students who did not have a Smarty Ants engagement level and had a low engagement level in Achieve3000 Literacy.

Results of Statistical Analysis

The Achieve3000 Literacy data retrieved for this program included pretest, interim, and posttest Lexile measures. Descriptive statistics were generated for these items and the new variables were saved to create *Z* scores, thereby standardizing the scores. The interim results in this study were only used for descriptive purposes as this study employs a pretest-posttest design. While Achieve3000 Literacy pretest Lexile measures and Lexile growth measures were present for all students in the sample, 240 students completed the interim test and only 94.2% of students (*n* =227) had a posttest Lexile measure in their dataset. Archived records were reviewed to confirm that the data generated represented third-grade students who were enrolled during the 2020-2021 school year. This verified that any missing Achieve3000 Literacy posttest data was not due to student withdrawal from a site during the academic year.

Histograms were generated to evaluate the frequency and distribution of student pretest and posttest scores for Smarty Ants and Achieve3000 Literacy as well as Lexile growth measures in Achieve3000 Literacy. While the figures for frequency distributions of Smarty Ants placement levels were not included in this paper, Table 7 provides a relative distribution of students' benchmark placement levels in Smarty Ants. Figure 2 displays a normal curve in the frequency distributions of students' Achieve3000 Literacy pretest Lexile measures ranging from -270L to 880L. Figure 3 shows the frequency distributions of students' Achieve3000 Literacy posttest Lexile measures, ranging from-145L to 1120L. Figure 4 illustrates the frequency distribution of students' Achieve3000 Literacy Lexile growth measures ranging from -205L to 570L.

Figure 2

Frequency Distribution of Students' Achieve3000 Literacy Pretest Lexile Measures

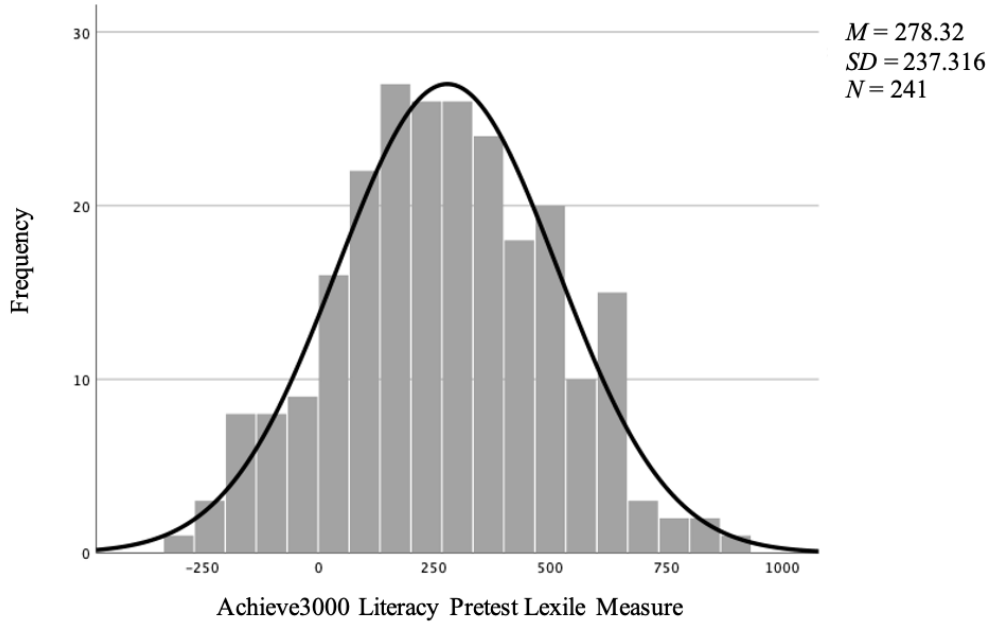


Figure 3

Frequency Distribution of Students' Achieve3000 Literacy Posttest Lexile Measures

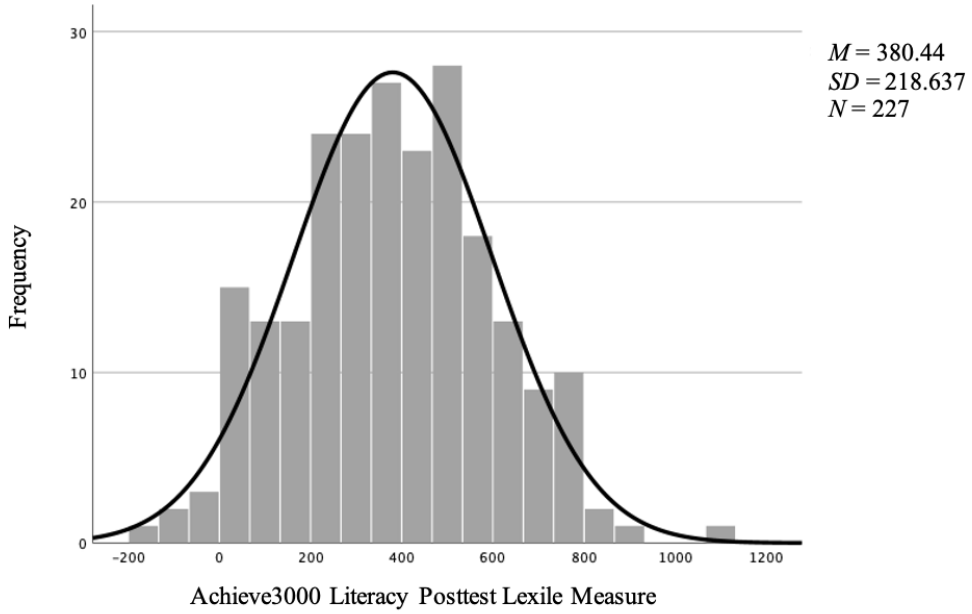
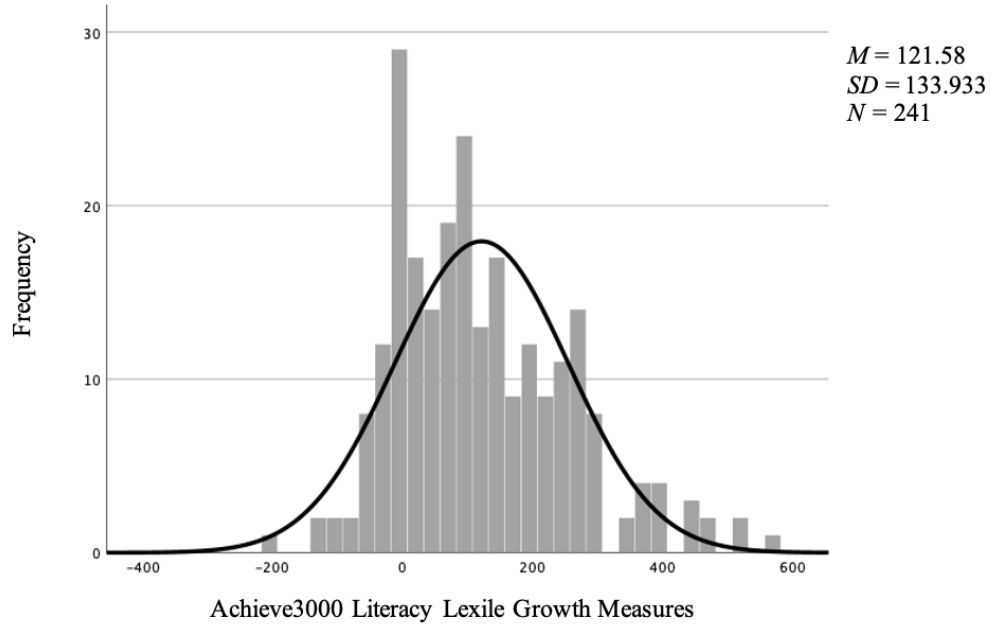


Figure 4

Frequency Distribution of Students' Achieve3000 Literacy Lexile Growth Measures



A comparison of student Achieve3000 Literacy pretest and posttest Lexile measure results is provided in Table 11 according to the third-grade level performance standards in the Lexile metric (MetaMetrics, 2021b), which Achieve3000 and MetaMetrics (2020) refer to as the College and Career Readiness Proficiency Ranges (CCR) (see Table 2). Of the 241 students, 14 did not have posttest data that could be accounted for in Table 11. According to the Achieve3000 Literacy pretest results illustrated in Table 11, 18.7% of students (n = 45) placed at or above third grade CCR levels as compared to 25.3% of the students (n = 61) assessed on the posttest. On the pretest most students, 81.3% (n = 196), fell below the grade level expectation of 520L. While fewer students completed the posttest (n = 227), 73.1% of the students assessed (n = 166) placed below the third-grade level expectations of 520L. From the Achieve3000 Literacy pretest to the posttest, the number of students far below grade level expectations (CCR) decreased by 49, while the number of students approaching CCR increased by 19, and the number at grade level increased by 17. Achieve3000 Literacy pretest results indicated that 49.8% of students (n = 120) scored far below CCR as compared to 29.5% (n = 71) on the posttest. Additionally, 31.5% (n = 76) of students approaching CCR on the pretest increased to 41.8% (n = 95) of the students assessed on the posttest. The performance standards in the Lexile metric (MetaMetrics, 2021b) presented in Table 2 were used to contextualize the level of proficiency for the students who fell below a third grade CCR level of 520L. Based on this table, student scores below 190L were at a reading level lower than first grade, while sores below 420L were at a reading level lower than second grade. Of the students who were not on track for third grade CCR on the Achieve3000 Literacy pretest, 36.1% students (n = 87) placed below a first-grade level on the pretest (190L and below), as compared to 20.3% of students who completed the posttest (n = 46). Although,

34.9% of students (*n* = 84) ranked below second grade levels according to CCR levels (between 195L and 420L) on the pretest, the number was decreased by two in the posttest results (*n* = 82). Thus, while growth was demonstrated in the reduced the number of students performing below a first grade reading level from the pretest to the posttest and in the number of students at or above the expected third-grade Lexile level, there was still a considerable number of students who concluded the school year at a Lexile level below second grade expectations.

