Can I Do Math If I Can't Read? The Relationship between Reading and Mathematics Standards of Learning Assessments in One High School in Virginia

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Abstract

How well students perform in mathematics and sciences continues to be a measure of a country's worth (Conference Board of the Mathematical Sciences [CBMS], 2012). Nations that want an educated citizenry have consistently studied ways in which to improve performance in mathematics (Claessens & Engel, 2013; Dearing et al., 2012; Draper & Siebert, 2004). More and more researchers have examined the relationship reading has on mathematics performance (Grimm, 2008; Halaar, Kovas, Dale, Petrill, & Plomin, 2012). This study was an effort to contribute to this growing body of knowledge. Therefore the purpose of this study was to examine what relationship exists between reading and mathematics and whether early reading performance could predict subsequent mathematics performance as measured by the Virginia Standards of Learning Assessments.

Using a sample of students from a Virginia high school, this quantitative study utilized Virginia Standards of Learning (SOL) tests as instruments and Chi-square Test of Association as the analysis to address the research questions:

1. What is the relationship between Virginia Standards of Learning (SOL) reading performance and SOL mathematics performance at each grade level in Grade 3 through Grade 8?
2. What is the relationship between SOL reading performance in Grade 3 and subsequent performance on Virginia SOL End-of-Course Algebra I assessment?
3. To what extent does SOL reading performance in Grade 3 predict subsequent performance on Virginia SOL End-of-Course Algebra I assessment?

Virginia SOL reading performance was found to be associated with mathematics performance at each grade level. Reading performance at Grade 3 was not found to be associated with Algebra I EOC performance. Grade 5, Grade 6, Grade 7, and Grade 8 reading performance were all found to be associated with Algebra I EOC performance.

As a limitation, this study utilized data from assessments designed to assess the 2001 Virginia SOL standards, which have since been updated. Therefore should be replicated using

the current standards. The results of this study could be used to assist teacher leaders, principals, division leaders, and teacher preparation program leaders with working with teachers to address reading and mathematics deficiencies in a different way.

Dedications

I would like to dedicate this entire journey first to God, without whom nothing is possible and who has blessed me over and over to be where I am today. Secondly I would like to dedicate this to my son Jaylen (The Boy) and my fiancé (husband by graduation) Donald, who have sacrificed much time with me while I have gone through this process. You have been the wind beneath my wings and your patience is amazing. Next, I would like to dedicate this to my mother, Dr. Fides Ushe. In addition to being my personal statistician, she is my inspiration and the yardstick on which I measure myself. Thank you for your guidance, courageous conversations, and help along this journey. To my brother Dr. Mwiza Ushe and my sister Kumbi Ushe, thank you form always reminding me that “We don’t quit.” I would also like to dedicate this to my late father Dr. Samson Ushe, who opened the door to higher education for me. Finally, I would like to dedicate this to my late grandparents, Plaston Chilonde and Variness Chapasi Chunda, who were the first to instill in me the love for learning, and the importance of education. I know they are both smiling down on me from heaven.

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Table of Contents

List of Tables

List of Figures

List of Appendix Tables

Chapter One

Introduction

Background of the Problem

In the publication, *Before It's Too Late: A Report to the Nation from the National Commission on Mathematics and Science Teaching for the 21st Century,* the National Commission on Mathematics and Science wrote, "The commission is convinced that the future wellbeing of our nation and people depends not just on how well we educate our children generally, but on how well we educate them in mathematics and science specifically" (National Commission on Mathematics and Science Teaching for the 21st Century, 2000, p. 4). This belief is held worldwide. The Programme for International Student Assessment (PISA) is a worldwide assessment administered by the Organisation for Economic Co-operation and Development (OECD) to measure 15-year-old students' performance in mathematics, science, and reading. The 2013 PISA report urged participating countries to recognize that how well students perform in mathematics is "a strong predictor" (p. 6) of how well students will progress in their education beyond secondary school, as well as the standard of living they will achieve based on their future earnings (Organisation for Economic Co-operation and Development [OECD], 2013). In the same year, the OECD also conducted the Survey of Adult Skills, in which they demonstrated that basic skills in mathematics impact the overall quality of life and the prospects for future income of an individual.

> The survey shows that poor mathematics skills severely limit people's access to better-paying and more-rewarding jobs; at the aggregate level, inequality in the distribution of mathematics skills across populations is closely related to how wealth is shared within nations. Beyond that, the survey shows that people with strong skills in mathematics are also more likely to volunteer, see themselves as actors in rather than as objects of political processes, and are even more likely to trust others. Fairness, integrity, and inclusiveness in public policy thus also hinge on the skills of citizens. (OECD, 2013, p. 6)

Today's high school graduates are expected to be strong at the critical thinking, problem solving, and analytical skills that a strong grasp of mathematics provides (Mathematics Advisory Panel, 2008; NCTM, 1998; OECD, 2013; Wimberly & Noeth, 2005). Many researchers have invested time to examine factors that influence how students perform in mathematics (Ball, 2005; Battista, 1999; Claessens & Engel, 2013; Shaftel, Belton-Kocher, Glasnapp, & Poggio, 2006). Some have explored how students' socioeconomic backgrounds influence mathematics performance (Evans, 2005). Others have honed in on the early preparation of students (Claessens & Engel, 2013), while still others have examined classroom instruction in order to identify areas in which we can improve mathematics performance for all students (Battista, 1999, 2006). What scholars do agree on is that to be well-versed in mathematics, one must learn to be a critical thinker and be able to decipher information beyond the rote memorization required for proficiency in arithmetic computation (Ball, Hill, & Bass, 2005; Battista, 2006, NCTM, 1998). One must be a problem solver who understands mathematics well enough to use it as a means for problem solving, as well as a means for communication. In other words, the language of mathematics must be mastered so that students can not only access the knowledge required to solve the real-life problems before them, but also communicate that solution to others and be able to generalize the solution to similar situations (Battista, 2006; NCTM, 1998). This mathematical language mastery happens through reading and writing (National Council of Teachers of Mathematics [NCTM], 2000). Those who wish to have robust participation in the 21st century will have to "read and write more than at any other time in human history" (National Institute for Literacy, 2007, p. 1). These literacy skills are paramount to accessing daily life information, as well as performing in one's chosen career.

Presented in this chapter will be the statement of the problem followed by the conceptual framework that drove the investigation and the purpose of the research study. The significance of this study, research questions, and definition of terms, will follow the purpose of the study. At the conclusion of the chapter will be the limitations and delimitations of the study, as well as a brief outline of the dissertation document.

Statement of the Problem

Many empirical studies in the United States have focused on improving reading and writing (i.e. literacy) and mathematics separately (Ball et al., 2005; Buechler, 2004; Draper & Siebert, 2004). Some studies have examined the relationship between reading comprehension and testing (Abedi, 2004; Craig, Zhang, Hensel & Quinn, 2009; Mullins, 1955). More studies have examined how other interventions have affected mathematics and reading performance together (Oakland & Stern, 1989; Draper & Siebert, 2004). In recent years, more and more researchers are studying the relationship between reading and mathematics (Grimm, 2008; Halaar, Kovas, Dale, Petrill, & Plomin, 2012; Hart, Petrill, Thompson, & Plomin, 2009). Vista (2013) in Australia and Bohlman and Pretorius (2008) in South Africa examined the relationship between reading comprehension and mathematics performance. In both cases, the researchers sought to examine the relationship between English reading comprehension and mathematics when English is the language of learning, but not the first language of the student. More recently, there have been studies that have examined reading proficiency as a predictor of mathematics performance (Halaar et al., 2012; Hart et al., 2009). The intent of this study was to contribute to this growing body of knowledge. The purpose of the current study was to examine what relationship exists between reading and mathematics and whether early reading performance can predict subsequent mathematics performance as measured by the Virginia Standards of Learning Assessments. This was in an effort to determine the predictability of mathematics performance based on reading performance, thereby finding another area of early intervention so that we can improve mathematics performance.

National Council of Teachers of Mathematics (NCTM) Perspective and Conceptual Framework

In 1989**,** the National Council of Teachers of Mathematics (NCTM), the international professional organization for mathematics teachers, published *Curriculum and Evaluation Standards for School Mathematics* in order to establish common goals for mathematics education. Following extensive input from various sources, in 1998 the NCTM released *Principles and Standards for School Mathematics* as a resource for curriculum, teaching, and assessment of mathematics. This 1998 publication identified principles and content standards for Pre-Kindergarten through grade 12. Perhaps most significant to the current study are the NCTM's process standards. These standards are problem solving, reasoning and proof, communication, connections, and representations (NCTM, 2000). Under each process standard, there are related skills students should be able to develop as they learn mathematics from prekindergarten through Grade 12. For example, under reasoning and proof, students are supposed to draw and investigate mathematical conclusions based on data (NCTM, 2000). The process standards most relevant to this study were problem solving and communication. The

NCTM stresses that students' problem solving is not only what is to be learned in mathematics but also the process by which mathematics is learned. Related to the ability to learn, apply, and problem solve in mathematics is the ability to read and comprehend on a high level. Reading is also central to being able to accomplish the process standard of communication, which requires that students share ideas and clarify the problem solving process in writing and orally (NCTM, 2000). Based on these processing standards, it is evident that learning mathematics is no longer just a rote practice of computation in order to arrive at an answer (Battista, 1999). One of the goals of learning and teaching mathematics is to create problem solvers who can understand, interpret, model, and communicate solutions to complex problems that are in the context of real life (Battista, 1999; Johnson & Uline, 2005; Phillips, 2007). The conceptual framework that drove this study was that the ability to read, comprehend, discern, and critique information cannot exist without the ability to think critically, to communicate, and to problem solve—all of which are critical to the successful learning of mathematics. Figure 1 illustrates this framework.

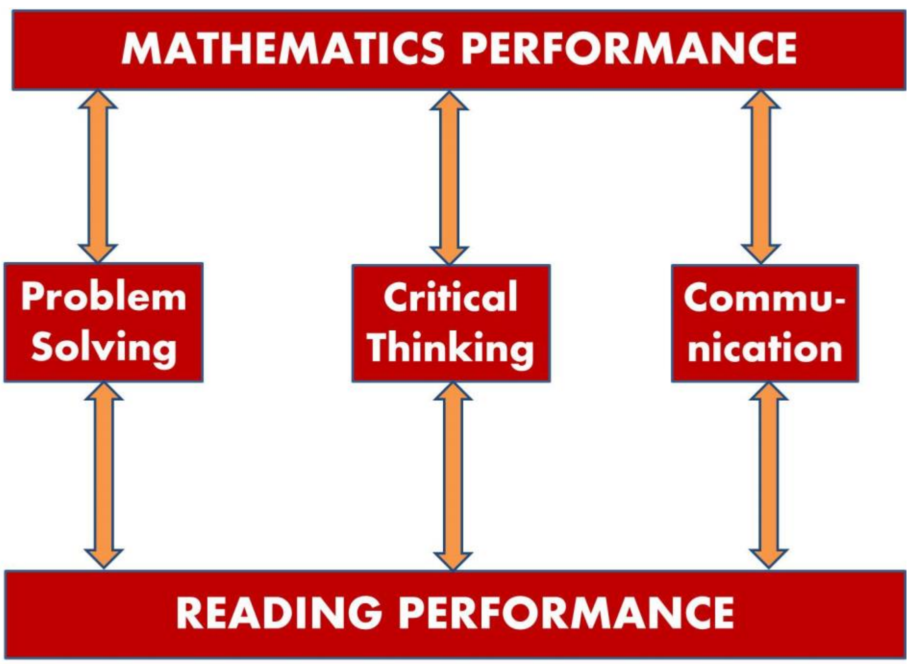

Figure 1. *Conceptual Framework. The relationship between reading performance and mathematics performance.*

Purpose of the Study

Mathematics education is crucial to the growth of any community or nation (National Mathematics Advisory Panel, 2008; OECD, 2013). As such, it is paramount that educators seek ways to ensure that students are successful in mathematics. Given the importance of reading to achieving mathematics proficiency at the level detailed by the NCTM, it is important that we examinee this relationship directly. To that end, the purpose of this study was to examine what relationship exists between reading and mathematics and whether early reading performance can predict subsequent mathematics performance as measured by the Virginia Standards of Learning Assessments.

Significance of the Study

Educators are constantly seeking to discover research-based strategies that can be undertaken at the school level to improve student achievement in all areas (Adelman, 2006; Draper & Siebert, 2004). Mathematics instruction has not been immune to this scrutiny (Battista, 1999; Coles, 2014). While this body of research is growing, it is important to continue the discussion and examine the direct relationship between reading and mathematics, and whether or not reading performance can predict mathematics performance. The present study examined this relationship directly, with the intent of identifying a potential area of intervention for improving mathematics performance for all students. This study was significant in that it provides empirical evidence to support examining how secondary mathematics content-area teachers are trained so that reading becomes part of the preparation they receive before becoming teachers. The results of this study should be used by leaders in school division to examine how the teaching and learning of mathematics and reading is currently approached in order to support making necessary changes that will improve student achievement in both areas.

Research Questions

This study sought to address the following questions:

1. What is the relationship between Virginia Standards of Learning (SOL) reading performance and SOL mathematics performance at each grade level in Grade 3 through Grade 8?

2. What is the relationship between SOL reading performance in Grade 3 and subsequent performance on Virginia SOL End-of-Course Algebra I assessment?
3. To what extent does SOL reading performance in Grade 3 predict subsequent performance on Virginia SOL End-of-Course Algebra I assessment?

Definition of Terms

Some key terms were used throughout this paper and are defined to aide in understanding their usage.

Content Literacy. The term content literacy was coined to describe the ability for one to gain knowledge in a particular discipline through reading and writing (McKenna & Robinson, 1990).

Standards of Learning (SOL) End-of-Course Assessments. This term is used to denote summative assessments administered at the conclusion of a particular course to measure the level of mastery in the course (Virginia Department of Education, 2014). The Commonwealth of Virginia administers these criterion-referenced assessments.

