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Reading Ability and Success in Algebra 1: Using Reading Scores and Regression to Predict Success on the Ohio Algebra 1 EOC

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Reading Ability and Success in Algebra 1: Using Reading Scores and Regression to Predict Success on the Ohio Algebra 1 EOC

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The thesis entitled '**Reading Ability and Success in Algebra 1: Using Reading Scores and Regression to Predict Success on the Ohio Algebra 1 EOC'** presented by **Joshua Klein and Renee Lambert**, candidates for the degree of **Master of Science in Mathematics,** has been approved and is worthy of acceptance.

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ABSTRACT

The state of Ohio requires high school students to meet course credit and testing requirements in order to graduate. The purpose of standardized testing is to ensure all students are being taught and learning the same standards at the same proficient level. An algebra teacher who is already teaching the Ohio algebra standards would assume that students would be successful on the algebra 1 EOC exam. When students are not successful, it becomes necessary to determine where instruction has failed, or what interventions must be used to supplement learning to achieve success. Because these are high-stakes tests, being able to determine before instruction which students need more attention and supplementing that instruction from the start can be much more beneficial. One goal of this study was to use data that can be easily accessed to determine which students are more likely to need additional support to improve student achievement. The other main purpose was to determine the need to include reading intervention strategies, content specific reading, working on interpreting word problems, and putting a focus on vocabulary within our lessons will help to improve reading strategies and comprehension.

Linear regression techniques were used to determine that a Star instructional reading level reliably predicts scores for the algebra 1 EOC exam. Combined with other predictors, multiple regression analysis compiled an equation to predict algebra 1 EOC scores. A statistically reliable model included Star instructional reading level, eighth-grade course grade and math EOC score, and school district to predict the algebra 1 EOC score.

Logistic regression methods were used to create a model to predict success on the algebra 1 EOC exam. Success is defined as a score of 684 or higher on the Ohio algebra 1

EOC. The full model was statistically significant with all predictors, but the reduced model was a better fit with the data. The backward step regression reduced the model to four predictors: 8th grade English course grade and EOC, math EOC, and gender. Again, as predicted reading and comprehension skills are predictive of success on the algebra 1 EOC exam.

The results confirmed that reading and comprehension skills are necessary, foundational skills needed to be successful in algebra. The researchers determined formulas to be used to help predict scores on the algebra 1 EOC or predict success on the algebra 1 EOC. Using these formulas, students can be identified before starting algebra to better supplement instruction and provide strategies to support struggling readers. Ultimately if students are below a certain reading level additional reading support could be provided in addition to differentiations in the algebra course. The results imply that there is an undeniable literacy component to the algebra 1 EOC exam.

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CHAPTER I: Introduction

Introduction

High stakes testing has been a long-standing measure of student success in public education, and will continue to be so for the distant, foreseeable future. Thus, the need to find ways to help students be successful and meet graduation requirements is of utmost importance and concern. Many factors contribute to a student's academic success and how we assess, weigh, analyze, and attempt to measure is constantly changing. Just like education and learning theories are constantly changing and evolving, our process to measure and assess the state of teaching and student learning is also changing and evolving. Currently, these high stakes tests are the measure to ensure that Ohio’s youth are receiving a fair and equal education across the state and to an extent, the nation.

One of the high stakes tests that Ohio currently uses is the algebra I end-of-course exam. Of all the factors that contribute to a student’s success on this test, literacy plays a key role. How much a student’s literacy level predicts success on the algebra test brings into question the design of the test, fairness of the test, and the needs that algebra teachers must meet for students to be successful. Acknowledging the need to find ways to help struggling students be successful is the goal of this study, with a secondary benefit of identifying the need to further examine test design.

Background of the Problem

Ever since public education began in one-room schoolhouses, the focus has been on reading, writing, and arithmetic. Over the years, content, instructional methods, and the beliefs behind learning and teaching have changed significantly, but one constant remains, the importance of reading, writing, and arithmetic. Today, as industry and technology continue to make advancements, it is a natural progression for education to follow suit to meet these growing demands. That said, arithmetic has moved past just simple addition and subtraction facts to higher level topics including algebra, geometry, and calculus.