Table 11

*Comparison of Students' Achieve3000 Literacy Pretest and Posttest Lexile Measure Results (*N = *241)*

	Fall Far Below CCR (≤265L)	Approaches CCR (270-515L)	Meets CCR (520L-820L)	Exceeds CCR (≥825L)	*n*
Pretest Lexile Score	120	76	42	3	241
Posttest Lexile Score	71	95	59	2	227
Difference	-49	+19	+17	-1	-14

Note. Students at or below 0L are classified as Beginning Readers (MetaMetrics, 2021b), meaning they are nonreaders. College and Career Readiness Proficiency Ranges (CCR) is a term used by Achieve3000 and MetaMetrics (2020), but the levels were created by MetaMetrics (2021b). Ranges in this chart are adapted from "Table 37: Revised A3K 4-Level Performance Standards in the Lexile Metric, Revised June 2012" by MetaMetrics, 2021b, September, 2021, *Achieve3000 LevelSet (Version 2): Development and Technical Guide* (5th ed.), p. 79, MetaMetrics, Inc; copyright 2021 by MetaMetrics, Inc.

Table 12 presents the distribution of students' Achieve3000 Literacy Lexile growth during the 2020-2021 school year. Achieve3000 calculated Lexile growth from the initial pretest results to the final Lexile measure (i.e., the last benchmark assessment results available or the last monthly Lexile adjustment available). According to these scores 14.1% of students (*n* = 34) demonstrated a decline in their Lexile measure, while 8.7% (*n* = 21) showed no change. In contrast, 77.2% of the students (*n* = 186) demonstrated some type of growth and 47.7% (*n* = 115) grew over 105L. Of the 241 students, 29.5% (*n* = 71) experienced growth between 5L to 105L, while 22.0% of students (*n* = 53) demonstrated 105L to 200L growth. Few students had growth between 205L and 300L growth (17.8%, *n* = 43) and far fewer experienced growth over 305L (7.9%, *n* = 19) during

the school year. The following section will discuss the application of the data discussed hitherto in the statistical analyses used to answer each research question.

Table 12

*Distribution of Student Lexile Growth in Achieve3000 Literacy (*N = *241)*

	Lexile Growth Range					
	-5L to -205L	0L	5-100L	105- 200L	205-300L	305-570L
n	34	21	71	53	43	19
%	14.1%	8.7%	29.5%	22.0%	17.8%	7.9%

Results for Research Question 1

The first research question asked: To what extent does high or low student engagement in Smarty Ants, as defined by the number of levels completed, affect Lexile measures in Achieve3000 Literacy? This question evaluated the impact of student engagement in Smarty Ants on Achieve3000 Literacy posttest Lexile measures and Lexile growth measures. In response to this question, descriptive statistics were conducted, followed by paired samples tests, and analyses of covariance according to Smarty Ants engagement levels. The Achieve30000 Literacy Lexile ranges according to Smarty Ants engagement levels are provided in Table 13. Pretest results demonstrated that the Lexile range for students with low engagement (-270L to 860L) were wider than the range for students with high engagement (-115L to 740L), while the range for students without an engagement level were between -225L to 880L. Posttest Lexile ranges indicated that the range for the high engagement group (55L to 1120L) was higher than for the low engagement group (-145L to 775L). While the group with no engagement data had a smaller population, their range showed higher scores (-60L to 815L) than the low engagement group. Lexile growth ranges for each of the engagement groups indicated a wider range for the high engagement group (-205L to 570L) than for the low engagement group (-140L to 525L),

while the range for the group with no engagement scores was situated within the ranges for the other groups (-55L to 365L).

Table 13

Achieve3000 Literacy Lexile Measure Ranges According to Smarty Ants Engagement Levels

	High Engagement			Low Engagement			No Engagement Data		
Variables	*n*	*minimum*	*maximum*	*n*	*minimum*	*maximum*	*n*	*minimum*	*maximum*
Pretest Lexile measures	74	-115L	740L	118	-270L	860L	49	-225L	880L
Posttest Lexile measures	73	55L	1120L	114	-145L	775L	40	60L	815L
Lexile growth measures	74	-205L	570L	118	-140L	525L	49	-55L	365L

Descriptive statistics for the Achieve30000 Literacy pretest Lexile measures, posttest Lexile measures, Lexile growth measures, and the corresponding *Z* scores divided according to Smarty Ants engagement levels are presented in Table 14. The results of *Z* score statistics showed an increase in the Means for students with high engagement between the pretest (M = .19, SD = .78) and the posttest (M = .35, SD = .95). Conversely, *Z* score results for students with low engagement exhibited a decrease in the Means between the pretest (M = -.24, SD = 1.02) and the posttest (M = -.36, SD = .95). The *Z* score statistics for students without engagement data confirmed a wider standard deviation on the pretest (M = .29, SD = 1.12) than the posttest (M = .39, SD = .86), while the Means increased from the pretest and the posttest. The Means of *Z* score Lexile growth measures were similar for students with low engagement (M = -.11, SD = 1.05) and no engagement (M = -.10, SD = .78), though the standard deviation was wider for the former. Students with high engagement had a larger Means of *Z* score Lexile growth measures and a wider standard deviation (M = .24, SD = 1.02) than the other two groups.

Table 14

Descriptive Statistics of Achieve3000 Literacy Lexile Measures According to Smarty Ants Engagement Levels

	High Engagement			Low Engagement			No Engagement Data		
Variables	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
Pretest Lexile measure	74	323.04	186.04	118	221.53	241.68	49	347.55	265.86
Posttest Lexile measure	73	456.58	208.00	114	301.80	208.22	40	465.63	187.47
Lexile growth measure	74	154.12	136.27	118	106.91	140.57	49	107.76	104.53
Pretest Lexile *Z* score	74	.19	.78	118	-.24	1.02	49	.29	1.12
Posttest Lexile *Z* score	73	.35	.95	114	-.36	.95	40	.39	.86
Lexile growth *Z* score	74	.24	1.02	118	-.11	1.05	49	-.10	.78
	Valid *n* = 73			Valid *n* = 114			Valid *n* = 40		

Note. The group without an engagement level did not receive the treatment and therefore had no Smarty Ants data to establish an engagement level.

Following descriptive statistics, the SPSS file was split according to Smarty Ants engagement levels and paired samples tests were conducted to evaluate the significance of difference between the Means of variables used in response to this research question. Table 15 provides the results of the *t*-test for Achieve3000 Literacy pretest and posttest Lexile *Z* scores while Table 16 presents the *t*-test results for Achieve3000 Literacy pretest Lexile *Z* scores and Lexile growth *Z* scores divided according to Smarty Ants engagement levels. The focus of this analysis was only the high and low engagement groups. According to the results, the effect sizes were small for both high engagement (d = -.22) and low engagement groups (d = .20). Results showed a statistically significant difference between the Means of Achieve3000 Literacy pretest and posttest Lexile *Z* scores for the low engagement group ($t(117)$ = 2.08, $p < .05$), which rejected the null hypothesis. In contrast, there was no statistically significant difference between

the Means of Achieve3000 Literacy pretest and posttest Lexile *Z* scores for the high engagement group (*t(72)* = -1.84, *p* = .069), which failed to reject the null hypothesis. Paired samples correlations revealed a moderate correlation between the Achieve3000 Literacy pretest and posttest Lexile *Z* scores for the high engagement group (*r* = .666, *p* < .001) and a slightly stronger paired samples correlation between the Achieve3000 Literacy pretest and posttest Lexile *Z* scores for the low engagement group (*r* = .711, *p* < .001). In both cases the null hypothesis is rejected. The data verified 95% confidence that the Means between Achieve3000 Literacy pretest Lexile *Z* scores and posttest Lexile *Z* scores for students with high engagement was between -.33 and .01, as well as 95% confidence that the Means between Achieve3000 Literacy pretest Lexile *Z* scores and posttest Lexile *Z* scores for students with low engagement was between .01 and .29.

Table 15

Paired Samples Statistics for Achieve3000 Literacy *Pretest Lexile Measures and Posttest Lexile Measures According to Smarty Ants Engagement Levels*

	High Engagement					Low Engagement				
Paired Sample	*M*	*SD*	*t*(72)	*p*	*d*	*M*	*SD*	*t*(113)	*p*	*d*
Pretest Lexile *Z* scores & Posttest Lexile *Z* scores	-.16	.73	-1.84	.069	-.22	.15	.75	2.08	.04*	.20

Note. *$p < .05$

The *t*-test results for pretest Lexile *Z* scores and Lexile growth *Z* scores divided according to Smarty Ants Engagement Levels presented in Table 16 did not confirm significant differences between the Means of pretest Lexile *Z* scores and Lexile growth *Z* scores for the high engagement group (*t*(73) = -.32, *p* = .75) or the low engagement group (*t*(117) = -.78, *p* = .44); both failed to reject the null hypothesis. While very small effect sizes were demonstrated for

groups with high (d = -.04) and low engagement (d = -.07), paired samples correlations revealed a statistical significance in the difference between the Means of Achieve3000 Literacy pretest Lexile Z scores and Lexile growth Z scores for students with both high (r = -.326, $p < .01$) and low engagement (r = -.525, $p < .001$). While both cases rejected the null hypothesis, the paired samples correlation for the high engagement group was low while the correlation for the low engagement group was moderate. This model established 95% confidence that the Means between Achieve3000 Literacy pretest Lexile Z scores and Lexile growth Z scores for students with high engagement was between -.26 and .19, while the Means between Achieve3000 Literacy pretest Lexile Z scores and posttest Lexile Z scores for students with low engagement was between -.25 and .11.