Delimitations and Limitations

Delimitations detail the constraints placed upon a study by the researcher (Roberts, 2010). The sample of this study is limited to students in the selected school for whom the desired data points for analysis are available. Thus, it will be difficult to generalize to the larger population (Creswell, 2009). Therefore, generalization beyond the school in the study is not recommended (Howell, 2011).

Limitations, however, are those outside the control of the researcher (Creswell, 2009). The limitations of this study were particularly attributed to sample selection. The use of existing data prohibited the researcher from being able to control the conditions under which students were tested and how the data were recorded and reported. Because the sample was limited to students for whom all desired scores existed, the sample size may have been affected by attrition resulting in a threat to internal validity (Creswell, 2009). Another limitation involved the time elapsed between the times that the compared scores occurred, which could have involved various factors to explain the variability in the scores. Elapsed time made it difficult to account for any other interventions that may have been in place that may have affected the outcome (Rudestam & Newton, 2015).

Organization of the Dissertation

This dissertation will be presented in five chapters. Following this introductory chapter, chapter 2 contains a review of literature relevant to the study which includes other factors that have been shown to have a relationship with mathematics performance, research in content literacy and studies that have examined the relationship between reading and mathematics. The methodology is presented in chapter 3, detailing the population being examined, the instrumentation, and the analysis employed. Chapter 4 contains the results of the data analysis and in chapter 5 the researcher presents the summary, implications for practice, and recommendations for further study based on the findings.

Chapter Two
Review of Literature

Introduction

The purpose of this study was to examine what relationship exists between reading and mathematics and whether early reading performance can predict subsequent mathematics performance as measured by the Virginia Standards of Learning Assessments. Presented in this literature review are factors that have been shown to impact mathematics performance in school children. The focus, however, was on research that examined the relationship between reading, literacy, and mathematics performance. The review started with a cursory presentation of the issues that have been found to influence mathematics performance globally. These issues were socio-economic status (SES), mathematics teaching methods, teacher preparation, and early exposure to mathematics.

In researching mathematics performance, the conceptual framework driving this study was that student performance in mathematics has a relationship with performance in reading through the skills of critical thinking, problem solving, and communication. In exploring the relationship between reading and mathematics specifically, it was important to explore work done in content literacy and its relationship to learning in general, as well as to the learning of mathematics. The relationship between language and testing of mathematics, and the relationship between reading and the testing of mathematics was also examined. This included how the reading grade-level of mathematics test items is related to mathematics test performance, as well as how language and reading may affect English Language Learners and Students with Disabilities.

Search Process

The primary sources of literature used in this review were online research databases, starting with the resources of the Virginia Tech University Libraries. To present the current state of affairs, it was necessary to delve into the National Center for Educational Statistics (NCES) website, which was a tremendous source for the data that are presented in this review. The majority of the publications used were published or written in the last 20 years and the search was limited to peer-reviewed journals and national policy reports and documents. The keywords used in the search were "relationship between reading and mathematics", "content literacy", "efficacy and mathematics", "early mathematics exposure", "mathematics teacher preparation", "SES and mathematics", "achievement gap". Articles unearthed from these keywords led to scholarly databases such as EBSCOHost, ScienceDirect, Springer, and ERIC which in many cases provided works that cited the current article, as well as directed me to works that were relevant to the topic of interest. This led to resources that were available from international organizations and government agencies dedicated to education research. Oft cited works were also examined for relevance to the current research and included as primary sources.

Issues Related to Mathematics Performance

Socioeconomic status (SES). Socioeconomic status (SES) is typically defined by one's social position usually associated with levels of education, career, income, and wealth (Batool et al., 2010; Chaudhury, 1986). SES is often discussed in research as a factor influencing achievement and performance because of its relationship with student performance (Caro, McDonald & Willms, 2009; Evans, 2005; Hunter & Bartee, 2003; Van Laar & Sidanius, 2001). Many researchers believe that the racial and language achievement gaps are in fact gaps along income lines (Evans, 2005; Krashen & Brown, 2005; Yeung & Conley, 2008).

The discrepancy in mathematics performance of children from low-income and high-income backgrounds can be as much as three grade levels and the gap widens as students grow older (Murphy, 2009). In a 2005 study, Kamii, Rummelsburg, and Kari examined 26 low-income, low-performing first graders in Bay Point, California. The focus of the study was on their mathematics performance. What the researchers discovered was that these students came to school without what the researchers termed "logico-mathematical" skills (Kamii, Rummelsburg, & Kari, 2005). Kamii, et al. defined "logico-mathematical foundation" as the "mental relationships which have a source in each individual's mind" (Kamii et al., 2005, p. 40). For example, when the authors showed students a number of chips and asked students how many there were, these students were able to count and state the correct number. When the researchers hid the same number of chips, however, and asked the students how many chips they were hiding, the students were not able to make the connection and give the same answer (Kamii et al., 2005). This logico-mathematical knowledge seems to be better developed in students from middle class families than in lower-income families (Kamii et al., 2005). Kamii et al. reported that low-SES first graders perform about as well as wealthier three-to-four-year olds.

Dearing and Tang (2010) asserted that time, effort, and materials provided to support education are integral in the academic growth of a child. These tend to be limited, if not missing completely in homes with limited financial resources. According to the authors, children must be provided with materials that stimulate learning, as well parents who have the time and resources to be personally involved in their children's education. In a 2011 study that examined the spatial and early numeric skills of 127 low-income girls between the ages of six and seven, Dearing, Casey, Ganley, and their colleagues reported that once the general educational quality of students' home and mathematics exposure were made equal, there was no significant relationship between SES and mathematics performance (Dearing et al., 2012). Evans (2005), in studying the achievement gap between the mathematics performance of African American and Latino students and the performance of White and Asian students, suggested that the gap is due more to economic conditions over which schools do not have control than simply racial lines. As Evans reported, "Nearly 90% of the variance in students' math scores on some tests can be predicted without knowing anything about their schools; one only needs to know the number of parents in the home, the level of the parents' education, the type of community in which the family lives, and the state's poverty rate" (p. 584).

There are scholars, however, who have cautioned that it is too simplistic and shallow to look at SES alone as a factor in educational outcomes (Mayer, 2002; Yeung & Conley, 2008). These researchers have advised that it is important to examine differences among high SES and low SES parents and students. These scholars have suggested that there are characteristics that account for the differences in school performance that are difficult to measure such as ambition, parenting style, and even genetically endowed intelligence (Yeung & Conley, 2008). For example, Magnuson and Duncan (2006) encouraged looking deeper at what low SES means to a family's mental and physical health and how that translated to school performance for children. Magnuson and Duncan maintained that wealthy parents tend to be healthier and thereby provide better learning environments for their children. Of course it is unwise to generalize that this is true for all wealthy parents as there are many examples to the contrary. The converse is also true in that not all poor parents are unable to provide a suitable learning environment for their children.

Other scholars have argued that schools tend to treat students differently based on the student's SES status. Children from poor families are often placed with other low-income, low-achieving students, thereby widening the achievement gap (Caro et al., 2009). Using data from Canada's National Longitudinal Study of Children and Youth, Caro et al. (2009) examined the achievement gap between low and high SES students between the ages of 7 and 15. The focus was on mathematics performance. The researchers found that beginning at age 12, the achievement gap began to widen as high-SES students gained mathematical knowledge at a fairly constant rate, while the mathematical knowledge of low-SES students actually started to decline (Caro et al., 2009). Caro and colleagues asserted that practices such as tracking and ability grouping have been shown to perpetuate the achievement gap in mathematics because poor students tend to be placed in the lower tracks, while more affluent students are exposed to advanced and college preparatory coursework (Caro et al., 2009).

In addition to the issue of the performance of studying low-income-student, Flores (2007) discussed how schools in low-SES neighborhoods have a difficult time attracting and retaining talented teachers who can offer the rigor necessary for students to advance in mathematics. He pointed out that about 34% of those teaching mathematics in low-income schools do not have a major in the subject compared to only 19% in high-income schools (Flores, 2007). Although there is much debate on how SES affects learning, especially in mathematics, researchers agree that SES is a factor that does influence performance for some, if not most students.

Mathematics teaching methods. The discussion of best practice in teaching mathematics is ongoing (Ball, et al. 2005; Battista, 1999; Conference Board of the Mathematical Sciences [CBMS], 2012; Kapur 2009). While most scholars have agreed that mathematics teaching should move beyond mere memorization of facts to a focus on problem solving and conceptual understanding (Ball et al., 2005; Cole, 2014; Kapur, 2014) there are still differing ideas about the best way for students to learn mathematics. There are those who believe in a constructivist approach with an emphasis on inquiry and problem solving (Battista, 1999; NCTM, 1998), as opposed to the typical teach-practice-reteach method present in many schools. Battista (1999) has argued that the reason the United States continues to lag behind other countries in mathematics is because American educators have ignored what research says about how students learn mathematics. He has likened the phenomena to being treated by physicians who ignores current findings and insists on treating their patients using outdated methods and equipment. Battista has chided educators by stating that the current methods of teaching mathematics focus merely on computation and do not teach students a conceptual understanding of the mathematics taking place behind the computation. Instead, Battista has stated, educators should recognize that "all major scientific theories describing students' mathematics learning agree that mathematical idea must be constructed by students as they try to make sense of situations (including, of course, communications from others and textbooks)" (Battista, 1999, p. 429).

Kapur (2009), like Battista (1999), favored the constructivist approach and has asserted that students learn more when they struggle through mathematics. Kapur coined the phrase "productive failure" (p. 1008), whereby students are allowed to struggle through a problem to the point where they fail to arrive at a correct solution. Kapur (2014) theorized that this failure leads students to think in a different way that causes them in turn to develop a deeper understanding of the mathematical concept they were initially studying (Kapur, 2014). Oguntoyinbo (2012) discussed how productive failure is in direct contrast with how mathematics is currently taught in many K-12 institutions. He theorized that the focus on testing has led teachers to teach for testing rather than for complete and thorough understanding of the mathematics and the reasoning behind the steps (Oguntoyinbo, 2012). This in turn has minimized the thinking required to truly understand mathematics.

As a point of consideration, however, Kirschner, Sweller, and Clark (2010) cautioned against reliance on minimal guidance, or discovery, and problem-based learning without developing the appropriate prior knowledge necessary for students to access the desired content. The researchers urged that as students increase their knowledge through direct instruction, they have the tools to then be successful in inquiry-based instruction (Kirschner, Sweller, & Clark, 2010). Whether discussing Battista's (1999) constructivist approach, or Kapur's (2009, 2014) productive failure, learning of mathematics cannot occur without the ability to read for comprehension.

Teacher preparation. "Although the typical methods of improving U.S. instructional quality have been to develop curriculum, and—especially in the last decade—to articulate standards for what students should learn, little improvement is possible without direct attention to the practice of teaching" (Ball, Hill, & Bass, 2005, p. 14). In other words, we cannot have a conversation about mathematics learning and neglect how the intimate knowledge of the subject matter and ability to teach it affect student performance. What a teacher knows is significantly related to how students perform and achieve (Hill, Rowan, & Ball, 2005).

With the understanding that teacher knowledge is important to student achievement, the No Child Left Behind Act (NCLB),

> requires that all new middle- and high-school teachers demonstrate subject-matter competency by 1) passing a state academic subject test in each of the subjects in which they teach; or 2) completing an academic major, a graduate degree, coursework equivalent to an undergraduate academic major, or advanced certification or credentialing in each of the subjects in which they teach. (Public Law 107-110, Section 9101 [23])

However, according to Educational Testing Service (ETS) (2010), 17% of teachers teach for three years before taking the Mathematics Praxis 2 Exam, which is required in most states for teacher certification and credentialing (Gitomer & Qi, 2010). Of those who take the exam, those who pass on their first attempt, pass by mean scores that are as high as two standard deviations above those who fail it. This means that those who fail it cannot possibly pass the test without gaining new knowledge in the subject matter (Gitomer & Qi, 2010). Therefore, in some cases teachers have been teaching mathematics while lacking the necessary knowledge to do so.

The possibility that there are teachers who may not have the proper mathematical knowledge to teach is consistent with the findings of the Conference Board of Mathematical Sciences (2012), which has asserted that most middle school mathematics teachers do not have the preparation needed to teach mathematics at the rigor level necessary for students to be prepared for high-school mathematics and beyond. The board has stated that most of the mathematics teachers teaching at middle and high school levels have general education elementary school preparation, and therefore the board has recommended that schools move to having teachers with specialization in teaching middle and high school mathematics (CBMS, 2012). Ma (1999), perhaps stated it most profoundly when she questions “Could it be that the learning gap was not limited to students?” (p. xix).

Research also indicates that mathematics teachers and other content teachers are rarely taught how to teach reading in their content (Shanahan & Shanahan, 2008). Research, however, has been weak in identifying exactly how teacher knowledge impacts student achievement, and thus what interventions can be made. It becomes difficult to quantify how knowledge of mathematics translates to student achievement because of inconsistent methods in determining the competencies necessary for teachers to effectively improve student achievement. While there is agreement that teacher subject-matter knowledge is important, there is little research that has been able to draw concrete conclusions about specific factors that influence good teaching or teaching that results in improved student achievement (Ball et al., 2005; National Mathematics Advisory Panel, 2008).

Early exposure to mathematics. Scholars have agreed that early exposure to mathematics has far-reaching implications in students' subsequent mathematics achievement and performance (Aubrey, Dahl, & Godfrey, 2006; Claessens & Engel, 2013; Entwistle, Alexander, & Olson, 2005; Sarama, Lange, Clements, & Wolfe, 2012; Siegler et al., 2012). Research on the life-cycle learning process has shown that there is a multiplier effect on skill, meaning that one needs a previously learned skill in order to be able to gain a new skill (Cunha, Heckman, Lochner, & Masterov, 2006).