The need for higher level mathematics in public education has since sparked decades of debate and arguments. Harvard was the first college to require algebra in 1820 and geometry in 1844. A study was done in 1908 that found "almost all secondary schools in the U.S. provided at least one year of algebra and geometry, that 50% of schools had one more semester of algebra, and that less than 20% of schools offered any higher mathematics" (Willoughby, p.7). Though beliefs of the need for mathematics in public education were being researched and introduced in many areas, the big push for higher level math for all came post World War 2 and more specifically after the USSR launched Sputnik. The need for the United States to be in the "space race" required more rigorous education in all areas but specifically math and science (Furr (Weggener), 1996).

The Elementary and Secondary Education Act of 1965 began the push for public education that would provide equal opportunity for every student to attain a quality education. This along with many other acts (Every Student Succeeds, No Child Left Behind, Individuals with Disabilities) pushed states to make graduation requirements. With the push for graduation requirements, the need for accountability became apparent. Many states began requiring algebra 1 and geometry credits for graduation (ECS, 2019) These two courses are likely to remain graduation requirements as they are considered foundational for building reasoning and problem-solving skills necessary for the many aspects of a student's future career and everyday life.

Fluency in mathematics, specifically algebra, has been identified as a major predictor for future success in college and careers (Gervasi 2004; Hickey, 2009). The problem-solving techniques, abstract thinking, and real-life application of many mathematical algorithms is the primary reasoning used as a support for the need for the study of algebra. Because of its significance, algebraic thinking first enters the curriculum as early as kindergarten or first grade when students are asked to find missing values. Then, in eighth or ninth grade, when students take algebra 1, they take many of the parts and pieces they have previously learned and apply them to generalize mathematical ideas and use them to problem solve. Today, most states, including Ohio, require credit in algebra 1 for graduation (Ealy et al.; 2019). In addition to needing a credit in algebra 1, the Ohio Department of Education also requires students to show proficiency on an end-of-course examination, or EOC exam. To have consistency across schools, districts, and the state, a common assessment is the most preferred measurement. Currently, the EOC exam is that common assessment, and is how Ohio measures success amongst its students enrolled in an algebra 1 course.

With all the changes and requirements that came with each new education act, the need for accountability and proof began to emerge. The need for some way to evaluate what was being taught and/or what was being learned became the main topic of discussion. The idea of a need for a common assessment for all Ohio students began in the late 1980’s with the ninth-grade proficiency test being the prototype of graduation tests that would follow (Ohio Department of Education (ODE), 1998). The ninth-grade proficiency test was intended to measure learning in mathematics, reading, writing, and citizenship. To graduate a student must pass all four sections. Any failed section would then be taken again the following spring or fall.

A new series of tests had been developed and was first administered in the spring of 2005. The Ohio Graduation Test, or OGT, would eventually phase out the ninth-grade proficiency tests as a graduation requirement by 2007 (Betts, 2008). The OGT was made up of five tests, English, Writing, Mathematics, Science and Social Studies. This test was administered to students their sophomore year, and a passing score on each of the tests were required for graduation. Although the OGT will be completely phased out in 2022, in 2014, a new testing series was under development to replace the OGT, this time with the option of testing on a computer. In Spring of 2015, Ohio used the national, standardized test called the PARCC, Partnership for Assessment of Readiness for College and Careers, test which required proficient scores in English Language Arts 1 and 2, algebra 1, Geometry, Biology, and American History, and Government. This test had been administered for two consecutive years before switching to a different provider, the American Institute of Research, or AIR. With the introduction of the AIR test, all tests were to be administered online, unless granted an exception needed to satisfy accommodations on a student’s Individualized Education Plan, IEP.

All the aforementioned changes have led to today’s testing requirements. The AIR test, despite undergoing several changes, remains the current graduation test for Ohio students. The testing series originally required students to score an acceptable number of points, 18, on a series of seven tests, each with a total of five possible points. This requirement has since changed and been reduced to achieving a score of 684 on each of two tests, algebra I and English 2 usually taken during a student's freshman and sophomore years (Ealy et al.).