Table 16

Paired Samples Statistics for Achieve3000 Literacy Pretest Lexile Measures and Lexile Growth Measures According to Smarty Ants Engagement Levels

	High Engagement					Low Engagement				
Paired Sample	*M*	*SD*	*t*(73)	*p*	*d*	*M*	*SD*	*t*(117)	*p*	*d*
Pretest Lexile *Z* score & Lexile growth *Z* score	-.05	1.47	-.32	.75	-.04	-.13	1.81	-.78	.44	-.07

After concluding the *t*-tests, the file split in SPSS was removed and two ANCOVAs with an alpha level of .05 were conducted to evaluate the significance of differences among group scores, while controlling for "initial group differences on variables used" (Mills & Gay, 2019, p. 255). The first ANCOVA evaluated the relationship between Smarty Ants engagement levels and posttest Lexile measures. In this analysis the variables included the Smarty Ants engagement levels as the independent variable, the Z scores for posttest Lexile measures as the dependent variable, and the Z scores for the pretest as the covariate. The results presented in Table 17

indicated a significant interaction between Smarty Ants engagement and posttest Lexile measures when controlling for the pretest, $F(1, 184) = 16.12$, $p < .001$. While the ANCOVA controlled for the pretest, these results still denoted significance, $F(1, 184) = 168.65$, $p < .001$. Both rejected the null hypothesis. Additionally, the *R* squared correlation illustrated that 53.9% of the points in this analysis fell within the regression line ($R^2 = .539$), indicating a correlation of moderate strength. The *F*-test for Heteroskedasticity generated in this ANCOVA revealed no statistical significance ($F_{1,185} = .449$, $p = .50$).

Table 17

Analysis of Covariance Evaluating Posttest Lexile Measures According to Smarty Ants Engagement Levels with Pretest Lexile Measures as the Covariate

Source	*SS*	*df*	*MS*	*F*	*p*
Pretest Lexile Measure	80.18	1	80.17	168.65	.000***
Smarty Ants Engagement Level	7.66	1	7.66	16.12	.000***
Error	87.48	184	.48		

Note. ***p <.001; R Squared = .539 (Adjusted R Squared = .534).

A second ANCOVA was conducted to evaluate the relationship between Smarty Ants engagement levels and Lexile growth measures at an alpha level of .05. The variables included Smarty Ants engagement levels as the independent variable, the *Z* scores for Lexile growth measures as the dependent variable, and the *Z* scores for the pretest as the covariate. The results are presented in Table 18. While there was a low correlation ($R^2 = .232$), results indicated a significant interaction between Smarty Ants engagement levels and Lexile growth measures when controlling for the pretest, $F(1, 189) = 16.49$, $p < .001$, which rejected the null hypothesis. Again, despite the controls, pretest Lexile measures also demonstrated statistical significance in relation to Lexile growth and rejecting the null hypothesis, $F(1, 189) = 50.41$, $p < .001$. The *F*-

test for Heteroskedasticity generated in this ANCOVA did not yield statistical significance ($F_{1,190} = 1.27$, $p = .26$).

Table 18

Analysis of Covariance Evaluating Lexile Growth Measures According to Smarty Ants Engagement Levels with Pretest Lexile Measures as the Covariate

Source	*SS*	*df*	*MS*	*F*	*p*
Pretest Lexile Measure	43.05	1	43.05	50.41	.000***
Smarty Ants Engagement Level	14.08	1	14.08	16.49	.000***
Error	161.40	189	.85		

Note. ***p <.001; R Squared = .232 (Adjusted R Squared = .224).

Results for Research Question 2

The second research question asked: To what extent does high or low student engagement in Achieve3000 Literacy, as defined by the number of program criteria completed, affect Lexile measures in Achieve3000 Literacy? This question evaluated the role of engagement in Achieve3000 Literacy on Lexile outcomes, defined as posttest Lexile measures and Lexile growth measures. In response to this question, descriptive statistics were generated to understand the range, Means, and standard deviation of each data set (see Table 19). As indicated in Figure 2, Achieve3000 Literacy pretest Lexile measures for all students ($N = 241$) ranged from -270L to 880L. The Lexile Means and standard deviation for this range ($M = 278.32$, $SD = 237.32$) are provided in Table 19. Though they were not used as a variable in this study, the Achieve3000 Literacy interim assessment was completed by most students ($n = 240$). Descriptive statistics showed a Lexile range of -190L to 840L ($M = 309.38$, $SD = 213.74$). The Achieve3000 Literacy posttest was completed by 94.2% of students ($n = 227$). The Lexile range of these scores was between -145L to 1120L (see Figure 3). Table 19 provides the Lexile Means and standard

deviation for this range (*M* = 380.44, *SD* = 218.64). Although there was a decline in participants completing each benchmark assessment, descriptive statistics for Lexile results demonstrated an increase in the Lexile Means of results from each benchmark assessment period and a decrease in the standard deviation between pretest and posttest results (see Table 19). The range for Lexile growth measures was between -205L and 570L (see Figure 4). As indicated in Table 19, descriptive statistics for Lexile growth measures indicated that the Means score of 121.58 (*SD* = 133.93), illustrating that although some students experienced in a decline in performance, the average student demonstrated over 100L growth. The Lexile growth results are available in Table 12.

Table 19

*Descriptive Statistics of Students' Achieve3000 Literacy Benchmark Assessment Lexile Measures and Lexile Growth Measures (*N = *241)*

Variables	*n*	*M*	*SD*
Pretest Lexile measure	241	278.32	237.32
Interim test Lexile measure	240	309.37	213.74
Posttest Lexile measure	227	380.44	218.64
Lexile growth measure	241	121.58	133.93
		Valid *n* = 226	

When split according to Achieve3000 literacy engagement levels, descriptive statistics revealed differences in the Lexile measure ranges of high and low engagement groups (see Table 20) as well as a difference in between the Means and standard deviations of the engagement groups (see Table 21). While the low engagement group had a larger population (*n* = 157) than the high engagement group (*n* = 84), the Lexile range of Achieve3000 literacy pretest scores was lower for the high engagement group (-270L to 740L) than the Lexile range of the low engagement group (-225L to 880L). However, the Means for the high engagement group was

higher (*M* = 318.27, *SD* = 211.90) than for the low engagement group (*M* = 256.94, *SD* = 247.86), who demonstrated a wider standard deviation. The Achieve3000 Literacy posttest Lexile measures showed greater variation between Lexile measures and especially in the Means of the two groups, which was much greater for the high engagement group. Lexile ranges show higher scores for the high engagement group (20L to 1120L) than for the low engagement group (-145L to 775L). Additionally, descriptive results also demonstrated a higher Means for the high engagement group (*M* = 521.61, *SD* = 199.29) than for the low engagement group (*M* = 297.52, *SD* = 184.80) (see Table 21). Similarly, students in the high engagement group showed larger growth than students in the low engagement group. The Lexile growth score range for the high engagement group was between -40L and 570L (*M* = 204.88, *SD* = 138.07), and between -205L and 385L (*M* = 77.01, *SD* = 108.25) for the low engagement group. The difference in Means results indicated that the high engagement group experienced greater gains than the low engagement group. While Lexile measures were used to explain this analysis of descriptive statistics, their standardized form (*Z* scores) was used in the statistical analysis.

Table 20

*Lexile Measure Ranges According to Achieve3000 Literacy Engagement Levels (*N = *241)*

	High Engagement			Low Engagement		
Variables	*n*	*minimum*	*maximum*	*n*	*minimum*	*maximum*
Pretest Lexile measure	84	-270L	740L	157	-225L	880L
Posttest Lexile measure	84	20L	1120L	143	-145L	775L
Lexile growth measure	84	-40L	570L	157	-205L	385L
Pretest Lexile *Z* score	84	-2.31	1.95	157	-2.12	2.54
Posttest Lexile *Z* score	84	-1.65	3.38	143	-2.40	1.80
Lexile growth *Z* score	84	-1.21	3.35	157	-2.44	1.97

Table 21

Descriptive Statistics for Lexile Measures According to Achieve3000 Literacy Engagement Levels

	High Engagement			Low Engagement		
Variables	*n*	*M*	*SD*	*n*	*M*	*SD*
Pretest Lexile measure	84	318.27	211.90	157	256.94	247.86
Posttest Lexile measure	84	521.61	199.29	143	297.52	184.80
Lexile growth measure	84	204.88	138.07	157	77.01	108.25
Pretest Lexile *Z* score	84	0.17	0.89	157	-0.09	1.04
Posttest Lexile *Z* score	84	0.65	0.91	143	-0.38	0.85
Lexile growth *Z* score	84	0.62	1.03	157	-0.33	0.81
	Valid *n* = 84			Valid *n* = 142		

Paired samples tests were conducted to evaluate the significance of difference between the Means of variables used in response to this research question. To investigate this relationship the file was split by Acheive3000 Literacy engagement levels and *t*-tests were conducted for each pair of variables. Table 22 provides the results of the paired sample statistics evaluating pretest Lexile measures and posttest Lexile measures according to Achieve3000 Literacy engagement levels. These results indicated a statistically significant difference between the Means of the pretest and posttest *Z* scores for the high engagement group ($t(83) = -7.31$, $p < .001$) and for the low engagement group ($t(142) = 6.10$, $p < .001$), therefore the null hypothesis was rejected. Paired samples correlations were also significant for the high ($r = .780$, $p < .001$) and low engagement groups ($r = .805$, $p < .001$); both reject the null hypothesis. The low engagement group exhibited a moderate effect ($d = .51$), while high engagement group showed a large negative effect size *(*$d = -.80$). Finally, data establish 95% confidence that the Means between pretest Lexile *Z* scores and posttest Lexile *Z* scores for students with low engagement

was between .34 and .68, and that the Means between pretest Lexile *Z* scores and Lexile growth *Z* scores for students with high engagement is between -1.04 and -.55.

Table 22

Paired Samples Statistics for Pretest Lexile Measures and Posttest Lexile Measures According to Achieve3000 Literacy Engagement Levels

	High Engagement					Low Engagement				
Paired Sample	*M*	*SD*	*t*(83)	*p*	*d*	*M*	*SD*	*t*(142)	*p*	*d*
Pretest & Posttest Lexile *Z* scores	-.48	.60	-7.31	.000***	-.80	.31	.62	6.10	.000***	.51

Note. ***$p < .001$

Table 23 displays the results of the paired samples statistics evaluating the statistical difference between the Means of pretest Lexile measures and Lexile growth measures according to Achieve3000 Literacy engagement levels. Data show that there was a statistical significance between the Means of pretest Lexile *Z* scores and Lexile growth *Z* scores for students with high engagement ($t(83) = -2.57$, $p < .05$), but not for the low engagement group ($t(156) = 1.81$, $p = 0.07$). While the former rejected the null hypothesis, the latter did not. Additionally, the high engagement group demonstrated a moderate paired samples correlation between these variables ($r = -.417$, $p < .001$) and a slightly larger paired samples correlation for students with low engagement ($r = -.635$, $p < .001$). Both cases rejected the null hypothesis. Data exhibited a low effect size for high engagement group ($d = -.28$) and a lesser effect size for the low engagement group ($d = .15$). Results indicated 95% confidence that the Means between pretest Lexile *Z* scores and Lexile growth *Z* scores for students with low engagement was between -.02 and .30, and that the Means between pretest Lexile *Z* scores and Lexile growth *Z* scores for students with high engagement was between -.50 and -.06.