This is certainly true of mathematics. Children who enter school with some knowledge of mathematics consistently perform better than their less prepared counterparts (Aubrey et al., 2006). In their 2006 study of six-year-old elementary school students, Aubrey et al. (2006) found that children who came to school with more mathematical knowledge scored higher on tests taken one year after entering school. In a 2013 study, Claessen and Engel (2013) used the Early Childhood Longitudinal Study-Kindergarten Cohort data to follow a group of students to the eighth grade. The researchers found that early math skills predicted reading, math, and science achievement, as well as grade retention from kindergarten through eighth grade. The impact of these math skills on later performance increases over time (Claessens & Engel, 2013) and has been found to be a predictor for subsequent success in Algebra once students reach high school (Siegler et al., 2012) and a predictor for high school graduation (Dearing et al., 2012). This means that the gap between those who come to school with previous knowledge and those who do not will either be maintained or will only widen as those more prepared students grow at faster academic rates than those without the early preparation. "It is concluded that without active intervention, it is likely that children with little mathematical knowledge at the beginning of formal schooling will remain low achievers throughout their primary years and, probably, beyond" (Aubrey et al., 2006, p. 27).

As discussed earlier, wealth can determine the extent to which students have access to early preparation in mathematics because "many children from low-SES backgrounds come to first grade with no… notion of numbers, but they are expected to learn arithmetic" (Kamii et al., 2005, p. 39). The National Mathematics Advisory Panel (2008) concurred with this assessment and has recognized that there are children from low-income backgrounds who start school behind their middle-to-upper-income counterparts and many times never catch up to them. Dearing et al. (2012) contended that interventions that involve mathematics activities at an early age, however, have been shown to mediate the effects of socio-economic status. Specifically, Dearing and colleagues studied 127 first-grade girls' early numerical and spatial skills, while examining the home environment in which these skills were developed. The authors found that when poor students were provided with the resources in the home to prepare them mathematically, they entered school with fewer disadvantages than those without the resources. These resources can be books, games, and other material that engage students and stimulate spatial and numerical skills in children (Dearing et al., 2012).

In 1973, while studying scientists, Merton introduced what is commonly known as the *cumulative advantage theory*. Merton's theory is that one's advantage (whether social, political, wealth, etc.) over another person increases over time (Merton, 1973). Therefore, students who do not begin with the same knowledge as others will have a difficult time gaining equal footing. It becomes, then, imperative for educators to continue to find ways to bridge the learning gap for students in all areas, especially mathematics. One area in which we can do so is through the very method by which students access learning and are able to apply the learning. This area is literacy and more specifically, content literacy (Vacca & Vacca, 2005).

Content Literacy

It is difficult to find a scholar at any point in time who does not agree that the ability to read and to read with comprehension is fundamental to learning. In recent years more emphasis has been placed on the ability to read within the subject matter or content, which has led to the term "content literacy" (McKenna & Robinson, 1990; Vacca & Vacca, 2005). Researchers have enough empirical evidence to support the importance of content literacy that they champion direct instruction in the reading and writing within individual content areas (National Institute for Literacy, 2007). It is critical for students to be able to gain knowledge by reading information and understanding the language of subjects like mathematics, history, and science (Moss, 2005). The same is true for testing this knowledge within various content areas. Students need to be able to understand what is being asked and then be able to apply their acquired knowledge to respond correctly to the questions (Moss, 2005; Moats, 2001). "Furthermore, they need to develop the critical reading abilities associated with thinking like a mathematician, historian, or scientist (Moss, 2005, p. 49). When it comes to mathematics, reading becomes even more specialized and precise, with each word having a special meaning depending on the context (Shanahan & Shanahan, 2008). Specifically, "without well-developed reading and language skills, learners will not be able to develop mathematical thinking skills such as generalizing, explaining, describing, observing, inferring, specializing, creating, justifying, representing, refuting, and predicting" (Bohlman & Pretorius, 2008, p. 49).

Reading and the Implications for Mathematics Performance

In recent years, more researchers are examining the relationship between reading and mathematics (Grimm, 2008; Halaar et al., 2012; Hart et al., 2009; Sokol, 2012). In the recent past, however, reading and mathematics were the dependent variables in studies that examined the effect of another intervention. In many others, the focus was on how English as a second or foreign language affected mathematics performance, but not how reading directly affects mathematics performance. Thus, the literature presented included studies from other nations as well as studies that investigated the impact of reading or content literacy and language on the learning and testing of mathematics.

Timothy and Cynthia Shanahan of the University of Illinois at Chicago are cited by numerous content literacy researchers and are arguably regarded as authorities in the field (Entwistle et al., 2005; National Institute for Literacy, 2007; Yeung & Conley, 2008). They have conducted several studies on the subject, and their stance is that we need to be even more specific by discussing "disciplinary literacy" as opposed to just the thought that each teacher needs to also teach reading (Shanahan & Shanahan, 2008). They have cautioned that without recognizing the different needs of the different disciplines, teachers will become frustrated trying to teach literacy in a manner that may be irrelevant to their subject matter.

In their 2008 study, Shanahan and Shanahan sought to study disciplinary literacy by consulting content experts and subject teachers to identify the specific types of literacy needed in mathematics, history, and chemistry. Through their Carnegie Corporation project in Chicago the study was aimed at identifying strategies for teaching literacy to adolescents. They brought together teachers and other experts to read and then recorded their thoughts on what they were looking for as they read. The experts were placed into teams by content, and the teams consisted of two college professors who were researchers in the content, two teacher educators who worked preparing teachers to teach the content in high school, and two high school teachers who were currently teaching the content. The Shanahans served as literacy experts on each team. They collected data on how these disciplinary experts read and used their individual texts, the types of comprehension strategies needed, and how each discipline could teach those strategies to adolescents in order to improve student achievement. The first year of the study was to work with mathematics, history, and chemistry teachers and specialists to identify the skills necessary for students to be able effectively learn the material. The second year of the study was spent training beginning teachers in the strategies, implementing the strategies, and collecting data on how the strategies worked.

The Shanahans (2008) discovered that indeed there are different types of reading and literacy necessary for success in each subject matter. For example, chemistry teachers talked about how they visualized and wrote formulas or drew diagrams as they read. This led the team to identify the strategy of transformation of information. The history teachers focused on the author or primary sources. Central to this review, the mathematics specialists pointed to close reading and rereading as two of their most impactful strategies. In mathematics, the teams discovered that “function” words were important. For example “the” can require a completely different problem solving strategy than “a”. The mathematics team discussed how reading in mathematics requires “a precision of meaning” (p. 50) with each individual word having a specific meaning that is important in understanding and applying mathematical concepts. This study provided the specific emphasis on the type of reading skills needed for mathematics. The concern is the ability to generalize to how students truly learn mathematics. Students learn differently, and I question whether the strategies discussed truly would work for all children.

Relationship between reading and mathematics. As the relationship between reading and other contents becomes more evident, more researchers are examining this relationship more directly (Bohlman & Pretorius, 2008; Craig, Zhang, Hensel, & Quin, 2009; Halaar et al., 2012; Hart et al., 2009; Sokol, 2012).

Grimm (2008) examined the relationship between early reading and changes in mathematics to see if students with better earlier preparation in reading had faster growth in mathematics. Grimm sought to determine if there were any longitudinal associations between early reading performance and three components of mathematical knowledge. These components were Problem Solving and Data Interpretation, Mathematical Concepts and Estimation, and Mathematical Computation. Grimm used data from the Chicago Public Schools database. The instrument of measurement was the Iowa Test of Basic Skills (ITBS). He examined the ITBS scores of a cohort of 46, 373 students from their 3rd through 8th grade school years. Using latent growth models to examine the changes, Grimm (2008) found a statistically significant relationship between 3rd grade reading comprehension and each of the components of mathematics learned. Interestingly, males and African-American students showed shallower growth than females and non-African-American students. This finding supports the belief that reading comprehension is necessary for mathematical success. Perhaps the most profound finding of this study was that reading comprehension has a relationship with the conceptual understanding and problem solving that are essential to success in mathematics.

Harlaar et al (2012) examined the different ways in which word decoding and reading comprehension are related to mathematics. Using 5,162 pairs of 12-year-old twins who were part of the Twin Early Development Study in London, England, the authors were seeking to find if word decoding and reading comprehension affected mathematics in similar manners. The researchers used various instruments to measure cognitive, reading, and mathematics ability. Structural equation modelling was used to analyze the data. The findings suggest that while both decoding and comprehension showed significant relationships with mathematics, the relationship between reading comprehension and mathematics was stronger (Harlaar et al, 2012). This finding, once again, indicates the importance of reading comprehension in relations to mathematics success.

Simmons (2011) examined the connection between language acquisition and mathematics achievement as demonstrated by student performance on the New England Common Assessment Program (NECAP), an assessment in Vermont. The analysis was conducted at grades three through eight from 2006 to 2009. This longitudinal study examined the relationship between fourth-grade reading performance and seventh-grade mathematics performance on the NECAP. A Pearson correlation coefficient was used to analyze the range of correlations for the scores of the individual components of the reading NECAP assessment to the mathematics NECAP assessment. Significant positive correlations were found between the individual components of the reading and the mathematics scaled scores. Simmons (2011) found that a significant relationship existed between reading performance and mathematics performance over the four years.

Conducting research in South Africa and Australia respectively, Bohlmann and Pretorius (2008) and Vista (2013) sought to determine whether mathematics performance was related to performance on literacy tests in the first language of the students and in English, which was the language of learning and testing. Bohlman and Pretorius examined literacy from the angles of language proficiency and reading comprehension, while Vista related reading comprehension to problem solving, a necessary skill in mathematics proficiency.

The sample in the Bohlman and Pretorius (2008) consisted of seventh grade students from both a government school and a private school. The first school was a state school of 600 students (107 seventh graders) in which students were primarily from low SES families. Students were taught in the native language (Northern Sotho) until third grade at which time the language of learning changed to English. The second school was a private school where most students came from wealthier families, although out of 300 students in the school, 80 came from poor families and attended on full scholarships. Students were taught in English throughout their schooling.

Students were tested in reading and language using both the native language and English, and this was compared to their final examination grades in mathematics as assessed by their teachers. The scores were analyzed using Pearson Product Moment correlation to determine if a correlation existed between the reading test scores and the mathematics scores.

Bohlmann and Pretorius (2008) found that "English reading is strongly supportive of mathematics achievement" (p. 51). They emphasized that "English *reading* rather than the more general construct of English language proficiency seems to determine mathematics achievement" (Bohlman & Pretorius, 2008, p. 51). Their findings suggested that the ability to read and comprehend English as the language of testing was more impactful on mathematics achievement than how well students spoke the language.

The major limitation that the Bohlmann and Pretorius (2008) noted was that the private school's mathematics teacher was better trained and more experienced than the public school's teacher, which may have influenced student performance. Another issue to consider is that the mathematics assessments the students took were not developed or administered by the researchers unlike the English and reading tests. Although these limitations may give pause, the comparisons within each school still indicated that students with stronger reading comprehension skills in English performed better on mathematics assessments conducted in English (Bohlman & Pretorius, 2008).

Vista (2013) conducted a study in Victoria, Australia with the intent of examining the effect of reading comprehension on reasoning. Vista, agreeing with the NCTM (1999), contended that reasoning is essential to the understanding and application of mathematics. As such, a relationship exists between reading and mathematics. The aim was to examine the effect of reasoning ability on mathematics performance among students who spoke various languages in Australia. The participants were from 61 public schools involved in a special project. Within these schools, 5,886 students of various language backgrounds and English proficiency participated in the study. The students were divided into two groups, those whose birth language was English, and those whose birth language was something other than English. Students were assessed using tests that measure student performance in numeracy, reading comprehension, and problem solving. The tests were administered in 3^{rd} through 10^{th} grades, although the focus for the study was students in Grades 3 through 8.

The hypothesis driving the study was that although problem solving ability has been found to be related to performance in mathematics, it not a direct relationship. Mediating the effect was reading comprehension skills, which, in turn, was moderated by language background. Baron and Kenny (1986) have explained the difference between a moderating variable and a mediating variable by defining a moderator as the variable that influences the relationship between an independent and the dependent variable while a mediator is a variable that explains the relationship. The extent to which reading comprehension mediates problem solving, therefore, depends on “whether or not the student is a native speaker of the test language” (Vista, 2013, p. 27).

The mediation model was tested using Structural Equation Modeling (SEM). The variables were reading comprehension ability, problem solving ability, and gains in mathematics. The results showed that language background had no impact on how reading comprehension skills affected the relationship between problem solving and growth in mathematics. There was, however, a finding that reading comprehension itself mediates problem solving skill, which in turn affects mathematics performance (Vista, 2013).

Vista (2013) indicated that the study was limited to public schools in one section of Australia. Another limitation of the study is that reading comprehension was tested indirectly as a factor that affects mathematics performance. As admitted by the researcher, the relationships between language, reading comprehension, and problem solving were weak, and the study would have to be replicated in other countries to fully examine the effect of reading comprehension on mathematics performance. Also worth discussing is that some of the students who performed poorly on the mathematics assessment were from low-income families. Therefore it is difficult to determine if language or reading were the only factors that made the difference.

While examining the relationship between reading and mathematics performance, it is important to distinguish how reading affects the testing of mathematics. Mullins, Martin, and Foy (2013) examined the reading required to perform well on the TIMSS assessments in mathematics and science at the fourth grade level. In their study, the researchers hypothesized the reading demands of the assessments would not affect the performance of students with higher reading levels, while those with lower reading levels would be affected (Mullins, Martin, & Foy, 2013). The researchers coded items on the mathematics tests based on low, medium, or high reading demand and students were grouped by reading ability (low, medium, high) based on their performance on the Progress in International Reading Literacy Study (PIRLS) test. The study was conducted using data from all 34 countries that participated in the assessment. While there were some variations, overall Mullins et al. found that students at higher reading levels performed significantly better on items that required more reading than did students with lower reading performance. It should be noted that this study was conducted in countries where English is the language of learning and testing (Mullins et al., 2013).

Together, the findings in these studies suggest that reading needs to be examined more closely in relation to mathematics. Both Bohlmann and Pretorius (2008) and Vista (2013) ruled out language as the barrier to mathematics and identified reading comprehension as the culprit. The Vista (2013) study extended the results by specifically pointing to the fact that reading comprehension influences problem solving which is vital to mathematics. Mullins et al. (2013) showed the most direct connection between reading ability and mathematics performance. These studies support the conceptual framework in that reading ability is found to be the root to mathematics performance, although its influence may seem indirect. Vista (2013) showed that to be a problem solver, one must have strong reading comprehension skills.