From the origination of state testing, it comes as no surprise that the idea of requiring an arbitrarily sufficient grade on a single test, or sequence of tests, to graduate was met with much debate. Test anxiety for students, teaching to the test for teachers, fairness of the test, and loss of classroom learning time for test administration were some of the primary concerns raised. Additionally, the fairness of the tests was challenged with respect to African American students, ESL learners, and charter schools (Furr (Weggener), 1996). Therefore, given that no changes have been made to any of the state mandated tests to rectify these concerns, students' literacy levels are still of concern to pass the algebra 1 EOC. All things considered, due to the newness of Ohio's current graduation test, there is very little data and or research compiled in order to verify the fairness of the algebra 1 EOC.

Statement of the Problem

The problem this study will address is the interconnectedness between literacy and success on the Ohio algebra 1 EOC exam. Predicting which students will struggle allows teachers to implement appropriate interventions to help each student succeed. Many students struggle to pass this test regardless of their grades and abilities in the algebra course. The wording of the problems on the test becomes a huge obstacle for students who may not be reading at grade level. While the test is intended to measure mathematical ability, the wording and phrasing of many questions prove to be challenging to students who read at grade level. Thus, it is understandable that students who read below grade level are more likely to experience frustration and become discouraged while taking the EOC. Therefore, teachers are tasked with teaching the algebra standards as well as incorporating literacy skills needed to decode the wording of the questions. The overarching goal of the study is to examine factors that may predict success on algebra 1 EOC exam.

Purpose of the Study

The purpose of the study is twofold: (1) to examine the connection between literacy and success on the algebra 1 end-of-course exam; and (2) identify significant predictors of success on the algebra I EOC. Student literacy scores were chosen as the primary predictor/s of interest for this study due to the challenging wording and comprehension level of the algebra I EOC. Once predictors that contribute significantly to success on the EOC can be identified and quantified, this will allow the creation of intervention and differentiation strategies to be implemented in a more directed and advantageous manner to the test taker.

The main benefit of this study is to establish the need for algebra teachers to provide reading strategies to better help their students become successful. Algebra teachers who maintain a focus solely on the math standards will need to simply resort to “teaching to the test.” In other words, from the results of this study, algebra 1 teachers may find they need to spend more time focusing on reading strategies, using similarly worded problems, and teaching techniques for finding contextual clues within the problems to develop a student’s ability to answer the types of questions asked on the EOC. Ultimately, by determining the best predictors of success on the algebra I EOC exam, the benefit of this study is to better situate teachers to be able to identify students that may need intervention or additional support to be successful on the algebra 1

EOC. Once these students are identified as less likely to be successful, teachers can then implement intervention and support strategies to help bridge gaps in the students' learning and achieve a proficient score on the EOC exam, thus meeting the Ohio graduation requirement for algebra 1.

In addition to helping teachers identify at-risk students, the results of this study may help address the design of the exam to measure a student's mathematical ability more accurately. This would require further research involving a more in-depth study of questions, question types, and wording of questions. For now, the idea behind this study is to first determine if there is a significant connection between literacy scores and passing scores of the students at the two selected schools.

Significance of the Study

This study is significant to any teacher, administrator, and/or school district that wants to identify the most significant predictors of success on the Ohio algebra 1 EOC, as well as identify any students who may need intervention or support to pass the algebra 1 EOC. Once provided the information in this study, teachers can then implement the appropriate interventions necessary to guide these students towards success on the EOC. In addition to benefiting teachers and districts to intervene when needed, this study may also be beneficial to anyone who wants to further investigate fairness and/or any discriminatory elements that might be part of the test design and development.

Gaps in the research for Ohio's state testing are primarily due to the newness of the currently administered test. Ohio students who entered their freshman year by July 1, 2014, were the last graduating class to be administered the Ohio Graduation Test. Ohio then adopted the PARCC test for the Spring of 2015 and 2016, and then switched to the

AIR test in Spring of 2017. Since 2017 Ohio has used the current testing format and provider. Ohio test designers have worked on improving the test design by putting an emphasis on the depth of knowledge as referenced in the algebra 1 EOC blueprints and test specifications. All things considered, due to many changes in test format, design, and provider, additional changes to Ohio's New Learning Standards, and recent interruptions to testing due to the COVID-19 pandemic, there is very little consecutive data from year to year that can be used due to a lack of consistency. Therefore, this study looks to begin filling this gap starting with two, rural school districts by analyzing the data available to the schools to predict student success.

Overall, with the goal of achieving success for all students, this study aims to improve student achievement, teachers' abilities to identify students that need intervention, and inspire future research that considers overall fairness of the test design.