Table 23

Paired Samples Statistics for Pretest Lexile Measures and Lexile Growth Measures According to Achieve3000 Literacy Engagement Levels

	High Engagement					Low Engagement				
Paired Sample	*M*	*SD*	*t*(83)	*p*	*d*	*M*	*SD*	*t*(156)	*p*	*d*
Pretest Lexile *Z* scores & Lexile growth *Z* scores	-.45	1.62	-2.57	.01*	-.28	-.24	1.68	1.81	.07	.15

Note. *$p < .05$.

The file split according to Achieve3000 Literacy engagement levels was removed for the successive step of conducting ANCOVAs to assess the significance of difference among the group scores while controlling for the pretest. To evaluate the relationship between Achieve3000 Literacy engagement levels and posttest Lexile measures, the first ANCOVA used the Achieve3000 Literacy engagement levels as the independent variable, the *Z* scores for posttest Lexile measures as the dependent variable, and the *Z* scores for the pretest as the covariate, as well as an alpha level of .05. These results are presented in Table 24 and showed a strong *R* squared correlation ($R^2 = .718$). Moreover, results presented a statistically significant interaction between Achieve3000 Literacy engagement and posttest Lexile *Z* scores when controlling for the pretest, $F(1, 224) = 136.47$, $p < .001$, as well as between the pretest Lexile measure and posttest Lexile growth *Z* scores, $F(1, 224) = 375.65$, $p < .001$. Each rejected the null hypothesis. In this ANCOVA, the *F*-test for Heteroskedasticity did not generate statistical significance ($F_{1, 225} = .18$, $p = .68$).

Table 24

Analysis of Covariance Evaluating Posttest Lexile Measures According to Achieve3000 Literacy Engagement Levels with Pretest Lexile Measures as the Covariate

Source	*SS*	*df*	*MS*	*F*	*p*
Pretest Lexile Measure	106.75	1	106.75	375.65	.000***
Achieve3000 Literacy Engagement level	38.78	1	38.78	136.47	.000***
Error	63.66	224	.28		

Note. ***p <.001; R Squared = .718 (Adjusted R Squared = .716).

To evaluate the interaction between Achieve3000 Literacy engagement levels and Lexile growth measures, a second ANCOVA with an alpha level of .05 was generated using the Achieve3000 Literacy engagement levels as the independent variable, the *Z* scores for Lexile growth measures as the dependent variable, and the *Z* scores for the pretest as the covariate. The results, presented in Table 25, demonstrated a modest correlation between the variables (R^2 = .443). Additionally, the interaction between Achieve3000 Literacy engagement levels and Lexile growth measures was statistically significant, $F(1, 238) = 112.10$, $p < .001$. Similarly, the interaction between pretest Lexile *Z* scores and Lexile growth *Z* scores was also statistically significant $F(1, 238) = 100.41$, $p < .001$. In both cases, the null hypothesis was rejected. In this ANCOVA the *F*-test for Heteroskedasticity revealed statistical significance between Achieve3000 Literacy Engagement Levels and Lexile Growth Measures ($F_{1, 239} = 33.93$, $p <$ .001).

Table 25

Analysis of Covariance Evaluating Lexile Growth Measures According to Achieve3000 Literacy Engagement Levels with Pretest Lexile Measures as the Covariate

Source	*SS*	*df*	*MS*	*F*	*p*
Pretest Lexile Measure	56.41	1	56.41	100.41	.000***
Achieve3000 Literacy Engagement Levels	62.98	1	62.98	112.10	.000***
Error	133.71	238	.56		

Note. ***p <.001; R Squared = .443 (Adjusted R Squared = .438).

Results for Research Question 3

The third research questions asked: to what extent does high or low student engagement in both Smarty Ants and Achieve3000 Literacy affect Lexile measures in Achieve3000 Literacy? To continue the analysis in pursuit of the third research question, new variables were created to account for engagement, posttest scores, and growth. The distribution of individual and combined engagement levels in Smarty Ants and Achieve3000 Literacy are presented in Table 10. The new variable for engagement was created for students who had high engagement in one or both programs. Students with high engagement in both Smarty Ants and Achieve3000 Literacy (n =37) were given one categorical value while students with high engagement in either Smarty Ants or Achieve3000 Literacy (n = 83) were assigned a different categorical value. This variable was termed "combined engagement." Students with low or no engagement levels were not assigned a variable and were not the focus of the analysis for this question. To account for the combined impact of posttest scores, a variable was created by adding each participant's Smarty Ants posttest placement level to their corresponding posttest scores from Achieve3000 Literacy. Of the 241 students, 13 had no posttest data for either program and did not receive a combined posttest score, however, these students had a calculated gain score and were kept in

the sample, though SPSS corrected the model accordingly. The combined growth variable was a calculated gain score created by adding the Achieve3000 Literacy pretest and posttest scores, then dividing them by two. The data were imported to SPSS and descriptive statistics were generated on the combined posttest score and the calculated gain score to establish standardized *Z* scores for each variable. Table 26 provides the descriptive statistics for combined posttest scores and calculated gain scores sorted according to combined engagement level. A review of these results indicated that students with no engagement levels, also the largest group in the population (n = 108), had the lowest Mean *Z* scores and the widest standard deviation in each of the measures. In addition, students with a combined high engagement level, also the smallest group (n = 37), had the highest Means for each measure. The combined high engagement group had a greater Means for the pretest Lexile *Z* score (M =.35, SD = .71) than the pretest Lexile *Z* score for the combined low engagement group (M =.17, SD = .92). Additionally, the Means scores for students with combined high engagement were significantly greater on the combined posttest *Z* score (M = .95, SD = .85) as compared to that of the combined low engagement group (M = .13, SD = .87). Furthermore, the calculated gain *Z* score Means for the combined high engagement group (M = .71, SD = .79) was also significantly higher than for students with combined low engagement (M = .12, SD = .87).

Table 26

*Descriptive Statistics for the Combined Posttest Scores and Calculated Gain Score According to Combined Engagement Levels (*N = *241)*

	Combined High Engagement			Combined Low Engagement			No Engagement Data		
Variables		*M*	*SD*		*M*	*SD*	*n*	*M*	*SD*
Pretest Lexile measure	37	362.30	170.02	83	282.35	218.57	121	249.88	261.38
Combined posttest score	37	598.05	188.12	83	415.96	192.32	108	292.06	196.29
Calculated gain score	37	471.22	169.74	83	344.40	187.09	121	253.70	218.58
Pretest Lexile *Z* score	37	.35	.71	83	0.17	.92	121	-.12	1.10
Combined posttest *Z* score	37	.95	.85	83	.13	.87	108	-.43	.89
Calculated gain *Z* score	37	.71	.79	83	.12	.87	121	-.30	1.02

Following the analysis of descriptive statistics, paired samples tests were conducted to determine if the Means between the variables used in response to the third research question were statistically significant at an alpha level of 0.05. Table 27 illustrates the results from paired samples statics assessing pretest Lexile *Z* scores and combined posttest *Z* scores according to combined engagement levels for Smarty Ants and Achieve3000 Literacy. Results presented statistical significance between these variables for students with high engagement ($t(36) = -6.90$, $p < .001$) and rejected the null hypothesis. The differences in Means between the pretest Lexile *Z* scores and combined posttest *Z* scores for students with low engagement were not statistically significant ($t(82) = -1.40$, $p = .17$) and failed to reject the null hypothesis. Results indicated 95% confidence that the Means between pretest Lexile *Z* scores and combined posttest *Z* scores for students with high engagement was between -1.55 and -.72, and that the Means between pretest Lexile *Z* scores and combined posttest *Z* scores for students with low engagement was between -.37 and .06. Paired samples correlations show a stronger correlation for the high engagement group ($r = .785$, $p < .001$) than for the low engagement group ($r = .651$, $p < .001$). Paired

samples correlations established statistical significance and rejected the null hypothesis for high engagement and low engagement groups. While the high engagement group results demonstrated a moderate effect size (d = .53), results from the low engagement group confirmed a high effect size (d = .75).

Table 27

Paired Samples Statistics for Pretest Lexile Measures and Combined Posttest Scores According to Combined Engagement Levels

	High Engagement					Low Engagement				
Paired Sample	*M*	*SD*	*t*(36)	*p*	*d*	*M*	*SD*	*t*(82)	*p*	*d*
Pretest Lexile Z scores & Combined Posttest *Z* scores	-.60	.53	-6.90	.000***	.53	-.11	.75	-1.40	.17	.75

Note. ***p < .001

Paired samples statics were conducted to assess the statistical significance in the difference between the Means of pretest Lexile *Z* scores and calculated gain *Z* scores according to combined engagement levels for Smarty Ants and Achieve3000 Literacy. Results provided in Table 28 indicated statistical significance between the Means of pretest Lexile *Z* scores and calculated gain *Z* scores for students with high engagement ($t(37) = -8.04$, $p < .001$) and rejected the null hypothesis. Pretest Lexile *Z* scores and calculated gain *Z* scores *t*-test results for students with low engagement were also statistically significant ($t(83) = -2.62$, $p < .05$), and rejected the null hypothesis. Results indicate 95% confidence that the Means between pretest Lexile *Z* scores and calculated gain *Z* scores for students with high engagement was between -1.76 and -.87, and 95% confidence that the Means between pretest Lexile *Z* scores and calculated gain *Z* scores for students with low engagement was between -.51 and -.07. Both the high group (d = -1.32) and low group (d = -.29) showed negative low effect sizes. Paired samples correlations demonstrate a

strong association between pretest Lexile *Z* scores and calculated gain *Z* scores for students with high engagement ($r = .940$, $p < .001$), and for students with low engagement ($r = .919$, $p < .001$). Both samples reject the null hypothesis.