What these studies indicate is that, while the conversation is taking place about reading and its connection to mathematics, the research community still has a great deal of work to do to connect how these findings change classroom instruction, which in turn will change student performance.

Reading and testing of mathematics. Several researchers have asserted that performance on mathematics tests may be more a factor of reading the test items than mathematics knowledge or ability (Abedi, Hofstetter, Baker, & Lord, 2001; Lamb, 2010). In an effort to explore if the reading grade level of mathematics test items had any relationship to student performance, Lamb (2010) conducted a study using the Texas Assessment of Knowledge and Skills (TAKS) mathematics assessments.

Using the released tests and item analysis from 2006, Lamb studied 483 items on Grades 3-11 mathematics assessments. His purpose was to determine if students performed better on mathematics items that were written at or below their grade level in comparison to those written above their current grade levels. Lamb (2010) used Lexile® Measurement to determine the reading grade level of items on the TAKS. Using analysis of covariance, Lamb found that the reading grade level of test items affected student performance. He found that students performed significantly lower on items that had a reading grade level above their current grade level than they did on items that were at-or-below their current grade level. He found that this was most evident at the elementary and middle grades, but not as much at the high school grades.

As a limitation, Lamb (2010) noted that Lexile® typically assigns grade levels to passages that contain 125 words, while the math items rarely have that many words. Therefore, the reading grade levels may not have been as accurate as they should have been. The number of assessment items analyzed also presented another limitation. After categorization, each grade level had less than 20 items that could be considered above grade level. This small sample size makes generalization difficult.

Shaftel, Belton-Kocher, Glasnapp and Poggio (2006) examined the effect of language in mathematics items on student performance on the items on the Kansas state assessment. The population studied was students with disabilities (SWD), English language learners (ELL), and general education students in 4th, 7th, and 10th grades in Kansas. The unit of analysis was the individual test item. The researchers analyzed 208 items at the fourth-grade level, 203 items at seventh grade, and 183 items at 10th grade on four parallel test forms for each grade level, all of which were in a multiple-choice format. About 2,000 students per test form participated, representing a fairly large number of students. These students were identified and coded based on disability designation or language proficiency designation. All items were presented as word problems with as low as two words to as high as 177 words. Students who were dually labeled as SWD and ELL were removed from consideration as SWD and analyzed with the general population to avoid confounding the results and conclusions.

To determine item difficulty, the mean item scores were computed for each of the three groups (i.e. general education, SWD, and ELL). Using a 3×3 univariate analysis of variance (ANOVA), the researchers evaluated grade level (i.e., 4, 7, 10) and student group (i.e., general, SWD, ELL) interactions to determine item means. The results showed that there was no significant difference in performance between SWD and ELL students. Both ELL and SWD performed significantly lower than the general education student group (Shaftel, Belton-Kocher, Glasnapp, & Poggio, 2006).

Using multiple regression, the researchers analyzed the interaction between linguistic features and grade level. The researchers found that for items in the study, linguistic features "have meaningful impacts on student performance with a moderate-to-large effect at Grade 4, a medium effect at Grade 7, and a smaller effect at Grade 10" (Shaftel et al., 2006, p. 120). Specifically, "Words that are unclear, colloquial, or slang, or that have multiple meanings depending on context for interpretation" (Shaftel et al., 2006, p. 120) presented a significant challenge for all students. Interestingly, the authors did not find that ELL and SWD students were affected any differently by the language in mathematics when compared to general education students.

A limitation that should be noted in the Shaftel et al. (2006) study is that the test items came from one state; therefore, it is difficult to generalize to other states and other testing conditions. It is also difficult to generalize from year to year, as items selected for inclusion may vary from year to year while test designers attempt to meet state guidelines for different standards and essential skills being tested. Another limitation to consider is the fact that the general education student results may have been confounded by the inclusion of dually labeled (i.e. SWD and ELL) students into the general group. It is interesting that the very reason they were excluded from the individual ELL and SWD groups is now a limitation on the results obtained for the general group.

Abedi, Hofstetter, Lord, and Baker (2001) examined accommodations received by Limited English Proficient (LEP) students to determine which had the biggest impact on the mathematics portion of the 1997 National Assessment of Educational Progress (NAEP). The study involved 946 eighth-grade mathematics students in an urban school in Southern California. Over 50% of students were considered to be LEP, 17% were native English speakers, and the remaining students were graduates of LEP programs who were considered proficient in English. Eighty-five percent of the students spoke another language besides English and 82% of those students spoke Spanish. Students were randomly assigned to five groups. The first group was administered the test in its original format. The other four groups took the test modified as follows:

> The linguistic structures in the items were modified; (a) mathematical terms were retained, but non-math vocabulary was simplified, and complex syntactic structures were reduced; or (b) the original wording was retained, but a glossary was provided; the margins of the test booklet pages included definitions for non-math vocabulary items that might be difficult or unfamiliar; or (c) extra time was given for the test; or (d) both a glossary and extra time were provided. (Abedi et al., 2001, p. 11)

Each student in the study also took a reading test and completed a language background questionnaire.

The researchers reported that LEP and non-LEP students who were given a glossary plus extra time, as well as those who took the modified English version performed significantly higher than students who were not given these accommodations. The researchers reported, “Two thirds of the variance in math scores between LEP and non-LEP students was explained by differences in level of reading proficiency in English”. It is important to note that a limitation of this study is the inability to generalize to students who are not English Language Learners.

These studies present an important consideration for any organization involved in high-stakes mathematics testing. Ideally, mathematics test items should test mathematics ability. While reading is essential to understanding mathematics, the reading level of an item should not be the deciding factor when trying to assess what a student knows about mathematics. As noted by Lamb (2010), it is important that all teachers teach reading skills when teaching mathematics to account for the various reading grade levels that appear on mathematics assessments. The findings in these studies, collectively, support that reading and language should be considered when designing assessments of mathematics, and as such, they should be considered when teaching and learning mathematics.

Summary

The importance of a solid mathematics education has far-reaching implications for individuals as well as national economies. From ensuring that there are workers in STEM careers to having a citizenry that is comfortable in participating in the responsibilities of running households, corporations, schools, and nations, it behooves those of us in education to ensure we understand what affects quality mathematics instruction and learning for all students. The reality is that the United States has lost some of its prowess when it comes to mathematics performance and readiness of the children and adults. To compound the issue, American students' ability to read well enough to comprehend the learning of mathematics is subpar (National Institute for Literacy, 2007; National Mathematics Advisory Panel, 2008).

Researchers have examined many possible reasons for factors that influence mathematics achievement, especially performance on tests. As examined in the review, socioeconomic status, teaching methods, teacher preparation, and early exposure to mathematics contribute to the conversation about variance in mathematics performance. The focus of this review, however, was on how reading is related to mathematics learning and mathematics testing. The relationship between mathematics and reading was examined from how reading should be taught and learned in a mathematics classroom, to simply looking at how Students with Disabilities and English Language Learners perform on mathematics assessments that require significant reading. The studies examined all support the fact that the ability to read is fundamental to the learning of mathematics. It is important to note that there are specific reading strategies that support mathematics performance. If our students are to know them, we must ensure that our teachers know and practice them as well.

The literature examined also emphasized the importance of early exposure to mathematics has far-reaching consequences for mathematics. The same is true for reading. However, only a few studies have examined how early reading performance impacts later performance in mathematics for the purpose of finding interventions that support both subjects.

Chapter Three
Methodology

Introduction

This study examined the relationship between reading and mathematics as measured by Virginia SOL assessments for students in one Virginia high school. The purpose of this study was to examine what relationship exists between reading and mathematics and whether early reading performance can predict subsequent mathematics performance as measured by the Virginia Standards of Learning Assessments. This was in an effort to address underperformance in mathematics by American students (Adelman, 2006; CBMS, 2012; Dearing et al., 2012; Evans, Gray, & Olchefske, 2006).

In the beginning of this chapter the purpose of the study and the research questions will be presented. The design of the study and the research methodology will be presented next. Following will be the description of the sample, setting, and instruments, including their psychometric properties. Finally, ethical safeguards and methods for ensuring the data was treated in a secure manner will be discussed.

The purpose of the study was to examine what relationship exists between reading and mathematics and whether early reading performance can predict subsequent mathematics performance as measured by the Virginia Standards of Learning Assessments. The research questions guiding the study were:

1. What is the relationship between Virginia Standards of Learning (SOL) reading performance and SOL mathematics performance at each grade level in Grade 3 through Grade 8?
2. What is the relationship between SOL reading performance in Grade 3 and subsequent performance on Virginia SOL End-of-Course Algebra I assessment?
3. To what extent does SOL reading performance in Grade 3 predict subsequent performance on Virginia SOL End-of-Course Algebra I assessment?

Design

A quantitative correlational design was employed to address the research questions. This approach is recommended for studies that seek to discover a relationship between variables

(Butin, 2010; Howell, 2011). The study utilized secondary data analysis of administrative, school level data. The Statistical Package for Social Sciences (SPSS) and MATLAB software were used to conduct the analyses.

Sample

The study was conducted using student-level data from a high school in a large suburban school division in Central Virginia. The selected high school had failed to meet the minimum pass rate in mathematics for the Virginia SOL and was currently in the process of school improvement. Thus the school division was working to find ways to increase mathematics scores for the school. Based on the division report card, the school division had approximately 35,000 students in Pre-K – Grade 12. In the 2014-2015 school year, the division educated 43% White students, 36% Black students, 8.9% Asian students, 7.6% Hispanic students and 4.2% were identified as “other”. The school in the study was not demographically representative of the school division. The school had approximately 1,600 students in Grades 9 through 12. Eighty four percent of students attending the school were Black, 11% were White, and 5% were Hispanic. Approximately 90% of the students in the high school came from two nearby middle schools with one school sending 100% of the students and the other sending about 40% of the students. The middle that sent 100% of the students to the high school in the study had enough students on free and reduced lunch that it qualified for the federal government Title I assistance. All the elementary schools that feed into the high school qualified for Title I. Another 8% came from other school zones in order to attend the high school’s two specialty centers, a Center for Engineering and an Advance College Academy. The remaining students were transfers from out of the zone and school division.

The two main feeder middle schools, as well as the elementary schools, were also in the process of school improvement because of failure to meet the minimum pass rate in mathematics and reading. The high school was one of two out of nine high schools that failed to meet the minimum requirements for accreditation.

Selection was limited to those students for whom both the Virginia SOL reading and mathematics scores existed at Grades 3 through 8 and who had also taken the Algebra I end-of-course assessment. These criteria yielded a sample size of 1401 students (731 male, 670 female).

The data used in the study were provided by the school division. To ensure confidentiality, student identifying information was not provided by the school division (see Appendix A for the Research Survey Approval). Data were maintained on the researcher's home computer for security. The computer was protected by a password and only the researcher had access to the data.

Permission to Conduct Study and Use Data

Prior to beginning the research process, the researcher participated in the university online training for human subject protection (see Appendix B). Written permission was sought from the Virginia Polytechnic Institute and State University's Instructional Review Board (IRB) to conduct the study. Once permission was received (see Appendix C), a request for the necessary data was submitted to the school division in the study. The data to be examined were compiled and maintained by the Department of Research and Planning in the school division. No personally identifying information about students was obtained, nor was any information collected directly from students. In addition, the school involved was not identified.

Instrument

Virginia Standards of Learning (SOL) assessments were the measurement instruments used. This section will provide an in-depth description of each assessment, including its psychometric properties.

Virginia SOL assessments. Virginia SOL Assessment are criterion-referenced assessments used by the state to determine proficiency as defined by the Virginia Standards of Learning. A student is considered passing on the Basic/Proficient level if he or she earns a scale score between 400 and 499. A student is considered Advanced/Proficient if he or she scores between 500 and 600 with 600 being the highest score. A student who scores below 400 is considered to have failed to meet the minimum standard for proficiency (Virginia Department of Education, 2013). In general, answering approximately 50% of the questions can result in a passing score on the Algebra I SOL assessment. Table 1 shows the ranges of correct responses for each proficiency level.

Table 1

Raw Score Ranges for Each Proficiency Level for Virginia SOL Grades 3-8 Mathematics and Reading Assessments and Algebra 1 End-of-Course Test

		Proficiency Level (Scale Score)		
Test	Number of Questions	Fail/Below Basic (0-399)	Pass/Proficient (400-499)	Pass/ Advanced (500-600)
Grade 3 Reading	35	0-20	21-30	31-35
Grade 3 Mathematics	40	0-25	26-35	36-40
Grade 4 Reading	35	0-22	23-30	31-35
Grade 4 Mathematics	50	0-30	31-44	46-50
Grade 5 Reading	40	0-25	26-36	37-40
Grade 5 Mathematics	50	0-30	31-44	45-50
Grade 6 Reading	45	0-27	28-39	40-45
Grade 6 Mathematics	50	0-27	28-44	45-50
Grade 7 Reading	45	0-27	28-38	39-45
Grade 7 Mathematics	50	0-30	31-44	45-50
Grade 8 Reading	45	0-27	28-38	39-45
Grade 8 Mathematics	50	0-30	31-46	47-50
Algebra I EOC	50	0-22	23-44	45-50

(VDOE, 2014)

Based on the Virginia Department of Education's SOL Technical Report (2011), the SOL tests have passed several validity and reliability analyses. The Virginia Department of Education uses Cronbach's alpha to report the item level reliability at acceptable levels. Tables 2 and 3 show the alpha ranges for the online mathematics and reading assessments (Virginia Department of Education [VDOE], 2011). These tables show the number of students used in the analyses and the associated Cronbach's Alpha for each grade combination for mathematics Grades 3 through 8 and Algebra I. For the online administrations, the Alphas ranged from .0.87 to 0.91. It is important to note that the Virginia SOL assessments were revised as a result of the implementation of more rigorous standards. The mathematics standards changed in 2009, and the assessments to match the new standards began at the end of the 2011-2012 school year. The English standards, which inform the reading assessments, changed in 2010, with the respective assessments beginning at the end of the 2012-2013 school year. To avoid confounding the results and to ensure all students would have been taught and tested under the same standards, for this study, all reading and mathematics assessments results used were based on the 2001 standards.