Primary Research Questions

Question 1: Is there a statistically significant correlation between a student's STAR Reading test score and the algebra 1 EOC score?

Question 2: Are eighth grade demographics (District/SWD/Gender), Star instructional reading level, mathematics and English course grades, and end-of-course exam scores (mathematics and English Language Arts, ELA) significant predictors of a student's score on the Ohio algebra 1 EOC?

Question 3: Are eighth grade demographics (District/SWD/Gender), Star instructional reading level, mathematics and English course grades, and end-of-course exam scores (mathematics and English Language Arts, ELA) significant predictors of a student's success (Pass/Fail) on the Ohio algebra 1 EOC?

Research Design

This study intends to predict success on the algebra 1 EOC exam by examining different variables such as 8th grade course grades, 8th grade state test scores in math and English, and 8th grade reading scores on the STAR test. There will be a focus on reading ability and scores looking for a significant relationship between STAR reading scores and algebra 1 EOC scores. Using multiple regression techniques, the study will look at the likelihood that STAR Reading tests, mathematics course grades, and End of Course (mathematics and English Language Arts, ELA) can accurately predict a student's algebra 1 EOC score and evaluate the strength of the predictions. Logistic regression techniques will also be used to determine if these factors can predict success (passing score) on the algebra 1 EOC exam. Hypothesis testing will also be used to determine if correlations are statistically significant.

Theoretical Framework

Education and learning have evolved over the years to reflect the current learning theory of the times. One of the first and most known educational theorists was B.F Skinner and his behaviorism theories. Skinner theorized that learning was achieved by rewards and consequences (Hoy, 2010). According to this learning theory, everyone is capable of learning the same information with the correct number of stimuli. Throughout the years, many other theories have been examined and researched, but the current emphasis seems to be the constructivist learning theory based on the work of Jean Piaget and Lev Vygotsky. Constructivist theory states that knowledge is constructed by the learner and builds upon whatever learning has already occurred (Hoy, 2010).

When learning is examined at this level, each student has unique needs to learn the same material. Every student who enters a classroom arrives with a wide array of experiences be it educational, social, or other various life experiences. For example, one student may have a vast amount of knowledge and life experiences on which they can build upon to better understand new material, whereas another may be lacking general knowledge due to a lack of life experiences which can make learning the same material significantly more challenging. Reading skills and ability are one of the foundations of learning and therefore, literacy level and reading experiences have the ability to greatly influence each student's ability to learn many things, more specifically in this study, algebra.

Assumptions, Limitations, and Scope

The data collected is from two, rural Ohio schools with relatively low socioeconomic status, little diversity, similar gender variation, and some variation in student ability. These schools were chosen out of convenience due to the ease of accessibility of data for the researchers, but also due to similarities between the two districts in size and demographics. Although more districts could have provided more insight, future studies can build upon the results provided in this study.

The data collected is about students who were in 8th grade during the ‘17-’18 school year and 9th grade during the ‘18-’19 school year. Those 8th grade students who took algebra in ‘17-’18 will be removed from this study, as their data is not consistent with the rest of the data. It is assumed that all students who took the algebra 1 EOC during the ‘18-’19 school year were placed into the appropriate course based on their grade level. It is also assumed that the EOC scores reflect a true representation of each student's ability.

The data also includes 8th grade math and English EOC state test scores, 8th grade STAR reading scores, 8th grade course grades in math and English, and 9th grade algebra I EOC scores.

Definition of Terms

Algebra 1 EOC - refers to the Ohio algebra 1 end of course exam that is a high stakes exam intended to measure algebra understanding. A competency score of 684, is required to graduate from any public Ohio high school (ODE, n.d.).

Eighth Grade Course Grades - Scores earned by sample participants in both English and mathematics courses during their 8th grade year.

Ohio State Assessments - Also referred to as the AIR test or end-of-course exams (EOC).

Performance Level- The algebra 1 EOC provides a test score and a rating. The performance levels are as stated from least to greatest. Limited, Basic, Proficient, Accelerated, Advanced. Students are expected to score proficient if they have met all standards.

Socio-Economic Status (SES) - an economic measure of a student’s family’s income. For this study, each student will be identified as either free/reduced lunch or not free/reduced lunch.