Table 28

Paired Samples Statistics for Pretest Lexile Measures and Calculated Gain Scores According to Combined Engagement Levels

	High Engagement					Low Engagement				
Paired Sample	*M*	*SD*	*t*(36)	*p*	*d*	*M*	*SD*	*t*(82)	*p*	*d*
Pretest Lexile Z scores & Calculated Gain *Z* scores	-.36	.27	-8.04	.000***	-1.32	-.10	.36	-2.62	.01*	-.29

Note. *$p < .05$; ***$p < .001$.

To investigate the significance of differences in combined posttest results between the high and low combined engagement groups, an ANCOVA with an alpha level of .05 was generated using the combined engagement variable as the independent variable, the *Z* score for the combined posttest variable as the dependent variable, and the *Z* score for the pretest as the covariate. The results of this analysis are displayed in Table 29. Findings revealed a moderate correlation between variables ($R^2 = .552$). Results also indicated a significant interaction between combined engagement levels and combined posttests scores, $F(1, 117) = 21.66$, $p < .001$, and rejected the null hypothesis. Additionally, the interaction between pretest and posttest Lexile measures was also statistically significant, $F(1, 117) = 101.35$, $p < .001$, and likewise rejected the null hypothesis. The *F*-test for Heteroskedasticity in this ANCOVA did not result in statistical significance ($F_{1,118} = .813$, $p = .369$).

Table 29

Analysis of Covariance Evaluating Combined Posttest Scores According to Combined Engagement Levels with Pretest Lexile Measures as the Covariate

Source	*SS*	*df*	*MS*	*F*	*p*
Pretest Lexile Measure	40.81	1	40.81	101.35	.000***
Combined Engagement level	8.72	1	8.72	21.66	.000***
Error	47.11	117	.40		

Note. ***p <.001; R Squared = .552 (Adjusted R Squared = .545).

A second ANCOVA was produced to investigate the relationship between growth outcomes and students combined Smarty Ants and Achieve3000 engagement levels. In this analysis the alpha level was set at .05, the combined engagement variable was assigned as the independent variable, the calculated gain *Z* score was assigned the dependent variable, and the *Z* score for the pretest as the covariate. The results of this analysis are presented in Table 30 and showed a very strong correlation among the variables (R^2 = .865). Results also illustrated a statistically significant interaction between combined engagement levels and calculated gain *Z* scores, $F(1, 117) = 18.66$, $p < .001$, as well as between pretest Lexile *Z* score and calculated gain *Z* scores, $F(1, 117) = 664.61$, $p < .001$. Both rejected the null hypothesis. The *F*-test for Heteroskedasticity in this ANCOVA did produce statistical significance ($F_{1,118} = .585$, $p = .446$).

Table 30

Analysis of Covariance Evaluating Calculated Gain Scores According to Combined Engagement Levels with Pretest Lexile Measures as the Covariate

Source	*SS*	*df*	*MS*	*F*	*p*
Pretest Lexile Measure	72.05	1	72.05	664.61	.000***
Combined Engagement level	2.02	1	2.02	18.66	.000***
Error	12.68	117	.11		

Note. ***p <.001; R Squared = .865 (Adjusted R Squared = .862).

Conclusion

The purpose of this study was to evaluate student Lexile growth resulting from their engagement in two concurrent literacy interventions, Smarty Ants and Achieve3000 Literacy. In pursuit of each research question, the study evaluated three pairs of relationships: the impact of engagement in Smarty Ants on Lexile measures, the impact of engagement in Achieve3000 Literacy on Lexile measures, and the impact of combined engagement on student performance outcomes. In response to each research question, descriptive statistics, two paired samples tests (*t*-tests), and two ANCOVAs were generated. Descriptive statistics indicated that although 77.2% of students demonstrated some growth, only 47.7% demonstrated over 105L of growth. In addition, the descriptive statistics regarding Lexile ranges for Smarty Ants, Achieve3000 Literacy, and combined engagement groups revealed that students in each high engagement group demonstrated an increase in Lexile measures from the Achieve3000 Literacy pretest to the posttest. In addition, each high engagement group also had stronger growth than the corresponding low engagement group. The results of paired samples tests demonstrated more frequent statistical significance in the difference between the Means with variables compared in reference to the second research question evaluating Achieve3000 Literacy engagement and the third research question investigating combined engagement, than for variables compared according to Smarty Ants engagement in response to the first research question on Smarty Ants engagement. The strongest paired samples correlations were generated between the Means of Achieve3000 Literacy pretest Lexile *Z* scores and calculated gain *Z* scores divided according to combined engagement levels. The greatest effect sizes were generated in the *t*-test for Achieve3000 Literacy pretest Lexile *Z* scores and combined posttest *Z* scores for both

engagement groups. The results of each ANCOVA showed statistical significance for each set of variables, with varying degrees of *R* squared correlations. The only *F*-test for Heteroskedasticity resulting in statistical significance was generated with the ANCOVA evaluating Achieve3000 Literacy engagement and Lexile Growth Z scores. The discussion of these findings, the significance of this study, and suggestions for the field as well as further areas of study are presented in the subsequent chapter.

CHAPTER 5

DISCUSSION

One key definition of the achievement gap in education has been the variation between performance outcomes of students of color as compared to their White counterparts (Boykin & Noguera, 2011; Rojas-LeBouef & Slate, 2012; Teale et al., 2007). Researchers have attempted to determine sources of the gap only to conclude that the problem is multifaceted and likely the result of a convergence of factors (Jeynes, 2015; Muhammad, 2015; Sanchez, 2008.). Efforts to close the achievement gap have been predominantly government or school based (Jeynes, 2015). Despite such determinations, the gap has persisted through the decades (Borrero & Bird, 2009; Boykin & Noguera, 2011; Carter, 2018; Dorn et al., 2020a; Jeynes, 2015; Johnson, 2002; Muhammad, 2015; Palumbo & Sanacore, 2009; Paschall et al., 2018; Snow & Biancarosa, 2003; Wenglinsky, 2004). The COVID-19 pandemic further exacerbated the achievement gap and highlighted the gross inequities in education during the context of this study (Dorn et al., 2020a, 2020b). The achievement gap has been a highly problematic issue of social justice in education as it has resulted in a variety of diminished academic, social, and economic outcomes for the larger society and for individuals, especially people of color from low SES backgrounds (Burroughs-Lange & Douëtil, 2007; Crouzevialle & Darnon, 2019; Dorn et al., 2020a; Jehangir et al., 2015; Milner, 2013; Muhammad, 2015; Palumbo & Sanacore, 2009; Papay et al., 2013; Partanen et al., 2019; Paschall et al., 2018; Reardon et al., 2012; Rojas-LeBouef & Slate, 2012). Though the achievement gap encompasses reading and math, this study specifically attends to the former. As a multidimensional skill that "is widely recognized as the best predictor of success in higher education and on-the-job performance" (Stenner, 1996, p. 9), literacy has been

instrumental in "social mobility, economic growth, and democratic participation" (Reardon et al., 2012, p. 18). Although some definitions of literacy have included reading and writing, the definition of literacy adopted for the purpose of this study referred to literacy as reading for comprehension, defined as the ability to read, comprehend, and use a text for the intended purpose (Achieve3000 & MetaMetrics, 2020; Petscher et al., 2020; Pilgrim & Martinez, 2013; Reardon et al., 2012; Tompkins, 2017; Venezky, 2016).

Academic performance has impacted educational attainment and economic opportunity (Crouzevialle & Darnon, 2019; Milner, 2013; Papay et al., 2013; Rojas-LeBouef & Slate, 2012) Research has shown that many students in secondary education are unprepared for postsecondary literacy requirements (Edmonds et al., 2009; Reardon et al., 2012; Smith, 2014a). Studies have also demonstrated that the challenge begins in the early years of a child's life and education (Burroughs-Lange & Douëtil, 2007; García & Weiss, 2017; Jehangir et al., 2015; Palumbo & Sanacore, 2009; Paschall et al., 2018). Students who were not effectively comprehending written texts with increased complexity by the third grade (Reardon et al, 2012), have fallen behind their counter parts (Murphy & Justice, 2019; Paschall et al., 2018; Pfost et al., 2014; The Nation's Report Card, 2019). As illustrated in the conceptual framework guiding this study (see Figure 1), students must concretize their foundational skill in literacy to effectively read and understand increasingly complex texts (Amendum et al., 2011; NICHD, 2019; Tompkins, 2017). Effective reading has necessitated "the development of decoding skills, the development of vocabulary and comprehension, and the learning of specific strategies and processes" (Hattie, 2009, pp. 129-130). While the greatest concentration of literature in literacy development has been on the early years of the education system (Hattie, 2009), Smith (2014a) argued for a shift

from the philosophy that reading development ends by the third grade to one that recognizes the continuous process of building reading skills beyond the third grade. Nonetheless, American education has been structured such that the emphasis on literacy development is in the primary grades, while in the third grade and beyond students are expected to independently read increasingly complex texts (Hattie, 2009; Snow & Biancarosa, 2003). Consequently, the literacy performance of third graders has become a key indicator of later success (Murphy & Justice, 2019; Snow & Matthews, 2016). Research has therefore established that it is critical for third-grade students to master foundational literacy skills (Hattie, 2009; Tompkins, 2017) as a prerequisite for advancing their skill in literacy as reading for comprehension (Reardon et al., 2012). The conceptual framework (see Figure 1) in this study visually represented the relationship between foundational literacy and reading for comprehension established in the research and used as a basis for this study. While researchers, policymakers, educators, and administrators have struggled to find effective solutions to close the achievement gap (Boykin & Noguera, 2011; Carter, 2018; Jeynes, 2015; Jehangir et al., 2015; Muhammad, 2015; Sanchez, 2008; Snow & Biancarosa, 2003; Wenglinsky, 2004), research has advocated for the potential of technology to enhance educational progress (Achieve3000, n.d.-b.; Pierce & Cleary, 2016; Smith, 2014a). This study investigated two technology-based literacy interventions, Smarty Ants and Achieve3000, used during the 2020-2021 school year by third graders at nine schools working with the same nonprofit.