Table 2

Cronbach's Alpha for Virginia SOL Mathematics Grades 3-8 and Algebra I End-of-Course (EOC) Tests (Online Administration)

Grade	N	Alpha
3	45,381	.88
4	47,227	.86
5	45,272	.90
6	46,053	.91
7	42,988	.91
8	27,677	.90
Algebra I EOC	52,366	.91

(VDOE, 2014)

Table 3

Cronbach's Alpha for Virginia SOL Reading for Grades 3-8

Grade	N	Alpha
3	22, 043	.85
4	28,495	.78
5	30,297	.81
6	36,393	.87
7	37,404	.87
8	27,677	.90

(VDOE, 2014).

Lexile® measure. According to MetaMetrics, the creator of the Lexile® Framework for Reading, Lexile® measure is a means by which reading ability and text can be quantified. A student's ability to read is measured on the Lexile® reader measure and the Lexile® text measure provides information about the readability level of text. Lexile® measures are reported in scores from BR which stands for Beginning Reader to 2000L, which means a student is considered to have the reading abilities necessary to comprehend any text. Typically these measures are used together to assist readers in choosing reading materials that are at appropriate reading levels. Table 4 shows approximate expected Lexile® reader score ranges by grade level for students between the 25th and 75th percentile. The Lexile® reader measure is determined by using any of several different reading comprehension tests, including state end-of-grade assessments. Virginia is one of the states whose end-of-course reading assessments had been correlated to Lexile® measure until the 2013-2014 school year when due to budget constraints, the state stopped reporting the correlated Lexile® score. The correlations are also included in Table 4. The inclusion of Lexile® scores for this study only served to provide a frame of reference to reading level based on the SOL reading score. Lexile® measure was not used in the analysis.

Table 4

Typical Lexile® Reader Measures, by Grade and Virginia SOL Correlations to Lexile Measures

Grade	Reader Measures, Mid-Year 25th Percentile to 75th Percentile	Fail/Basic	Pass/Proficient	Pass/Advanced
1	Up to 300L	At or Below 260L	265L to 595L	600L and Above
2	140L to 500L	At or Below 435L	440L to 730L	735L and Above
3	330L to 700L	595L and Below	600L to 870L	875L and Above
4	445L to 810L	685L and Below	690L to 970L	975L and Above
5	565L to 910L	860L and Below	865L to 1135L	1140L and Above
6	665L to 1000L	895L and Below	900L to 1180L	1185L and Above
7	735L to 1065L	920L and Below	925L to 1230L	1235L and Above
8	805L to 1100L	990L and Below	995L to 1275L	1280L and Above
9	855L to 1165L	At or Below 1020L	1025L to 1325L	1330L and Above
10	905L to 1195L	At or Below 1060L	1065L to 1370L	1375L and Above
11	940L to 1210L	At or Below 1105L	1110L to 1415L	1420L and Above
12	940L to 1210L	At or Below 1145L	1150L to 1465L	1470L and Above

(VDOE, 2014)

Analysis

Because the SOL test scores are reported as scaled scores and there are multiple forms, the scores were coded into categorical data for analysis (Howell, 2011). The categories were based on the proficiency levels of student performance. Students who scored in the “Fail/Below

Basic" range (0-399) were coded as zero (0), students who scored in the "Pass/Proficient" range (400-499) were coded as one (1), and students who scored in the "Pass/Advanced" range (500-600) were coded as two (2). To answer research questions one and two, a chi-square test of association was conducted to determine the existence of a relationship between the indicated variables. The chi-square test is applied when examining two categorical variables from a single population. It is used to determine whether two independent variables are dependent on each other (Howell, 2011). To examine the strength of association for the significant relationships, *Cramer's V* was calculated as a measure of effect size. *Cramer's V* is a correlation coefficient used to measure the association between two categorical variables (Howell, 2011). Associations with a *Cramer's V* measure of less than +/- 01.10 are considered very weak, +/- 0.10 to 0.19 are considered weak, +/- 0.20 to 0.29 are considered moderate, +/-0.30 or above are considered strong (Botsch, 2011). For question one, association was also examined for all scores from Grade 3 through Algebra 1. Each reading score was tested for association with the math score at the same grade level and all grade levels above, including Algebra I. Due to question one showing no significant association between Grade 3 reading and Algebra 1, no further analysis was conducted to address question 3.

Summary

Described in this chapter was the methodology of study, which included the design, data collection, and storage, as well as the analysis that was employed to answer the research questions. Also included was description of the instrument used as well rationale for selection. Psychometric properties of the various tests were also presented. The method of analysis was presented as Chi-square test of association with Cramer's *V* as the measure of effect size. The study was limited to students in one high school in one school division due to the school's "Accredited with Warning" status. While the data utilized for analysis was Virginia SOL reading and mathematics scores, Lexile® measures were provided to give a frame of reference for approximate reading ability of students based on performance on the reading assessments.

Chapter Four
Results of the Study

Introduction

The purpose of this study was to examine what relationship exists between reading and mathematics and whether early reading performance can predict subsequent mathematics performance as measured by the Virginia Standards of Learning Assessments. The research questions and hypotheses guiding the study were:

1. What is the relationship between Virginia Standards of Learning (SOL) reading performance and SOL mathematics performance at each grade level in Grade 3 through Grade 8?
2. What is the relationship between SOL reading performance in Grade 3 and subsequent performance on Virginia SOL End-of-Course Algebra I assessment?
3. To what extent does SOL reading performance in Grade 3 predict subsequent performance on Virginia SOL End-of-Course Algebra I assessment?

The study utilized existing student performance data provided by the school division. The sample was limited to students for whom scores existed for all tests requested. This resulted in 1401 students. The scale scores were categorized by proficiency levels of zero (0), “Fail/Below Basic” for the scaled scores between zero and 399, one (1), “Pass/Proficient” for the scaled scores between 400-499 , and two(2) “Pass/Advanced” for the scaled scores between 500 and 600 (see Table 5 and Table 6).

Table 5

Frequency at Each Proficiency Level for Virginia SOL Mathematics Tests Grades 3 through EOC Algebra I

	Level 0 Scale Score 0-399		Level 1 Scale Score 400-499		Level 2 Scale Score 500-600		
Test	N	%	N	%	N	%	Mean Score
Grade 3	203	15%	802	57%	390	28%	462
Grade 4	136	10%	661	47%	604	43%	487
Grade 5	154	11%	487	35%	760	54%	499
Grade 6	576	41%	699	50%	126	9%	413
Grade 7	685	49%	647	46%	69	5%	400
Grade 8	670	48%	576	41%	155	11%	407
Algebra I	411	29%	973	69%	17	1%	412

N = 1401

Table 6

Frequency at Each Proficiency Level for Virginia SOL Reading Tests Grades 3 through Grade 8

	Level 0 Scale Score 0-399		Level 1 Scale Score 400-499		Level 2 Scale Score 500-600		
Test	N	%	N	%	N	%	Mean Score
Grade 3	209	15%	802	57%	390	28%	462
Grade 4	219	16%	634	45%	548	39%	473
Grade 5	171	12%	820	59%	410	29%	468
Grade 6	255	18%	797	57%	349	25%	456
Grade 7	356	25%	857	61%	188	13%	437
Grade 8	475	34%	779	56%	147	10%	424

N = 1401

Data Analysis by Research Question

Research question 1. What is the relationship between Virginia Standards of Learning (SOL) reading performance and SOL mathematics performance at each grade level in Grade 3 through Grade 8? To answer research question 1 which sought a relationship in proficiency levels of student performance between the Virginia SOL reading and mathematics tests within the grade levels, a Chi-square test of association was performed. The analysis was to examine if there were a significant relationship in the frequency of students performing at each proficiency level between the tests. Further analysis was also conducted between each reading test and the mathematics test at the same grade level and each grade level above, including Algebra 1. In the cases where there was a significant association at p, .05, Cramer's V was calculated to indicate the strength of the associations. Table 7 shows the relationships between the tests.

Table 7

Chi-Square Test for Association between the Virginia SOL Reading Test at Grades 3 – 8 and Virginia SOL Mathematics at Grades 3 – 8 and Algebra

Virginia SOL Math	Grade 3			Grade 4			Grade 5			Grade 6			Grade 7			Grade 8		
	χ^2	*p*	*V*	χ^2	*p*	*V*	χ^2	*p*	*V*	χ^2	*p*	*V*	χ^2	*p*	*V*	χ^2	*p*	*V*
Grade 3	**53**	**< .001**	**.14**															
Grade 4	5	0.309	.04	**219**	**< .001**	**.28**												
Grade 5	**15**	**< .01**	**.07**	**51**	**< .001**	**.14**	**275**	**< .001**	**.31**									
Grade 6	4	3.565	N/A	**25**	**< .001**	**.09**	**39**	**< .001**	**.12**	**79**	**< .001**	**.17**						
Grade 7	2	.683	N/A	**45**	**< .001**	**.13**	**54**	**< .001**	**.14**	**76**	**< .001**	**.16**	**175**	**< .001**	**.25**			
Grade 8	**11**	**< .05**	**.06**	**72**	**< .001**	**.16**	**118**	**< .001**	**.20**	**106**	**< .001**	**.19**	**213**	**< .001**	**.28**	**331**	**< .001**	**.34**
Algebra I	4	.431	N/A	3	0.494	.03	**10**	**< .05**	**.06**	**27**	**< .001**	**.10**	**27**	**< .001**	**.10**	**38**	**< .001**	**.12**

Note: the column groups Grade 3 – Grade 8 are under the spanning heading "Virginia SOL Reading".

Grade 3 reading test performance associations with mathematics test performance. To examine the association between Grade 3 reading performance and performance on all mathematics tests at and above Grade 3, a Chi-square test of association was conducted. The actual performance frequencies differed significantly from the expected performance frequencies at each proficiency level only at Grade 3 mathematics, χ^2 (4, 1401) = 53, $p < .001$, *Cramer's V* = 0.14 (see Appendix D, Table D1), Grade 5 mathematics, χ^2 (4, 1401) = 15, $p < .01$, *Cramer's V* = 0.07 (see Appendix D, Table D3), and Grade 8 mathematics, χ^2 (4, 1401) = 11, $p < .05$, *Cramer's V* = 0.06 (see Appendix D, Table D6). This means that there were significant associations between Grade 3 reading performance and performance on Grade 3, Grade 5, and Grade 8 mathematics tests. Based on *Cramer's V*, there was a weak association between Grade 3 reading performance and Grade 3 mathematics performance, and very weak associations with Grade 5 and Grade 8 mathematics.

The results of the Chi-square test of association conducted between Grade 3 reading performance and Grade 4, 6, and 7 mathematics and Algebra I EOC indicated that the actual performance frequencies were similar to the expected performance frequencies indicating that there were no significant associations between Grade 3 reading performance and performance on Grade 4, Grade 6, Grade 7 mathematics or Algebra I EOC (see Appendix D, Table D2, Table D4, and Table D9).

Grade 4 reading associations with mathematics test performance. To examine the association between Grade 4 reading performance and perfromance on all mathematics tests at and above grade 4, Chi-square tests of association were conducted. The actual perfromance frequencies differed significantly from the expected perfroamance frequencies at each proficiency level at Grade 4 mathematics, χ^2 (4, 1401) = 219, $p < .001$, *Cramer's V* = 0.28 (see Appendix D, Table D8), Grade 5 mathematics, χ^2 (4, 1401) = 51, $p < .001$, *Cramer's V* = 0.14 (see Appendix D, Table D9), Grade 6 mathematics, χ^2 (4, 1401) = 25, $p < .001$, *Cramer's V* = 0.09 (see Appendix D, Table D10), Grade 7 mathematics, χ^2 (4, 1401) = 45, $p < .001$, *Cramer's V* = 0.13 (see Appendix D, Table D11), and Grade 8 mathematics, χ^2 (4, 1401) = 72, $p < .001$, *Cramer's V* = 0.16 (see Appendix D, Table D12). This means there were significant associations between Grade 4 reading test performance and perfromance on mathematics tests at Grades 4, 5, 6, 7, and 8. Based on *Cramer's V*, Grade 4 reading performance showed a moderate association with Grade 4 mathematics performance, weak association with Grades 5, 7, and 8 mathematics performance, and very weak association with Grade 6 mathematics performance.

When the relationship between Grade 4 reading performance and Algebra I EOC performance was examined using Chi-square test of association, the actual frequencies were similar to the expected frequencies meaning there was no significant association between the two tests (see Appendix D, Table D13).

Grade 5 reading associations with mathematics test performance. To examine the association between Grade 5 reading and all mathematics performances at and above Grade 5, Chi-square tests of association were conducted. The actual performance frequencies differed significantly from the expected performance frequencies at each proficiency level for all mathematics tests. This means that there were significant associations between the Grade 5 reading performance and performance on Grade 5 mathematics, χ^2 (4, 1401) = 275, $p < .001$, *Cramer's V* = 0.31 (see Appendix D, Table D14), Grade 6 mathematics, χ^2 (4, 1401) = 39, $p < .001$, *Cramer's V* = 0.12 (see Appendix D, Table D15), Grade 7 mathematics, χ^2 (4, 1401) = 54, $p < .001$, *Cramer's V* = 0.14 (see Appendix D, Table D16), Grade 8 mathematics, χ^2 (4, 1401) = 118, p < .001, Cramer's V = 0.21 (see Appendix D, Table D17), and Algebra I EOC . Based on *Cramer's V*, Grade 5 reading performance showed a strong association with Grade 5 mathematics performance, moderate association with Grade 8 reading performance, weak associations with Grades 6 and 7 mathematics perfromance, and very weak association with Algebra I EOC.