STAR Reading Test- a reading assessment that measures various aspects of literacy and provides the district with a score of each student's grade-level reading ability.

Success- receiving a proficient level or a score of 684 or higher on the algebra 1 EOC

Summary

Chapter 1 introduced the focus problem of this study; that is, student literacy levels may play a larger role in the passing of the algebra 1 EOC than a student's math ability. This chapter also discussed a brief history of how the role and purpose of higher-level mathematics in education has changed, and a brief history of state testing and the progression of Ohio's graduation requirements. Chapter 2 will include a literature review of resources relevant to this study. Finally, chapters 3-5 will include the methodology for this study, results, and finally a discussion of the findings from this study.

CHAPTER II: Background and Literature Review

Introduction

In this chapter, a brief overview is provided over the research and topics relevant to this study. Topics discussed in this chapter include:

1. Learning Theory: Constructivism
2. The Importance of Algebra
3. The Role of Literacy in Mathematics
4. History and Role of Standardized Testing
5. Ohio End of Course Exams and Graduation Requirements

The researchers' hope is that through the provided analysis and presentation of the following literature review, readers might gain a better understanding of the current Ohio graduation EOC exam requirements and the importance of literacy's role in the study of mathematics, but also see the progression of how students build skill and knowledge over the years. This process begins with the initial stages of learning during infancy using the work of Lev Vygotsky and Jean Piaget. Then, as children grow, they move into literacy development during the early elementary years. Finally, during their secondary education, students combine all their previously learned knowledge and apply it to their study of algebra. Therefore, the goal of the researchers from this literature review is to understand the already found correlations between reading and mathematics and promote student success (at similar schools) on the algebra 1 EOC by identifying statistically significant predictors.

Learning Theory: Constructivism

Constructivist Theory

Throughout the history of education, an abundant amount of research has been conducted on cognitive development and the learning process. Of that research, Jean Piaget and Lev Vygotsky were two of the major contributors to some of the more well-known and respected cognitive development theories. Moreover, Piaget and Vygotsky's work have both deeply impacted contemporary educational psychology and serve as a foundation for the constructivist approach to learning.

Although there is not just one single theory, the constructivist approach to learning is based on two key principles:

1. Learners are active in constructing their own knowledge
2. Social interactions are important in [the] knowledge construction process (Hoy, 2010; Bruning, Schraw, Norby, and Ronning, 2004).

Piaget's Theory of Cognitive Development

Piaget believed that human cognition develops over time beginning at birth and continuing through maturation (Hoy, 2010). He believed that the need to develop and construct knowledge is an innate part of human nature's desire to make sense of the world around them. Further, Piaget identified four stages of learning, or cognitive development, as well as four factors that work together to influence one's thinking as they move through the four stages of learning. The four stages of learning are, "Sensorimotor, preoperational, concrete operational, and formal operational," and the four factors include “Biological maturation, activity, social experiences, and equilibration” (Hoy, 2010, p. 32-34). Together, each of these factors contribute to, and influence, the development of how one makes sense of the world around them.

Before considering the four factors that promote growth and movement between the stages, it is important to understand what key changes occur within each stage of Piaget’s theory of cognitive development. In the sensorimotor stage, infants, approximately ages 0-2, are developing basic functions, object permanence and goal-directed activity (Hoy, 2010, p. 34; Wadsworth, 1996). Examples of skills learned during this stage include sight, smell, moving, understanding objects that exist despite being able to see them, and working towards an end result, i.e.: opening a container, stacking rings, etc. The second stage is preoperational and is experienced during the ages of 2-7. This stage is filled with gradual language development, use of gestures or symbols, and one-directional thinking. “Between the ages of 2 and 4, most children enlarge their vocabulary from about 200 to 2000 words" (Hoy, 2010, p. 34). Children will also use gestures to show the intended use of objects and show knowledge or understanding by the use of pretending while playing. Finally, even though children have begun the ability to express their thinking, it is often difficult for them to think backwards or explain things in reverse.