Smarty Ants was designed to provide phonics instruction for TK through second-grade students through a progression of 97 lessons across 18 levels (Achieve3000, n.d.-a). The purpose of using Smarty Ants in the third grade was to ensure all students had mastered the foundational

skills necessary to read independently. Consequently, engagement levels in this study were established by reviewing student lesson progress and benchmark assessments to evaluate program completion. High engagement was assigned to students who completed the program by the end of the school year, while low engagement was assigned to students who did not complete it. Completing Smarty Ants in the third grade was insufficient to developing literacy capacity to succeed academically. Studies have shown that to effectively navigate education and prepare for future learning and job performance, students must effectively navigate text complexity (Reardon et al., 2012; Smith, 2014a). Thus, Achieve3000 Literacy was adopted to strengthen student skill toward reading at or above grade level (Achieve3000, n.d.-c). Achieve30000 Literacy LevelSet assessments and reports measure growth in reading comprehension (Achieve3000, n.d.-c) and are powered by the Lexile Framework for Reading, a ubiquitous reading metric founded on over 20 years of research (MetaMetrics & Achieve3000, 2015). The monthly Lexile adjustment is generated using a Bayesian scoring algorithm (Achieve3000, 2017c) while Lexile growth measures are calculated based on student performance from the pretest to the most recent Lexile score (Achieve3000, n.d.-c). Engagement levels in Achieve3000 Literacy were evaluated according to criteria rooted in the literature on Achieve3000 Literacy.

The researcher in this study continues to be passionate about social justice in education. She maintained a commitment to closing the achievement gap, especially in literacy, that has evolved through her experience as a student, educator, and administrator serving in Catholic education. During the study, the researcher was a consultant working with a nonprofit to support Catholic elementary schools in closing the achievement gap. The nonprofit regularly collects and

archives student performance data. Consequently, the participants in this study were selected through purposeful convenient sampling. These included 241 third graders from nine Catholic schools who used two literacy interventions, Smarty Ants and Acheive3000 Literacy, concurrently during the 2020-2021 school year. While the participants were not directly involved in the study, their archived performance data generated by the two interventions during the 2020-2021 academic year were used with permission from the nonprofit.

The purpose of study was to evaluate the relationship between concurrent student engagement in two literacy interventions, Smarty Ants and Achieve3000 Literacy, and student Lexile outcomes, defined as posttest Lexile measures and Lexile growth measures. The study specifically addressed the following research questions:

1. To what extent does high or low student engagement in Smarty Ants, as defined by the number of levels completed, affect Lexile measures in Achieve3000 Literacy?
2. To what extent does high or low student engagement in Achieve3000 Literacy, as defined by the number of program criteria completed, affect Lexile measures in Achieve3000 Literacy?
3. To what extent does high or low student engagement in both Smarty Ants and Achieve3000 Literacy affect Lexile measures in Achieve3000 Literacy?

This study was a quantitative analysis of third-grade student literacy skills. While the achievement gap has referred to the lower performance outcomes for students of color, particularly in low SES areas, as compared to their White counterparts (Boykin & Noguera, 2011; Rojas-LeBouef & Slate, 2012; Teale et al., 2007), race and/or ethnic demographic data was not available for this study. As a result, this study attended to the difference between

students' actual and expected reading performance according to Lexile measures outlined in MetaMetrics (2021b) Lexile Framework for Reading. Grounded in a quasi-experimental pretest-posttest design, descriptive statistics, paired samples tests (*t*-tests), and analyses of covariance (ANCOVAs) were conducted in response to each research question. Using the conceptual framework (see Figure 1) to guide the investigation, the study assessed the relationship between concurrent engagement in the two literacy interventions and performance outcomes. The research conducted in this study can add to the literature and provide recommendations for future practice and study.

Discussion of Findings

With permission from the nonprofit, archived student data from the 2020-2021 school year were downloaded, consolidated, reviewed, and prepared for SPSS, then utilized in statistical analysis. In response to each of the three research questions, descriptive statistics for data were generated, in addition to two sets of paired samples tests (*t*-tests), and two ANCOVAs. As the study employed a pretest-posttest design, differences between the assessments can be credited to the intervention (Leavy, 2017). While the pretest-posttest design controls for individual differences on the assessments because of the relative nature of student performance, ANCOVAs were used to evaluate the significance of differences between the scores while also controlling for any initial advantages in the pretests (Mills & Gay, 2019). Evaluating student progress according to Lexile growth measures and combined gain scores also controlled for initial advantages. While the findings of these analyses are presented in Chapter 4, a discussion of the findings by research question is provided in the following section.

Analysis for Research Question 1

The first research question asked: To what extent does high or low student engagement in Smarty Ants, as defined by the number of levels completed, affect Lexile measures in Achieve3000 Literacy? This question investigated the relationship between student engagement in Smarty Ants and Lexile measures in Achieve3000 Literacy. Of the 241-participant sample, 74 students had completed the program and were categorized as having high engagement, while 118 students did not complete the program and were characterized as having low engagement. An additional 49 students did not receive an engagement score for Smarty Ants as they did not have any data to warrant one. Following the evaluation of engagement levels, descriptive statistics were generated on the Lexile measures as well as the *Z* scores for Lexile measures divided according to Smarty Ants engagement levels. The statistics revealed higher scores from the Achieve3000 Literacy pretest to the posttest for the high engagement group as compared to the low engagement group. Lexile growth scores also reflected greater gains for the high engagement group than for the low engagement group. Following descriptive statistics, a *t*-test was conducted to evaluate significance in the difference between the Means of the Achieve3000 Literacy pretest and posttest Lexile *Z* scores according to Smarty Ants engagement groups. This *t*-test revealed no statistically significant difference between the Means of pretest and posttest Lexile *Z* scores for the high engagement group. In contrast, statistical significance was found between the Means of the variables for the low engagement group. While results for the high engagement group failed to reject the null hypothesis, the results for the low engagement group rejected the null hypothesis. In addition, the Achieve3000 Literacy pretest and posttest Lexile *Z* scores for the high engagement group resulted in a moderate paired samples correlation with

statistical significance while the low engagement results demonstrated a strong paired samples correlation with statistical significance. Additional paired samples tests conducted on pretest Lexile *Z* scores and Lexile growth *Z* scores divided by Smarty Ants engagement levels revealed no significant difference between the Means of either engagement group, and failed to reject the null hypothesis. Additionally, a low paired samples correlation with statistical significance rejecting the null hypotheses was identified for the high engagement group while a moderate paired samples correlation with statistical significance rejecting the null hypotheses was noted for the low engagement group.

Succeeding the *t*-tests, the first ANCOVA generated in response to the first research question evaluated the relationship between student high or low engagement levels in Smarty Ants and *Z* scores for Achieve3000 Literacy posttest Lexile measures with *Z* scores for the Achieve3000 Literacy pretest Lexile measures as the covariate. The results of this analysis yielded statistical significance in the differences among the scores, rejecting the null hypothesis. An *R* squared correlation of moderate strength was produced, though results did not yield statistical significance in the *F*-test for Heteroskedasticity. The second ANCOVA generated in response to this question evaluated the relationship between student high or low engagement levels in Smarty Ants and *Z* scores for the Achieve3000 Literacy Lexile growth measures with *Z* scores for the Achieve3000 Literacy pretest Lexile measures as the covariate. Results for this analysis produced statistical significance that rejected the null hypothesis in the differences among the scores. The analysis also resulted in a low *R* squared correlation and no statistical significance in the *F*-test for Heteroskedasticity. Despite the small sample size, these results indicate that the interaction between student engagement levels in Smarty Ants and Lexile

measures in Achieve3000 Literacy was statistically significant. In summary: student's completion of Smarty Ants affected posttest Lexile measures and Lexile growth measures, though the relationship between Smarty Ants engagement and posttest Lexile measures was stronger than that of Smarty Ants engagement and Lexile growth measures.

Analysis for Research Question 2

The second research question asked: To what extent does high or low student engagement in Achieve3000 Literacy, as defined by the number of program criteria completed, affect Lexile measures in Achieve3000 Literacy? This question investigated the relationship between student engagement in Achieve3000 Literacy and Lexile measures in Achieve3000 Literacy. Using criteria to evaluate student engagement levels in Achieve3000 Literacy, 84 students met three or more criteria and were assigned high engagement, while 157 students met less than three criteria and were classified as low engagement. Descriptive statistics generated on the *Z* scores for the Achieve3000 Literacy pretest, posttest, and Lexile growth measures according to Achieve3000 Literacy engagement groups revealed that students in the high engagement group showed an increase in Lexile measures from the Achieve3000 Literacy pretest to the posttest. In addition, the Achieve3000 Literacy high engagement group also had stronger growth than the low engagement group. The paired samples tests conducted to evaluate the statistical significance between the Means of the Achieve3000 Literacy pretest and posttest *Z* scores according to Achieve3000 Literacy engagement levels were statistically significant for both engagement groups, thereby rejecting the null hypothesis. In addition, strong paired samples correlations with statistical significance were also found between variables for both engagement groups. In a second paired samples test evaluating the statistical significance between the Means

of the Achieve3000 Literacy pretest and Lexile growth *Z* scores according to Achieve3000 Literacy engagement levels revealed statistical significance among the scores for students with high engagement and rejected the null hypothesis, but not for the low engagement group. Additionally, results showed a low paired samples correlation with statistical significance for the high engagement group as well as a moderate paired samples correlation with statistical significance for the low engagement group.

Following the *t*-test, an ANCOVA was generated to evaluate the significance of differences among scores between student high or low engagement levels in Achieve3000 Literacy and *Z* scores for Achieve3000 Literacy posttest Lexile measures, while controlling for the Achieve3000 Literacy pretest Lexile measures by using the corresponding *Z* scores as the covariate. This analysis demonstrated statistical significance among the group scores that rejected the null hypothesis. While the *F*-test for Heteroskedasticity did not yield statistical significance in this ANCOVA, the analysis revealed a strong *R* squared correlation between variables, emphasizing the importance of the relationship between student engagement in Achieve3000 Literacy and posttest Lexile measures. The subsequent ANCOVA generated evaluated the relationship between student high or low engagement levels in Achieve3000 Literacy and Lexile growth *Z* scores with pretest Lexile *Z* scores as the covariate. This analysis demonstrated statistical significance that rejected the null hypothesis. While this ANCOVA generated a low *R* squared correlation between variables, the *F*-test for Heteroskedasticity produced statistical significance, further accentuating the importance of the relationship between student engagement in Achieve3000 Literacy and Lexile growth measures.