Grade 6 reading associations with mathematics test performance. To examine the association between Grade 6 reading and all mathematics test performances at and above Grade 6, Chi-square tests of association were conducted. The actual performance frequencies differed significantly from the expected performance frequencies at each proficiency level for all mathematics tests. This means that there were significant associations between the Grade 6 reading performance and perfromance on Grade 6 mathematics, χ^2 (4, 1401) = 79, $p < .001$, *Cramer's V* = 0.17 (see Appendix D, Table D19), Grade 7 mathematics χ^2 (4, 1401) = 76, $p < .001$, *Cramer's V* = 0.17 (see Appendix D, Table D20), Grade 8 mathematics, χ^2 (4, 1401) = 106, $p < .001$, *Cramer's V* = 0.20 (see Appendix D, Table D21), and Algebra I EOC χ^2 (4, 1401) = 27, $p < .001$, *Cramer's V* = 0.10 (see Appendix D, Table D22).

Based on *Cramer's V*, there was a weak association between Grade 6 reading perfromance and Grade 6 mathematics, Grade 7 mathematics, and Algebra I EOC performance. There was a moderate association between Grade 6 reading performance and Grade 8 mathematics performance.

Grade 7 reading associations with mathematics test performance. To examine the association between Grade 7 reading perfromance and performance on all mathematics tests at and above Grade 7, a Chi-square test of association was conducted. The actual frequencies differed significantly from the expected frequencies for all mathematics tests. This means there were signficant associations between Grade 7 reading performance and perfromance on Grade 7 mathematics, χ^2 (4, 1401) = 175, $p < .001$, *Cramer's V* = 0.25 (see Appendix D, Table D23), Grade 8 mathematics, χ^2 (4, 1401) = 213, $p < .001$, *Cramer's V* = 0.28 (see Appendix D, Table D24), and Algebra I EOC, χ^2 (4, 1401) = 27, $p < .001$, *Cramer's V* = 0.10 (see Appendix D, Table D25). Based on *Cramer's V*, there was a moderate association between Grade 7 reading performance and Grade 7 mathematics performance, a moderate association between Grade 7 reading performance and Grade 8 mathematics performance, and a weak association between Grade 7 reading performance and Algebra I EOC performance.

Grade 8 reading associations with mathematics test performance. To examine the association between Grade 8 reading and Grade 8 mathematics and Algebra I EOC performance, a Chi-square test of association was conducted. The actual frequencies differed significantly from the expected frequencies for both mathematics tests, meaning that there was a significant association Grade 8 reading performance and performance on Grade 8 mathematics, χ^2 (4, 1401) = 331, $p < .001$, *Cramer's V* = 0.34 (see Appendix D, Table D26), and Algebra I EOC, χ^2 (4, 1401) = 38, $p < .001$, *Cramer's V* = 0.12 (see Appendix D, Table D27). Based on *Cramer's V*, there was a strong association between Grade 8 reading performance and Grade 8 mathematics performance and a weak association between Grade 8 reading performance and Algebra I EOC performance.

Research question 2. What is the relationship between SOL reading performance in Grade 3 and subsequent performance on Virginia SOL End-of-Course Algebra I assessment? To address research question 2, a Chi-square test of association was conducted to examine if there were an association between student performance on the Grade 3 SOL reading test and subsequent performance on Algebra I EOC. There was no significant association between the two tests, $\chi 2$ (4, 1401) = 3.822, p = 0.43 (see Table 8).

Table 8

Results of Chi-square Test between Virginia SOL Grade 3 reading and Algebra I EOC Assessment Performance at Each Proficiency Level

Algebra I EOC Proficiency Levels		Grade 3 Reading Proficiency Levels: 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	61	144	4	209
	Expected Frequency	61	145	3	
1 Scale Score 400-499	Frequency	246	549	7	802
	Expected Frequency	235	557	10	
2 Scale Score 500 – 600	Frequency	104	280	6	390
	Expected Frequency	114	271	5	
Total		411	973	17	1401

Note. $\chi^2 = 4$, $df = 4$, $p = 0.431$, *Cramer's V* = 0.037

There was, however, a significant relationship between Grade 5, Grade 6, Grade 7, and Grade 8 reading and Algebra I EOC tests, $\chi^2 = 10$, $df = 4$, $p < .05$, *Cramer's V* = 0.06, $\chi^2 = 27$, $df = 4$, $p < .001$, *Cramer's V* = 0.10, $\chi^2 = 27$, $df = 4$, $p < .001$, *Cramer's V* = 0.10, $\chi^2 = 38$, $df = 4$, $p < .001$, *Cramer's V* = 0.12, respectively (see Table 9, Table 10, Table 11, and Table 12).

Table 9

Results of Chi-square Test between Virginia SOL Grade 5 reading and Algebra I EOC Assessment Performance at Each proficiency Level

Algebra I EOC Proficiency Levels		Grade 5 Reading Proficiency Levels 0 Scale Score 0 – 399	 1 Scale Score 400-499	 2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	55	115	1	171
	Expected Frequency	50	119	2	
1 Scale Score 400-499	Frequency	254	559	7	820
	Expected Frequency	241	569	10	
2 Scale Score 500 – 600	Frequency	102	299	9	410
	Expected Frequency	120	285	5	
Total		411	973	17	1401

Note. $\chi^2 = 10$, *df* = 4, $p < .05$, *Cramer's V* = 0.059

Table 10

Results of Chi-square Test between Virginia SOL Grade 6 reading and Algebra I EOC Assessment Performance at Each proficiency Level

Algebra I EOC Proficiency Levels		Grade 6 Reading Proficiency Levels 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	103	149	3	255
	Expected Frequency	75	177	3	
1 Scale Score 400-499	Frequency	229	562	6	797
	Expected Frequency	234	554	10	
2 Scale Score 500 – 600	Frequency	79	262	8	349
	Expected Frequency	102	242	4	
Total		411	973	17	1401

Note. $\chi^2 = 27$, $df = 4$, $p < .001$, *Cramer's V* = 0.098

Table 11

Results of Chi-square Test between Virginia SOL Grade 7 reading and Algebra I EOC Assessment Performance at Each proficiency Level

Algebra I EOC Proficiency Levels		Grade 7 Reading Proficiency Levels 0 Scale Score 0 – 399	 1 Scale Score 400-499	 2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	126	229	1	356
	Expected Frequency	104	247	4	
1 Scale Score 400-499	Frequency	249	599	9	857
	Expected Frequency	251	595	10	
2 Scale Score 500 – 600	Frequency	36	145	7	188
	Expected Frequency	55	131	2	
Total		411	973	17	1401

Note. $\chi^2 = 27$, *df* = 4, $p < .001$, *Cramer's V* = 0.097

Table 12

Results of Chi-square Test between Virginia SOL Grade 8 reading and Algebra I EOC Assessment Performance at Each proficiency Level

Algebra I EOC Proficiency Levels		Grade 8 Reading Proficiency Levels: 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	151	322	2	475
	Expected Frequency	139	330	6	
1 Scale Score 400-499	Frequency	229	544	6	779
	Expected Frequency	229	541	9	
2 Scale Score 500 – 600	Frequency	31	107	9	147
	Expected Frequency	43	102	2	
Total		411	973	17	1401

Note. $\chi^2 = 38$, *df* = 4, *p* < .001, *Cramer's V* = 0.116

Research question 3. To what extent does SOL reading performance in Grade 3 predict subsequent performance on Virginia SOL End-of-Course Algebra I assessment? Since there was no significant association between Grade 3 SOL reading and Algebra I performance, χ^2 (4, 1401) = 4, *p* = 0.431, it was determined that based on these tests, Grade 3 reading performance did not predict Algebra I EOC performance.

Summary

The purpose of this study was to examine what relationship exists between reading and mathematics and whether early reading performance can predict subsequent mathematics performance as measured by the Virginia Standards of Learning Assessments. In this chapter the results of analyses conducted to address the research questions were presented. The research questions were (a) What is the relationship between Virginia Standards of Learning (SOL) reading performance and SOL mathematics performance at each grade level in Grade 3 through Grade 8?; (b) What is the relationship between SOL reading performance in Grade 3 and subsequent performance on Virginia SOL End-of-Course Algebra I assessment?; (c) To what extent does SOL reading performance in Grade 3 predict subsequent performance on Virginia SOL End-of-Course Algebra I assessment? The analysis utilized was Chi-square test of association. The test was conducted between student performance on the Grade 3 through 8 SOL reading tests and SOL mathematics tests at Grade 3 through 8 and Algebra I EOC. The frequency results based on performance at each proficiency level (Fail (0-399), Pass/Proficient (400-499), and Pass/Advanced (500-600)) were presented along with the results of the chi-square analyses conducted for each pair of tests.

The analysis showed that, at each grade level from Grade 3 through Grade 8, there were significant associations between how students performed on the reading tests and how they performed on the mathematics tests for that same grade level. While the associations were weak at Grades 3 and 6, all other grades showed moderate to strong associations. Although the focus of the study was on Grade 3 reading performance because that is the first time students are tested in Virginia, Grade 4 reading performance showed more significant relationships with all mathematics test performance except Algebra 1. Grade 3 reading performance was only associated with mathematics at Grades 3, 5, and 7. Starting with Grade 5, performance on every reading test showed a significant relationship with performance on every mathematics test including Algebra I. In Chapter 5 the findings, some implications of these relationships, and ideas for further study will be discussed.

Chapter Five
Summary and Conclusions

Introduction

In chapter 5, I will begin by reviewing the purpose of the study, research questions driving the study and the methodology. After this, a discussion of the findings will be presented along with implications for practice, and suggestions for further studies. The researcher's reflection on the process and experience of conducting this study will conclude the chapter.

The purpose of this study was to examine what relationship exists between reading and mathematics and whether early reading performance can predict subsequent mathematics performance as measured by the Virginia Standards of Learning Assessments. The study sought to examine the following research questions:

1. What is the relationship between Virginia Standards of Learning (SOL) reading performance and SOL mathematics performance at each grade level in Grade 3 through Grade 8?
2. What is the relationship between SOL reading performance in Grade 3 and subsequent performance on Virginia SOL End-of-Course Algebra I assessment?
3. To what extent does SOL reading performance in Grade 3 predict subsequent performance on Virginia SOL End-of-Course Algebra I assessment?

Chi-square test of association was conducted to examine the relationships and *Cramer's V* was calculated to determine the strength of the relationships. Following are the findings of the study.

Findings

After analyzing the data as they relate to the research questions, several findings became evident. Those findings are identified, explained, and related to prior research in the following paragraphs.

Finding 1. Students performed similarly on the Virginia SOL mathematics and reading tests within the grade level for grade levels 3 through 8. Student performance at each grade level showed that how an individual student performed on the reading test was associated with how he or she performed on the mathematics test at the same grade level. This was true for Grade 3 through Grade 8. There was a statistically significant association at every grade level with moderate to strong associations based on Cramer's *V* values of greater than .20.

This finding supports both Bohlman and Pretorius (2008) and Vista (2013), who found that reading comprehension was correlated to mathematics performance at primary and middle grade levels. It also supports Mullins et al (2013), who found that students who had higher levels of reading performed better on the mathematics section of the PIRLS test than students with lower reading levels.

Finding 2. There was no significant relationship between student performance on the Virginia SOL Grade 3 Reading and performance on the Virginia SOL Algebra I EOC. Student performance showed that there was no association between how a student performed on the Grade 3 reading test and subsequent performance on the Algebra I EOC test. This finding contradicts Grimm (2008) who a significant relation found a significant relationship between Grade 3 reading and later mathematics performance. Because there was no significant association, no further analysis was conducted to address the predictability of Algebra I performance based on earlier performance in Grade 3 reading.

Finding 3. Virginia SOL reading performance at Grade 4 was related to mathematics performance on all tests except Algebra I EOC. Although the aim of the study was to examine the relationship between Grade 3 reading performance and subsequent Algebra I performance, statistically significant associations were only found with Grade 5 mathematics, and Grade 8 mathematics. Cramer's *V* coefficients were less than .10 in both grades indicating a very weak association. There was no significant relationship between Grade 3 reading performance and Algebra I EOC performance. Grade 4, however, showed much more promise by being associated with all math tests except Algebra 1 EOC. This leads to the question of what is different about the Grade 4 test that led to student performance being related to mathematics performance at every other grade.

This finding supports Merton's *cumulative advantage theory*, which states that one's advantage over others increases over time (Merton, 1973). Students who performed well early (Grade 4), continued to perform well, and students who performed poorly continued to perform poorly, thus perpetuating the achievement gap. This finding also supports Simmons (2011) who found a correlation between Grade 4 reading and Grade 7 mathematics on the New England Common Assessment Program assessments.

Finding 4. Starting at Grade 5, students performed similarly on all Virginia SOL reading tests to how the performed on Virginia SOL mathematics tests at the grade level and the grade levels above through grade 8, including Algebra I EOC. Student reading performance at Grade 5 through Grade 8 showed statistically significant associations with mathematics performance at the same grade levels to all grade levels above (see Table 7). As stated in finding 2, within grade-level associations were stronger than between grade-level associations. Worth noting are the moderate to strong associations between Grade 5, Grade 6, and Grade 7 reading and Grade 8 mathematics based on *Cramer's V* values.

This means that students who performed well on Grade 5, Grade 6, and Grade 7 reading also performed well on Grade 8 mathematics. This again supports Simons (2011) who found a correlation between Grade 4 reading and Grade 7 mathematics on the PIRLS international assessment.

Finding 5. Student performance on Grade 5, Grade 6, Grade 7, and Grade 8 Virginia SOL reading tests was related to student performance on the Virginia SOL Algebra I EOC test. Student reading performance at Grade 3 and Grade 4 was not statistically significantly related to Algebra 1 EOC performance, $\chi^2 = 4$, $df = 4$, $p = 0.431$ and $\chi^2 = 3$, $df = 4$, $p = 0.494$ respectively. While this contradicts some of the research related to early reading being related to subsequent mathematics perfromance (Aubrey et al., 2006, Simons, 2011), performance in Grades 5, 6, 7, and 8 confirms this by being associated with Algebra I performance. Students who performed well on Grades 5, 6, 7, and 8 reading performed well on the Algebra I EOC assessment (see Table 7). Based on Cramer's *V* coefficient values, the associations were very weak to weak. Vista (2013) found that reading comprehension affected problem solving, which in turn affected mathemtics performance. This finding in the current study seems to support Vista's finding in relation to Algebra I. Typically students struggle with the problem solving aspects of mathematics (Battista, 1999). In support of Battista, this study showed that students who performed well on reading assessments at Grades 5, 6, 7 and 8 also performed well on the Algebra I EOC assessment.