The last two stages of Piaget’s theory of cognitive development are concrete operational, ages 7 to 11, and formal operational, 11 to adult (Wadsworth, 1996). During the concrete operational stage, Piaget suggests that children have finally developed the ability to reason logically in a hands-on manner. In this stage, children will also develop the ability to understand the ideas of identity, compensation, and reversibility (Hoy, 2010, p.35). This may pertain to understanding that characteristics of an object stay the same even though it may have changed appearance, focusing on more than one aspect at a time, and thinking through things backwards and not just forward. Ultimately, a child can think about what they can see and what they know, in other words, concrete ideas or tangible items. But they will most likely struggle with the idea of something that is abstract or hypothetical. Finally, this leads to the final stage of cognitive development, formal operational. Hoy defines Piaget's use of formal operations as “Tasks involving abstract thinking and coordination of a number of variables" (Hoy, 2010, p. 37). Thinking at this level switches from what is, to what could be, and includes inductive and deductive reasoning. According to professors of educational psychology Judith Meece and Denice Daniels, “The use of formal operational thinking is necessary for success in many advanced high school and college courses” (2008). Since formal operations are not linked to one’s physical environment, it is said that “[formal operational thinking] may be the product of practice in solving hypothetical problems and using formal scientific reasoning–abilities that are valued and taught in literate cultures, particularly in college. Even so, only about 30% to 40% of high school students can do Piaget’s formal-operational tasks” (Hoy, 2010; Meece & Daniels, 2008).

Now, having defined the four stages, it is important to consider how the four factors identified influence changes in thinking and help move individuals through the various stages. Piaget’s first two factors are maturation and activity. Maturation is the process of one’s body experiencing natural changes over time due to their specific, genetic coding. Of the identified factors, maturation is considered the only biological influence of cognitive development. That said, this is the only factor of the learning process where teachers have very little influence (Hoy, 2010). Activity, the second factor, is a direct result of maturation. As children develop physically, they are then able to act upon and respond to their environment in order to learn. Ultimately, the purpose of activity is to learn from one's environment by testing, exploring, and observing how the things around them work and behave. From these interactions, one can then organize the information gained to alter their thinking processes (Hoy, 2010, p. 32).

The next factor identified by Piaget is social experiences. Arguably, social interaction is one of the most important contributors to cognitive development. According to childhood educational psychologist Anita Hoy, "Without social transmission, we would need to reinvent all the knowledge already offered by our culture" (2010, p. 32). It is through social settings and written expression that knowledge is transferred, and more importantly preserved. Despite the major influence of social interactions on one's learning, the amount of knowledge gained from these social experiences depends on which stage of cognitive development an individual has reached.

Finally, equilibration then takes each of the aforementioned factors to find balance in the learning process. Simply put, Piaget uses the idea of schemes, or building blocks of thinking, to develop new ideas (Hoy, 2010, p. 32). As a person develops new schemes and moves towards higher-level thinking processes, individuals become more likely to make sense of their environment. From here, a person has two choices to adapt from the already developed schemes, assimilate, or accommodate. Assimilation means that an individual will take existing schemes in order to understand or make sense of new situations or information (Hoy, 2010, p. 33). Accommodation is taking those existing schemes and modifying them, or adjusting them, to fit a new situation. Ultimately, as stated before, equilibration is finding balance between accommodating and assimilating these schemes to make sense of added information and situations.

From the research above, it is apparent that Piaget's work sets the stage for the understanding of cognitive development and constructivist theory. Additionally, through Piaget's work, one is also able to understand what may be considered both age and developmentally appropriate material for students. This knowledge is important not only for parents and teachers, but also for those in charge of designing material for students, specifically those who are tasked with designing Ohio's state tests.

Vygotsky's Theory of Cognitive Development

Another researcher who plays a significant role in the work of constructivist theory is Lev Vygotsky. Although his work does not identify distinct stages in learning, Vygotsky suggests that all mental structures or learning constructs occur in cultural settings (Hoy, 2010, p. 42). Therefore, it is through social interactions that a child can begin developing higher mental processes, like problem solving, with the help of another individual before internalizing these skills and practicing them on their own. In addition to the social and cultural aspect, Vygotsky considered learning and language to be a crucial factor of cognitive development, as "thinking depends on speech" (Hoy, 2010, p. 44). Finally, the most recognized piece of Vygtosky's work is his idea of "zone of proximal development."