Based on the results of statistical analysis in response to this question, the interaction between student engagement in Achieve3000 Literacy and Lexile measures in Achieve3000 Literacy was statistically significant. The strong *R* squared correlation in the ANCOVA between student engagement levels in Achieve3000 Literacy and their posttest Lexile measures emphasized the significance of the relationship between these variables. Furthermore, as the *F*-test for Heteroskedasticity generated in the ANCOVA evaluating the relationship between engagement levels in Achieve3000 Literacy and Lexile growth *Z* scores was statistically significant, the importance of the relationship between these variables cannot be understated.

Analysis for Research Question 3

The third research question asked: To what extent does high or low student engagement in both Smarty Ants and Achieve3000 Literacy affect Lexile measures in Achieve3000 Literacy? This question investigated the relationship between the combined effect of both interventions (Smarty Ants and Achieve3000 Literacy) and Lexile measures in Achieve3000 Literacy. A combined engagement variable was defined by high in engagement in one or both programs. This resulted in categorizing 37 students as high engagement, meaning they had high engagement in both programs, and 83 students as having low engagement, meaning they had high engagement in either program. Of the remaining 121 students, 82 had low engagement in both programs while 39 had low engagement in Achieve3000 Literacy and no data in Smarty Ants. These students were not included in the statistical analysis. Additional variables were created for the combined posttest score and the calculated gain score. Combined posttest scores were created by adding the Smarty Ants posttest placement level and the Achieve3000 Literacy posttest Lexile measure while a calculated gain score was created by adding the Achieve3000

Literacy pretest and posttest scores then dividing the sum by two. Both variables were standardized through the creation of a *Z* score. As with the results of the previous research questions, descriptive analyses established that students in the combined high engagement group exhibited a greater increase in Lexile measures from the Achieve3000 Literacy pretest to the posttest as compared to the students in the combined low engagement group. In addition, the combined high engagement group had a higher calculated growth score than the combined low engagement group.

The paired samples test (*t*-test) evaluating Achieve3000 Literacy pretest Lexile *Z* scores and combined posttest *Z* scores according to combined engagement levels revealed statistical significance between the Means of the variables for students with high engagement, rejecting the null hypothesis. Results in this area were not statistically significant for students with low engagement and failed to reject the null hypothesis. However, strong paired samples correlations of statistical significance were identified for both engagement groups. In addition, the low engagement group demonstrated a high effect size. The ensuing *t*-test evaluated the relationship between Achieve3000 Literacy pretest Lexile *Z* scores and calculated gain *Z* scores according to combined engagement levels resulted in statistical significance between the Means of the variables for students in both engagement groups, rejecting the null hypothesis. Results also show statistical significance and very high paired samples correlations for both engagement groups.

The first ANCOVA conducted in response to the third research question evaluated the relationship between combined engagement levels and combined posttest *Z* scores with the Achieve3000 Literacy pretest Lexile *Z* scores as the covariate. The results for this analysis

generated statistical significance that rejects the null hypothesis, in the differences among the scores. Though results generated a moderate *R* squared correlation, they did not yield statistical significance in the *F*-test for Heteroskedasticity. The second ANCOVA evaluated the relationship between combined engagement levels and calculated gain *Z* scores with *Z* scores for the Achieve3000 Literacy pretest Lexile *Z* scores as the covariate. The results demonstrated statistical significance in the differences among the scores. Though the *F*-test for Heteroskedasticity in this ANCOVA did not show statistical significance, results generated very strong *R* squared correlations for both the high and low engagement groups; the strongest identified in the study. These findings established that the interaction between combined student engagement in Smarty Ants and Achieve3000 Literacy and Lexile measures in Achieve3000 Literacy was statistically significant, perhaps more so for the relationship between combined engagement and calculated gain scores. Although the sample size was small, these results showed that high engagement in both programs affected Lexile outcomes, affirming the literature on the relationship between foundational literacy and reading for comprehension.

Summary

While the ANCOVA controlled for the pretest, there was still a significant difference in the Means of the pretest and posttest Lexile measures. When a student has a pretest and treatment is applied over the course of a year, student performance generally improves in the posttest (R. Robnett, personal communication, March 10, 2022). Moreover, when using a pretest-posttest design, the difference can be attributed to the treatment (Leavy, 2017). The *t*-tests generated to evaluate the statistical significance between the Means of variables related to each research question revealed lower correlations for Smarty Ants than for Achieve3000 Literacy,

though all paired samples correlations tests were statistically significant. The results of each ANCOVA showed statistical significance at a p-value of $p < .001$ for each set of variables, with varying degrees of *R* squared correlations. The highest *R* squared correlation for the ANCOVAs as well corresponding paired samples correlations were between Achieve3000 Literacy engagement and posttest Lexile measures as well as between combined engagement and calculated gain scores. The relationship with the strongest level of statistical significance was between Achieve3000 Literacy engagement and Lexile growth due to the statistically significant results of the *F*-test for Heteroskedasticity corresponding with the ANCOVA for those variables. Despite the small sample size, the results indicated that student engagement levels in each and both programs together impacted student outcomes in Achieve3000 Literacy during the 2020-2021 academic year within the context of the COVID-19 pandemic. Given the strength of the *R* squared correlation results in the ANCOVAs and the *t*-tests, this was especially true for engagement in Achieve3000 Literacy and more so for combined engagement. In addition, these findings affirmed the literature regarding student engagement, the relationship between foundational literacy skills and reading for comprehension, and the literature on Achieve3000 Literacy.

Significance of the Study

This study can be a significant contribution to the literature. While most Achieve3000 research has been conducted with student data based on national results (Achieve3000, 2017b), this study centered on the work of nine Catholic elementary schools. Although the results may not be limited to the parochial school experience, they offer insight into the work of nonpublic schools and add to the limited literature on Catholic education. In addition, this study was among

the first to explore the role of students' concurrent engagement in Smarty Ants and Achieve3000 Literacy on Lexile outcomes. Results affirm the literature on foundational literacy skill development as a necessary element of reading for comprehension, which was used to develop the conceptual framework. As such, the findings serve to advocate for the concurrent use of the programs as a strategy for the acceleration of literacy development. Moreover, this study offers insight into the role of student engagement and technology in improving student reading outcomes while also affirming existing Achieve3000 Literacy research on the role of program engagement and student outcomes (Achieve3000, n.d.-c; Achieve3000 & MetaMetrics, 2020; MetaMetrics & Achieve3000, n.d.). By establishing a relationship between combined engagement in Smarty Ants and Achieve3000 Literacy and Lexile measures, this research also affirms the literature on the importance of foundational literacy in advancing reading for comprehension (Amendum et al., 2011; Hattie, 2009; NICHD, 2019; Tompkins, 2017). Having demonstrated statistical significance in the relationship between concurrent student engagement in Smarty Ants and Achieve3000 Literacy and Lexile outcomes, results reinforce the research that high student engagement on academic tasks improves student outcomes (Boykin & Noguera, 2011; Hattie, 2009; Sanchez, 2008). In addition to enhancing and affirming the existing literature, the results of this study can be used to promote recommendations for the field.

Recommendations for the Field

Research has demonstrated that inadequate literacy development reduces an individual's academic, economic, and career potential (Burroughs-Lange & Douëtil, 2007; Dorn et al., 2020a; Edmonds et al., 2009; Jehangir et al., 2015; Muhammad, 2015; Murphy & Justice, 2019; Palumbo & Sanacore, 2009; Partanen et al., 2019; Paschall et al., 2018; Pfost et al., 2014;

Reardon et al., 2012; Smith, 2014a). Adequate skill development in the five keys of foundational reading (vocabulary, phonics, phonemic awareness, comprehension, and fluency) has proven critical to shaping literacy development (Amendum et al., 2011; Hattie, 2009; NICHD, 2019; Tompkins, 2017). Among the challenges to developing a solid foundation, Petscher et al. (2020) contended that deficits in phonological processing contribute to reading difficulties. In addition, research has determined that "decoding and linguistic comprehension account for almost all the variance in reading comprehension" and that "linguistic comprehension and reading comprehension essentially form a single dimension" (Petscher et al., 2020, p. S270). Moreover, according to Pfost et al. (2014): "An absolute Matthew effect describes a developmental pattern in which the students who read better show further positive reading literacy gains, whereas the students who read worse show negative gains" (p. 205). Without adequate instruction, support, and/or intervention, the issue of equity and social justice in education has persisted as the most vulnerable members of our community "remain wedged at the bottom of the contemporary socioeconomic ladder" (Carter, 2018, p. 3). The impact of COVID-19 has increased the achievement gap and enhanced the urgency for accelerating student learning, especially in literacy (Lambert & Sassone, 2020; Smith, 2014a). Pursuant to this research as well as the literature on the widening achievement gap (Boykin & Noguera, 2011; Carter, 2018; Dorn et al., 2020a; Hansen et al., 2018 Jeynes, 2015; Johnson, 2002; Paschall et al., 2018; Wenglinsky, 2004), it is critical to ensure that students receive effective and adequate instructional opportunities to develop solid foundational literacy skills.

The results of this study provide insight to the potential benefit of technology-based solutions as tools for differentiation and acceleration (Pierce & Cleary, 2016; Smith, 2014a;

Taylor et al., 2020; Wilkes et al., 2020), especially as education shifts to academic acceleration in the context of COVID-19 (DeArmond et al., 2021; Lambert & Sassone, 2020; Lewis et al., 2021). In accordance with the conceptual framework underlying this study (see Figure 1) it would follow that ensuring students mastery of foundational skills while also receiving continuous opportunities to enhance their reading comprehension skills would increase reading capacity and performance. This was the rationale for the implementation of both Smarty Ants and Achieve3000 Literacy in the third grade at nine schools; while Smarty Ants addresses foundational skill building, including phonics (Achieve3000, n.d.-a, 2017a), Achieve3000 Literacy enhances reading comprehension with instructional linguistic opportunities (MetaMetrics & Achieve3000, n.d.). Due to the critical nature of foundational literacy in reading for comprehension (Amendum et al., 2011; Hattie, 2009; NICHD, 2019; Tompkins, 2017) as well as the design of Smarty Ants to address the five key areas (MetaMetrics & Achieve3000, n.d.), this study suggests that school leaders consider integrating Smarty Ants earlier on, perhaps requiring program completion as a prerequisite to third grade. As the strongest *R* squared and paired samples correlations were between combined engagement in Smarty Ants and Achieve3000 Literacy and calculated gain scores, results build the case for the integration of both programs in as a potential strategy for accelerating students' reading skill to address foundational literacy gaps in the third grade.