Implications for Practice

The results of this study have implications for teacher leaders, principals, division-level leaders, and leaders of teacher preparation programs. These groups of educators at their different levels of impact on students working together can use the findings in this study to affect student performance in reading and mathematics. This study can serve as a baseline measure to support further study about how these two subject areas are related, and to inform these practitioners' practices as they seek continuous improvement. Those implications are presented by group of practitioners in the following discussion.

For teacher leaders.

- **Teachers at all levels and subjects should examine their content areas to fully understand how reading impacts student performance (Supporting Finding 1, 2, 3, 4, and 5).** Teachers leaders must examine ways in which educators in different contents can come together to develop practices that lead students to be strong in content literacy. It is important that all teachers examine how they content is affected by the ability to read (Shanahan and Shanahan, 2008).
- **Teachers of mathematics and reading should examine the root causes of student underperformance in their subjects to determine if deficiencies in one are affecting the other (Supporting Finding 1, 2, 3, and 4).** Instead of implementing standard interventions in mathematics or reading, students should be assessed to see what skills they are missing in one or the other that may be informing performance (Vista, 2013). This is especially true for students with disabilities who are typically assigned accommodations in the area of low test scores, without necessarily addressing the other.

For principals.

- **Principals should ensure that teachers are addressing content literacy within their subject areas including mathematics (Supporting Finding 1).** In the observation-feedback cycle, principals should ensure that they are examining how reading skills that inform other contents are being incorporated into the teaching of other contents. Principals should assist teachers in reviewing standards to ensure that lesson plans and delivered lessons are strongly and intentionally addressing the required reading skills. Principals should be familiar with the type of reading skills necessary for success in each content area (Shanahan and Shanahan, 2008).

- **Principals should provide ongoing professional development for teachers who do not know how to address reading deficiencies to learn how to address them within their content areas (Supporting Finding 1, 2, 3, and 4).** Most secondary teachers have never had to learn how to teach reading comprehension because secondary school teachers tend to specialize in specific contents (Shanahan and Shanahan, 2008). Mathematics teachers are typically least likely to have backgrounds in teaching reading (Ma, 1999). Therefore, principals must purposely and intentionally provide time for ongoing professional development on how to incorporate appropriate reading skills.
- **Principals should seek to address reading and mathematics deficiencies for students who are underperforming in either subject to examine if deficiencies in one are related to underperformance in the other (Supporting Finding 1, 2, 3, and 4).** Typically when students underperform in mathematics or reading, the most common intervention is more tutoring in mathematical concepts or in reading strategies. Principals should seek to examine if support in either subject can assist students to perform better in the other. Principals should be aware of the reading and mathematics levels of all their students and how strengths and deficiencies will inform student performance in various subjects.

For division leaders.

- **Division leaders should ensure there is vertical teaming among elementary, middle, and high schools so that all teachers know the expectations for learning and testing at all levels for all subjects, especially reading and mathematics. (Supporting Finding 1, 2, 3, and 4).** Based on the findings, skills learned in early grades are related to skills required to be mastered in later grades. Therefore, teachers at each level cannot work in isolation. It is important that division leaders provide consistent and ongoing opportunities for collaboration between teachers at all levels.
- **Division leaders should ensure that curriculum specialists design district curriculum that is aligned for reading and mathematics by addressing the essential understanding at each grade level that correlate to success in**

mathematics and reading (Supporting Finding 1, 2, 3, and 4). It is important that curriculum specialists are well versed in the essential understandings in reading and mathematics performance that may affect student performance so that they can design curricula that supports them. The NCTM (2000) has stated that communication, in the form of reading and writing, is important in mathematics as it is the means by which mathematics is learned, as well as mastery is assessed.

For teacher-preparation program leaders.

- **Teacher preparation program leaders should ensure future secondary mathematics teachers are exposed to rigorous preparation in reading in the content area (Supporting Finding 1, 2, 3, and 4).** With the teacher shortage, there are various routes to teacher licensure. However, most universities and states have specific programs designed to prepare candidates for classroom instruction. It is important that teachers are exposed to rigorous coursework designed to specifically teach them how to address reading needs of students in their specific content area. Elementary reading teachers should be taught to expose students to various texts that address reading skills necessary for learning and testing in various contents (Lamb, 2010).

Suggestions for Further Study

1. As stated in chapter 3, this study utilized results from reading and mathematics tests that were designed to assess the 2001 standards of the Virginia Standards of Learning program. These standards have since changed to more rigorous standards. A study using current standards should be conducted once enough data are available to examine if the same relationships hold.
2. Researchers could study the reporting categories at each reading grade level to examine which ones are most closely correlated with mathematics performance.
3. Researchers could examine if there were a difference between students who took Algebra I in middle school and those who took it in high school and how their performance is related to early reading.

4. A study could be conducted to examine what reading skills are in Grade 5 that are not in Grade 3 or Grade 4 that have the most impact on Algebra 1.
5. A study could be conducted to explore if reading affects learning of mathematics or the testing of mathematics the most.
6. This study could be replicated for different groups of students to examine if the relationships are different (Ethnicity, disability status, language learners, SES, etc.).
7. This study could be replicated at the division, state, and national levels.
8. A study could be conducted to examine if reading performance affects mathematics performance, or if mathematics performance affects reading performance.
9. A study could be conducted to examine what other domains (e.g. intelligence, efficacy) are being measured by the reading and mathematics assessments that are informing the associations discovered.

Conclusion

The purpose of this study was to examine what relationship exists between reading and mathematics and whether early reading performance could predict subsequent mathematics performance as measured by the Virginia Standards of Learning Assessments. The data analysis showed that there were enough statistically significant relationships to suggest that this area of research deserves continued examination. While there was no significant relationship found between Grade 3 reading and Algebra I EOC, there were enough significant relationships to indicate that reading and mathematics maybe interrelated. Also to be considered is what other domain is being measured by these assessments. For example, are these are assessments measuring natural intelligence and that is why there are associations? How do we quantify this intelligence to properly examine it?

Reflections

In reflecting on the process of this research study, the researcher's own experience as a mathematics teacher informed the need to explore a possible area of intervention for students who struggle with mathematics. Quite often, it is acceptable to say, "I am just bad at math", without examining possible roots to the underperformance. Traditionally reading and mathematics have been seen as living on separate planets. Most people believe they can be successful at one or the other, but not necessarily both. The findings of this study suggest that one may not exist without the other. It is important that we, as educators, continue to explore this relationship so that we can discover specifically how they are related in an effort to increase performance in both areas.

As a researcher, I grew considerably during this process. The level of depth required is one that I had not experienced up to this point. I am grateful to the faculty of Virginia Tech for designing a program that met me at my infancy as a researcher, raised and trained me to produce a study that hopefully will contribute to the body of knowledge of education. As I continue to "stand on the shoulders of others", it is my hope that through this process I have provided some shoulders upon which others who will come after me can stand.

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Appendix A

Training in Human Subjects Protection Certificate

VIRGINIATECHVIRGINIATECHVIRGINIATECHVIRGINIATECHVIRGINIATECH

Certificate of Completion

This certifies that

Tinkhani Ushe Hargrove

Has completed

Training in Human Subjects Protection

On the following topics:

Historical Basis for Regulating Human Subjects Research

The Belmont Report

Federal and Virginia Tech Regulatory Entities, Policies and Procedures

on

September 8, 2012

David Moore, IRB Chair

Appendix B

Approval from School Division to Conduct Study

HCPS Henrico County Public Schools **Department of Research & Planning**

9/16/2014

Ms. Tinkhani Hargrove
12406 Sandbag Circle
Midlothian VA 23113

Dear Ms. Hargrove:

The Department of Research and Planning has reviewed and approved your research study entitled "The relationship between reading and mathematics performances". Your study was approved by the review committee with the following revisions and/or conditions:

- Your data request needs to be more detailed. What we need is an excel file extract, meaning an excel file with the specific data columns (variables) you would like. We need the specific group of students you are evaluating.
- By law, no SES data is allowed to be given by individual student only by aggregate. This means that you can have gender and race but no SES data.

Approval to conduct the study is limited to one year from the time of proposal submission. If the research timeline or any other aspect of your study changes during the time frame, please contact Helen Whitehurst and submit the changes for review prior to proceeding. If you are affiliated with an organization with an Institutional Review Board (IRB), the IRB approval letter must be on file in our office prior to beginning the study. Although your study has been approved, participation by individuals and schools is completely voluntary. Reports and publications generated from this study should not identify the individuals, schools, or the division and all research materials should accurately represent the party conducting the study. It is our expectation that you will submit a final report upon completion of the study to the Department of Research and Planning.

Please contact Helen Whitehurst at hswhiteh@henrico.k12.va.us or 804-652-3831 who will assist you in the process of beginning your research studies in the schools or offices that you have requested.

Thank you for your interest in Henrico County Public Schools.

Sincerely,

Tiffany Hinton

Tiffany Hinton, Ph.D.
Director of Research and Planning
Henrico County Public Schools
804-652-3835

Helen Whitehurst

Helen Whitehurst, Ph.D.
Educational Specialist - Research
Henrico County Public Schools
804-652-3831

Appendix C

Virginia Polytechnic Institute and University Institutional Board Review Permission to Conduct Study

VirginiaTech

Office of Research Compliance
Institutional Review Board
North End Center, Suite 4120, Virginia Tech
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-4606 Fax 540/231-0959
email irb@vt.edu
website http://www.irb.vt.edu

MEMORANDUM

DATE:	June 26, 2015
TO:	Carol S Cash, Tinkhani Ushe Hargrove
FROM:	Virginia Tech Institutional Review Board (FWA00000572, expires April 25, 2018)
PROTOCOL TITLE:	Can I Do Math If I Can’t Read? The Relationship Between Reading and Mathematics Standards of Learning Assessments in One High School in Virginia
IRB NUMBER:	**15-658**

Effective June 25, 2015, the Virginia Tech Institution Review Board (IRB) Chair, David M Moore, approved the New Application request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

http://www.irb.vt.edu/pages/responsibilities.htm

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As:	**Exempt, under 45 CFR 46.110 category(ies) 4**
Protocol Approval Date:	**June 25, 2015**
Protocol Expiration Date:	**N/A**
Continuing Review Due Date*:	**N/A**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Invent the Future

Appendix D

Supplementary Tables

Table D1

Results of Chi-square Test between Virginia SOL Grade 3 reading and Grade 3 mathematics Assessment Performance at Each Proficiency Level

Grade 3 Mathematics Proficiency Levels		Grade 3 Reading Proficiency Levels: 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	49	106	54	209
	Expected Frequency	30	135	44	
1 Scale Score 400-499	Frequency	74	568	160	802
	Expected Frequency	116	517	169	
2 Scale Score 500 – 600	Frequency	80	229	81	390
	Expected Frequency	56.5	251.4	82	
Total		203	903	295	1401

Note. $\chi^2 = 53$, $df = 4$, $p < .001$, *Cramer's V* = 0.14

Table D2

Results of Chi-square Test between Virginia SOL Grade 3 reading and Grade 4 mathematics Assessment Performance at Each Proficiency Level

Grade 4 Mathematics Proficiency Levels		Grade 3 Reading Proficiency Levels 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	23	105	81	209
	Expected Frequency	20	99	90	
1 Scale Score 400-499	Frequency	68	378	356	802
	Expected Frequency	78	378	346	
2 Scale Score 500 – 600	Frequency	45	178	167	390
	Expected Frequency	38	184	168	
Total		136	661	604	1401

Note. $\chi^2 = 5$, *df* = 4, *p* = 0.309, *Cramer's V* = 0.04

Table D3

Results of Chi-square Test between Virginia SOL Grade 3 reading and Grade 5 mathematics Assessment Performance at Each Proficiency Level

Grade 5 Mathematics Proficiency Levels		Grade 3 Reading Proficiency Levels: 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	30	83	96	209
	Expected Frequency	23	73	113	
1 Scale Score 400-499	Frequency	70	283	449	802
	Expected Frequency	88	279	435	
2 Scale Score 500 – 600	Frequency	54	121	215	390
	Expected Frequency	43	136	212	
Total		154	487	760	1401

Note. $\chi^2 = 15$, $df = 4$, $p < .01$, *Cramer's V* = 0.07

Table D4

Results of Chi-square Test between Virginia SOL Grade 3 reading and Grade 6 mathematics Assessment Performance at Each Proficiency Level

Grade 6 Mathematics Proficiency Levels		Grade 3 Reading Proficiency Levels 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	89	99	21	209
	Expected Frequency	86	104	19	
1 Scale Score 400-499	Frequency	341	393	68	802
	Expected Frequency	330	400	72	
2 Scale Score 500 – 600	Frequency	146	207	37	390
	Expected Frequency	160	195	35	
Total		576	699	126	1401

Note. χ^2 = 4, *df* = 4, *p* = 3.565, *Cramer's V* = 0.04

Table D5

Results of Chi-square Test between Virginia SOL Grade 3 reading and Grade 7 mathematics Assessment Performance at Each Proficiency Level

Grade 7 Mathematics Proficiency Levels		Grade 3 Reading Proficiency Levels: 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	106	95	8	209
	Expected Frequency	102	97	10	
1 Scale Score 400-499	Frequency	395	363	44	802
	Expected Frequency	392	370	40	
2 Scale Score 500 – 600	Frequency	184	189	17	390
	Expected Frequency	191	180	19	
Total		685	647	69	1401

Note. $\chi^2 = 2$, $df = 4$, $p = 0.683$, *Cramer's V* = 0.03

Table D6

Results of Chi-square Test between Virginia SOL Grade 3 reading and Grade 8 mathematics Assessment Performance at Each Proficiency Level

Grade 8 Mathematics Proficiency Levels		Grade 3 Reading Proficiency Levels: 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	121	71	17	209
	Expected Frequency	100	86	23	
1 Scale Score 400-499	Frequency	378	331	93	802
	Expected Frequency	384	330	89	
2 Scale Score 500 – 600	Frequency	171	174	45	390
	Expected Frequency	187	160	43	
Total		670	576	155	1401