In this study, the Achieve3000 Literacy pretest Lexile measures of 241 students showed that 81.3% of students (n = 196) were below the grade level College and Career Readiness expectation of 520L (MetaMetrics, 2021b). While 47.7% of students demonstrated Lexile growth over 105L during the 2020-2021 school year in the context of COVID-19, the Achieve3000

Literacy posttest Lexile measures of 227 students revealed that 73.1% of students (n = 166) were still below a third-grade reading level. MetaMetrics (2021a) articulated that "students who are performing below grade-level often need to double or triple their expected growth over the course of two to three years in order to achieve college and career readiness by high school graduation" (p. 14). Results show that student engagement in Smarty Ants and Achieve3000 Literacy during the 2020-2021 efforts made a difference, though the effort must continue to effectively close the gap between students' actual and expected grade level literacy performance.

While American education is structured such that foundational literacy is prioritized in the early years (Hattie, 2009; Snow & Biancarosa, 2003), educators, school leaders, and policymakers must recognize that concentrated efforts in the primary grades is insufficient. Reading development should not end with the second grade (Smith, 2014a). This is especially true when considering the pervasive and persistent convergence of elements facilitating the achievement gap at all levels, including but not limited to: access to quality early education, immigration status, English language proficiency, cultural expectations and experiences, and adverse childhood experiences (Borrero & Bird, 2009; Harris, 2015; Johnson, 2002; Sanchez, 2008; Waldfogel, 2012; Wenglinsky, 2004). In response to the call for social justice in education the academic structure must be adjusted to ensure a continuum of literacy development through all grades (Hattie, 2009).

Schools must be prepared to evaluate readiness, support acceleration to readiness, and dimmish challenges to close the gaps earlier on and throughout the academic continuum, since beginning readers exist at all ages and all grade levels. If children have not mastered the necessary prerequisites to thrive as independent readers at or above grade level, or the

opportunities provided in the primary grades are insufficient, it is critical to provide effective interventions at all grade levels to ensure that all elementary and middle school students have equitable access to opportunities to learn to read at or above grade level as soon as possible. Policymakers, school leaders, and educators must embrace a philosophy that literacy is an integrated and continuous process of skill development extending beyond the second grade (Smith, 2014a). Schools and districts must adopt aligned curriculum, reading interventions, and practices that are evaluated through rigorous empirical studies (Petscher et al., 2020). If they are to be effective, programs must be implemented to fidelity to provide the intended results (Dusenbury, 2012). Furthermore, the educational system must adopt the philosophy that teaching literacy is the duty of all teachers. Educational leaders must ensure that school expectations and support align to continuously and effectively build the capacity of all educators to understand, assess, and teach literacy development in any grade level. Teacher and leadership preparation programs, professional development, and school districts must equip teachers to accelerate foundational literacy development for all beginning readers regardless of their grade level. The structures of education must establish philosophies, policies, and practices that effectively integrate literacy across all subjects and equip all educators with effective tools, resources, and strategies to evaluate and ensure that all students are making adequate progress toward and beyond grade level literacy.

Recommendations for Further Study

There are multiple opportunities for further research stemming from this study. As this study focused on a small sample it could be replicated with a larger population, ideally using equivalent groups participating in both or just one intervention to evaluate the impact and

performance variations. Since the study did not have comparative demographic information, the research might also be enhanced with a larger population offering comparisons across schools or demographic categories such as SES, race and/or ethnicity, language development, or special education qualifications. As the researcher defined engagement in Smarty Ants with a binary measure of complete or incomplete, future research may consider redefining engagement, using the levels mastered as continuous variables, or including three defined groups such as, high, medium, and low engagement levels. Similarly, as the researcher determined the criteria for engagement in Achieve30000 Literacy, future research might reconsider the criteria defining engagement in this program and evaluate the impact of outcomes. One might also consider investigating the elements contributing to student engagement or the school-based elements contributing to the literacy gap and offering further analysis on the effect sizes of these components. Future research might also provide insight into the multifaceted role of school and class culture and climate by examining the role of teachers especially regarding quality, expectations, relationships, instructional methodology and practice, program implementation, professional development, teacher preparation, motivation, and other factors contributing to student engagement in the programs. Such opportunities might include an evaluation of the effect sizes of factors contributing to student engagement and how such technology-based interventions can ameliorate it. Moreover, future research could evaluate the role of administrators or the effect size of the administrator's role in outcomes or program implementation to fidelity. Alternatively, a study might consider the role of parents, fleshing out an operational definition of parent engagement, how it contributes to student outcomes, and the corresponding effect sizes of such contributions.

Another area of focus for future research might include the extent to which student engagement in the literacy interventions evidenced progress toward meeting grade level Lexile expectations, how much progress individual students made, and the conditions under which they progressed. Considering that the effect of interventions diminishes within a year (Petscher et al., 2020), researchers may investigate the long-term impact of the intervention, in a quantitative or mixed methods study, focusing on the annual performance data of students over a period of three years.

As these programs were newly implemented with some sites, studies may focus on the role of implementation and factors contributing to successful application of the programs. Dusenbury (2012) argued that the quality of fidelity is affected by the degree to which a program is implemented as intended. In this vein, a researcher might investigate fidelity to operationalize it or to better understand its role in student outcomes. Replicating this study or conducting any of the suggested analyses with such qualitative elements as observations, interviews, focus groups, and surveys could give voice to the experience of students, teachers, parents, and administrators.

Conclusion

The achievement gap, as the descriptor for the variation in student performance according to SES, is an issue of social justice in education brought to national attention in the 1960s that has been further intensified by the COVID-19 pandemic (Borrero & Bird, 2009; Boykin & Noguera, 2011; Carter, 2018; Dorn et al., 2020a, 2020b; Jeynes, 2015; Johnson, 2002; Palumbo & Sanacore, 2009; Paschall et al., 2018; Snow & Biancarosa, 2003; Wenglinsky, 2004). The gap has extended across subject areas impacting students from low SES backgrounds and has resulted in diminished academic and economic outcomes (Burroughs-Lange & Douëtil, 2007;

Dorn et al., 2020a; Edmonds et al., 2009; Jehangir et al., 2015; Muhammad, 2015; Murphy & Justice, 2019; Palumbo & Sanacore, 2009; Partanen et al., 2019; Paschall et al., 2018; Pfost et al., 2014; Reardon et al., 2012; Smith, 2014a). While research on the achievement gap has predominantly focused on SES and race (Boykin & Noguera, 2011; Paschall et al., 2018; Rojas-LeBouef & Slate, 2012; Teale et al., 2007), this study focused on a literacy gap defined as the disparity between students expected and actual reading performance, which remains a clear issue of social justice in education. According to research, literacy is a multidimensional skill that has afforded a position of privilege in economic advancement, societal participation, and social mobility (Reardon et al., 2012; Tompkins, 2017; Venezky, 2016); an opportunity which all students should have access to regardless of their zip code, SES, immigration status, race, ethnicity, language, or disability. This study addressed this issue of social justice in education in an investigation of third-grade student engagement in concurrent literacy interventions and reading outcomes to offer a potential remedy for third-grade illiteracy. Rooted in research, Smarty Ants and Achieve3000 Literacy are two technology-based platforms that were used concurrently by nine Catholic elementary schools to solidify foundational literacy and enhance reading comprehension skills during the 2020-2021 academic year. The focus of this study was grounded in a conceptual framework created by the researcher (see Figure 1) based on the literature on literacy development. In line with this research, the combination of two programs attempted to accelerate third-grade students' acquisition of foundational literacy skills toward grade-level reading to reduce the number of students at risk for future failure due to underdeveloped literacy competence (Murphy & Justice, 2019; Snow & Matthews, 2016).

The quantitative analyses conducted in this study were framed in a quasi-experimental pretest-posttest design and used archived student performance data from 2020-2021 school year to find statistical significance between student engagement in Smarty Ants and Achieve3000 Literacy and student posttest Lexile scores and Lexile growth scores. The findings in this study affirmed the research on the importance of foundational skills in the development of literacy (Amendum et al., 2011; Hattie, 2009; NICHD, 2019; Tompkins, 2017), as well as Achieve3000's claim that students who actively use of Achieve3000 Literacy make gains in their reading skills (MetaMetrics & Achieve3000 Literacy, n.d.), in addition to the value of technology as a potential resource for acceleration (Lambert & Sassone, 2020; Taylor et al., 2020; Wilkes et al., 2020). Since the results for combined engagement and calculated gain scores in the two programs showed statistical significance, they evidence the valuable relationship between concurrent engagement and student outcomes. While data showed that 77.2% of students exhibited growth on Lexile measures and 47.7% demonstrated over 105L growth, the extent to which individual students made progress toward grade-level reading was not the focus of this research. This suggests an opportunity for further study, as do several qualitative elements that were not included in this quasi-experimental study. For instance, one might also consider investigating the elements contributing to student engagement, perhaps redefining the terms, and offering further analysis on the effect sizes of these components. Longitudinal studies on the effect of interventions over time may also provide further contributions to the field and better inform practitioners seeking to stop the injustice of illiteracy in elementary education. This study focused on the third grade as the critical hinge point for future success (Murphy & Justice, 2019; Snow & Matthews, 2016), though there is a clear need to support students in fourth grade and

beyond as literacy is a lifelong skill requiring ongoing opportunities for development. In response to the call for social justice, literacy instruction across the grades must be bolstered to meet the needs of all learners, especially considering what is known about the convergence of factors perpetuating the literacy gap in education and the impact of COVID-19 on education. Consequently policymakers, administrators, and educators must heed the call and prepare all PK-12 teachers to effectively develop a rich literary capacity for all students at all grade levels in a collective effort close the achievement gap in literacy.

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