Note. $\chi^2 = 11$, $df = 4$, $p < .05$, *Cramer's V* = 0.06

Table D7

Results of Chi-square Test between Virginia SOL Grade 3 reading and Algebra I EOC Assessment Performance at Each Proficiency Level

Algebra I EOC Proficiency Levels		Grade 3 Reading Proficiency Levels 0 Scale Score 0 – 399	 1 Scale Score 400-499	 2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	61	144	4	209
	Expected Frequency	61	145	3	
1 Scale Score 400-499	Frequency	246	549	7	802
	Expected Frequency	235	557	10	
2 Scale Score 500 – 600	Frequency	104	280	6	390
	Expected Frequency	114	271	5	
Total		411	973	17	1401

Note. $\chi^2 = 4$, *df* = 4, *p* = 0.431, *Cramer's V* = 0.04

Table D 8

Results of Chi-square Test between Virginia SOL Grade 4 reading and Grade 4 mathematics Assessment Performance at Each Proficiency Level

Grade 4 Mathematics Proficiency Levels		Grade 4 Reading Proficiency Levels 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	60	127	32	219
	Expected Frequency	21	103	94	
1 Scale Score 400-499	Frequency	63	338	233	634
	Expected Frequency	62	299	273	
2 Scale Score 500 – 600	Frequency	13	196	339	548
	Expected Frequency	53	259	236	
Total		136	661	604	1401

Note. $\chi^2 = 219$, $df = 4$, $p < .001$, *Cramer's V* = 0.28

Table D9

Results of Chi-square Test between Virginia SOL Grade 4 reading and Grade 5 mathematics Assessment Performance at Each Proficiency Level

Grade 5 Mathematics Proficiency Levels		Grade 4 Reading Proficiency Levels			
		0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	42	92	85	219
	Expected Frequency	24	76	119	
1 Scale Score 400-499	Frequency	71	239	324	634
	Expected Frequency	70	220	344	
2 Scale Score 500 – 600	Frequency	41	156	351	548
	Expected Frequency	60	191	297	
Total		154	487	760	1401

Note. $\chi^2 = 51$, $df = 4$, $p < .001$, *Cramer's V* = 0.135

Table D10

Results of Chi-square Test between Virginia SOL Grade 4 reading and Grade 6 mathematics Assessment Performance at Each Proficiency Level

Grade 6 Mathematics Proficiency Levels		Grade 4 Reading Proficiency Levels: 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	115	93	11	219
	Expected Frequency	90	109	20	
1 Scale Score 400-499	Frequency	273	304	57	634
	Expected Frequency	261	316	57	
2 Scale Score 500 – 600	Frequency	188	302	58	548
	Expected Frequency	225	273	49	
Total		576	699	126	1401

Note. $\chi^2 = 25$, $df = 4$, $p < .001$, *Cramer's V* = 0.094

Table D11

Results of Chi-square Test between Virginia SOL Grade 4 reading and Grade 7 mathematics Assessment Performance at Each Proficiency Level

Grade 7 Mathematics Proficiency Levels		Grade 4 Reading Proficiency Levels: 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	133	84	2	219
	Expected Frequency	107	101	11	
1 Scale Score 400-499	Frequency	326	288	20	634
	Expected Frequency	310	293	31	
2 Scale Score 500 – 600	Frequency	226	275	47	548
	Expected Frequency	268	253	27	
Total		685	647	69	1401

Note. $\chi^2 = 45$, *df* = 4, *p* < .001, *Cramer's V* = 0.13

Table D12

Results of Chi-square Test between Virginia SOL Grade 4 reading and Grade 8 mathematics Assessment Performance at Each Proficiency Level

Grade 8 Mathematics Proficiency Levels		Grade 4 Reading Proficiency Levels 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	138	68	13	219
	Expected Frequency	105	90	24	
1 Scale Score 400-499	Frequency	327	264	43	634
	Expected Frequency	303	261	70	
2 Scale Score 500 – 600	Frequency	205	244	99	548
	Expected Frequency	262	225	61	
Total		670	576	155	1401

Note. $\chi^2 = 72$, $df = 4$, $p < .001$, *Cramer's V* = 0.16

Table D13

Results of Chi-square Test between Virginia SOL Grade 4 reading and Algebra I EOC Assessment Performance at Each Proficiency Level

Algebra I EOC Proficiency Levels		Grade 4 Reading Proficiency Levels 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	72	145	2	219
	Expected Frequency	64	152	3	
1 Scale Score 400-499	Frequency	192	434	8	634
	Expected Frequency	186	440	8	
2 Scale Score 500 – 600	Frequency	147	394	7	548
	Expected Frequency	161	381	7	
Total		411	973	17	1401

Note. $\chi^2 = 3$, $df = 4$, $p = 0.494$, *Cramer's V* = 0.04

Table D14

Results of Chi-square Test between Virginia SOL Grade 5 reading and Grade 5 mathematics Assessment Performance at Each Proficiency Level

Grade 5 Mathematics Proficiency Levels		Grade 5 Reading Proficiency Levels: 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	70	58	43	171
	Expected Frequency	19	59	93	
1 Scale Score 400-499	Frequency	70	348	402	820
	Expected Frequency	90	285	445	
2 Scale Score 500 – 600	Frequency	14	81	315	410
	Expected Frequency	45	143	222	
Total		154	487	760	1401

Note. $\chi^2 = 275$, $df = 4$, $p < .001$, *Cramer's V* = 0.31

Table D15

Results of Chi-square Test between Virginia SOL Grade 5 reading and Grade 6 mathematics Assessment Performance at Each Proficiency Level

Grade 6 Mathematics Proficiency Levels		Grade 5 Reading Proficiency Levels: 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	106	60	5	171
	Expected Frequency	70	85	15	
1 Scale Score 400-499	Frequency	321	424	75	820
	Expected Frequency	337	409	74	
2 Scale Score 500 – 600	Frequency	149	215	46	410
	Expected Frequency	169	205	37	
Total		576	699	126	1401

Note. $\chi^2 = 39$, *df* = 4, *p* < .001, *Cramer's V* = 0.12

Table D16

Results of Chi-square Test between Virginia SOL Grade 5 reading and Grade 7 mathematics Assessment Performance at Each Proficiency Level

Grade 7 Mathematics Proficiency Levels		Grade 5 Reading Proficiency Levels			
		0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	107	64	0	171
	Expected Frequency	84	79	8	
1 Scale Score 400-499	Frequency	423	367	30	820
	Expected Frequency	401	379	40	
2 Scale Score 500 – 600	Frequency	155	216	39	410
	Expected Frequency	200	189	20	
Total		685	647	69	1401

Note. $\chi^2 = 54$, *df* = 4, $p < .001$, *Cramer's V* = 0.14

Table D17

Results of Chi-square Test between Virginia SOL Grade 5 reading and Grade 8 mathematics Assessment Performance at Each Proficiency Level

Grade 8 Mathematics Proficiency Levels		Grade 5 Reading Proficiency Levels: 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	111	54	6	171
	Expected Frequency	82	70	19	
1 Scale Score 400-499	Frequency	432	332	56	820
	Expected Frequency	392	337	91	
2 Scale Score 500 – 600	Frequency	127	190	93	410
	Expected Frequency	196	169	45	
Total		670	576	155	1401

Note. $\chi^2 = 118$, *df* = 4, *p* < .001, *Cramer's V* = 0.21

Table D18

Results of Chi-square Test between Virginia SOL Grade 5 reading and Algebra I EOC Assessment Performance at Each Proficiency Level

		Grade 5 Reading Proficiency Levels			
Algebra I EOC Proficiency Levels		0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	55	115	1	171
	Expected Frequency	50	119	2	
1 Scale Score 400-499	Frequency	254	559	7	820
	Expected Frequency	241	569	10	
2 Scale Score 500 – 600	Frequency	102	299	9	410
	Expected Frequency	120	285	5	
Total		411	973	17	1401

Note. $\chi^2 = 10$, *df* = 4, $p < .05$, *Cramer's V* = 0.06

Table D19

Results of Chi-square Test between Virginia SOL Grade 6 reading and Grade 6 mathematics Assessment Performance at Each Proficiency Level

Grade 6 Mathematics Proficiency Levels		Grade 6 Reading Proficiency Levels 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	154	86	15	255
	Expected Frequency	105	127	23	
1 Scale Score 400-499	Frequency	319	424	54	797
	Expected Frequency	328	398	72	
2 Scale Score 500 – 600	Frequency	103	189	57	349
	Expected Frequency	144	174	31	
Total		576	699	126	1401

Note. $\chi^2 = 79$, $df = 4$, $p < .001$, *Cramer's V* = 0.17

Table D20

Results of Chi-square Test between Virginia SOL Grade 6 reading and Grade 7 mathematics Assessment Performance at Each Proficiency Level

Grade 7 Mathematics Proficiency Levels		Grade 6 Reading Proficiency Levels 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	176	76	3	255
	Expected Frequency	125	118	13	
1 Scale Score 400-499	Frequency	389	371	37	797
	Expected Frequency	390	368	39	
2 Scale Score 500 – 600	Frequency	120	200	29	349
	Expected Frequency	171	161	17	
Total		685	647	69	1401

Note. $\chi^2 = 76$, $df = 4$, $p < .001$, *Cramer's V* = 0.17

Table D 21

Results of Chi-square Test between Virginia SOL Grade 6 reading and Grade 8 mathematics Assessment Performance at Each Proficiency Level

Grade 8 Mathematics Proficiency Levels		Grade 6 Reading Proficiency Levels 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	183	69	3	255
	Expected Frequency	122	105	28	
1 Scale Score 400-499	Frequency	364	351	82	797
	Expected Frequency	381	328	88	
2 Scale Score 500 – 600	Frequency	123	156	70	349
	Expected Frequency	167	144	39	
Total		670	576	155	1401

Note. $\chi^2 = 106$, *df* = 4, *p* < .001, *Cramer's V* = 0.20

Table D22

Results of Chi-square Test between Virginia SOL Grade 6 reading and Algebra I EOC Assessment Performance at Each Proficiency Level

Algebra I EOC Proficiency Levels		Grade 6 Reading Proficiency Levels 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	103	149	3	255
	Expected Frequency	75	177	3	
1 Scale Score 400-499	Frequency	229	562	6	797
	Expected Frequency	234	554	10	
2 Scale Score 500 – 600	Frequency	79	262	8	349
	Expected Frequency	102	242	4	
Total		411	973	17	1401

Note. $\chi^2 = 27$, $df = 4$, $p < .001$, *Cramer's V* = 0.10

Table D23

Results of Chi-square Test between Virginia SOL Grade 7 reading and Grade 7 mathematics Assessment Performance at Each Proficiency Level

Grade 7 Mathematics Proficiency Levels		Grade 7 Reading Proficiency Levels 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	263	89	4	356
	Expected Frequency	174	164	18	
1 Scale Score 400-499	Frequency	379	441	37	857
	Expected Frequency	419	396	42	
2 Scale Score 500 – 600	Frequency	43	117	28	188
	Expected Frequency	92	87	9	
Total		685	647	69	1401

Note. $\chi^2 = 175$, *df* = 4, *p* < .001, *Cramer's V* = 0.25

Table D24

Results of Chi-square Test between Virginia SOL Grade 7 reading and Grade 8 mathematics Assessment Performance at Each Proficiency Level

		Grade 7 Reading Proficiency Levels			
Grade 8 Mathematics Proficiency Levels		0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	266	80	10	356
	Expected Frequency	170	146	39	
1 Scale Score 400-499	Frequency	368	400	89	857
	Expected Frequency	410	352	95	
2 Scale Score 500 – 600	Frequency	36	96	56	188
	Expected Frequency	90	77	21	
Total		670	576	155	1401

Note. $\chi^2 = 213$, $df = 4$, $p < .001$, *Cramer's V* = 0.28

Table D25

Results of Chi-square Test between Virginia SOL Grade 7 reading and Algebra I EOC Assessment Performance at Each Proficiency Level

Algebra I EOC Proficiency Levels		Grade 7 Reading Proficiency Levels 0 Scale Score 0 – 399	 1 Scale Score 400-499	 2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	126	229	1	356
	Expected Frequency	104	247	4	
1 Scale Score 400-499	Frequency	249	599	9	857
	Expected Frequency	251	595	10	
2 Scale Score 500 – 600	Frequency	36	145	7	188
	Expected Frequency	55	131	2	
Total		411	973	17	1401

Note. $\chi^2 = 27$, $df = 4$, $p < .001$, *Cramer's V* = 0.10

Table D26

Results of Chi-square Test between Virginia SOL Grade 8 reading and Grade 8 mathematics Assessment Performance at Each Proficiency Level

Grade 8 Mathematics Proficiency Levels		Grade 8 Reading Proficiency Levels 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	366	105	4	475
	Expected Frequency	227	195	53	
1 Scale Score 400-499	Frequency	280	401	98	779
	Expected Frequency	373	320	86	
2 Scale Score 500 – 600	Frequency	24	70	53	147
	Expected Frequency	70	60	16	
Total		670	576	155	1401

Note. $\chi^2 = 331$, $df = 4$, $p < .001$, *Cramer's V* = 0.34

Table D 27

Results of Chi-square Test between Virginia SOL Grade 8 reading and Algebra I EOC Assessment Performance at Each Proficiency Level

Algebra I EOC Proficiency Levels		Grade 8 Reading Proficiency Levels 0 Scale Score 0 – 399	1 Scale Score 400-499	2 Scale Score 500 – 600	Total
0 Scale Score 0 – 399	Frequency	151	322	2	475
	Expected Frequency	139	330	6	
1 Scale Score 400-499	Frequency	229	544	6	779
	Expected Frequency	229	541	9	
2 Scale Score 500 – 600	Frequency	31	107	9	147
	Expected Frequency	43	102	2	
Total		411	973	17	1401

Note. $\chi^2 = 38$, $df = 4$, $p < .001$, *Cramer's V* = 0.12