The use of language throughout cognitive development is imperative for individuals to express their thinking, ask questions to clarify and build knowledge, and ultimately develop higher-order thinking processes. Vygotsky's use of language is primarily found in his view of private speech. He suggests that the use of private speech is not simply juvenile behavior, but rather a means of development in the learning process. Hoy states that "Vygotsky suggested that these mutterings play an important role in cognitive development by moving children in stages toward self-regulation: the ability to plan, monitor, and guide one's own thinking and problem solving" (2010, p. 46). As children progress into adolescence, private speech turns into whispering to themselves and eventually silently thinking through problems in their heads, or inner speech. All these processes are a result of the use of language, further showing the vital role language plays in Vygotsky's theory.

Finally, the zone of proximal development, or ZPD, is the idea that there exists a window of difficulty in which students are best suited to learn. The ZPD is somewhere between a student's current development level and the level at which that student can achieve with the guidance of an adult or peer who is already capable (Vygotsky, 1978, p.86). With the idea of ZPD, Vygotsky suggests that at all times, there are certain problems that students are on the verge of being able to solve on their own, but needs either help, encouragement, or clues in order to solve the problem. That said, it is this optimal space in which teachers and students are able to work together to create understanding and exchange ideas.

Implications of Piaget and Vygotsky

Although Piaget and Vygotsky did not make specific recommendations for education and teaching, their work is able to point teachers towards best practice by understanding the role they play in guiding developing minds and knowing age-appropriate cognitive skills.

Even though their work was similar, the two did not fully agree on their approach to learning. Piaget believed that social interactions worked best between peers on the same level, whereas Vygotsky believed the best interactions were between child and adult, or a more advanced thinker (Hoy, 2010, p. 43). Despite this difference, it is clear they both agreed that socio-cultural experiences play a significant role in the development of student's thinking and reasoning skills. Additionally, Piaget's work suggested that knowledge is constructed through the use of internal processes, assimilation, and accommodation, where Vygotsky's work combined both internal factors and external factors (Hoy, 2010, p. 313; Moshman, 1982). Piaget might say that new knowledge develops from and adapts to fit prior knowledge; students learn best from exploring and discovering the world rather than just being taught the facts. Vygotsky would argue that knowledge develops in the same manner but requires the help of one's environment and social interactions including transference of language, beliefs, and experiences. In other words, students learn best from guided discovery, coaching, and direct teaching (Hoy, 2010; Bruning, Schraw, Norby, and Ronning, 2004).

Despite these differences, at the core of constructivism, both Vygotsky and Piaget emphasize the active use of knowledge, rather than rote memorization of facts, skills, and ideas. They encourage problem solving, inquiry, critical thinking, and open perspectives to promote student thinking (Driscoll, 2005). Thus, in order to incorporate Piagetian and Vygotskian theories into one's classroom, the following five conditions should be considered when using a constructivist approach to learning…

1. "Embed learning in complex, realistic, and relevant learning environments.
2. Provide for social negotiation and shared responsibility as part of learning.
3. Support multiple perspectives and use multiple representations of content.
4. Nurture self-awareness and an understanding that knowledge is constructed.
5. Encourage ownership of learning." (Driscoll, 2005; Hoy, 2010, pg. 314; Marshall, 1992)

Therefore, with all that has been discussed, it is a balancing act to provide work that is meaningful and appropriate, yet challenges students and fosters their growth. Disequilibration occurs when a student's means of thinking does not work to solve the problem at hand, or a task is simply too difficult to understand. Therefore, it is important from both Piaget and Vygotsky's perspectives that students are neither bored by, nor unable to understand the content that is being taught or presented (Case, 1985). Disequilibration must be kept to an appropriate level that encourages growth and fosters a student's cognitive development. Although this idea is heavily rooted in Piagetian theory, this is in essence Vygotsky's idea of the "zone of proximal development." Hoy states, "If people encounter something that is too unfamiliar, they may ignore it" (2010, p. 33).

Finding the right balance, or equilibrium, is how students are able to find success and expand their own knowledge into a meaningful experience and not just a reflection of someone else's.

Importance of Algebra

The beliefs surrounding what is most important and how to teach it are constantly changing and evolving in public education. In early American public education reading and writing were considered to be most important while math, especially higher-level math, was reserved only for those that were college bound. Throughout the twentieth century educators and politicians debated the content of math education. Some believed the math curriculum should be progressive, student centered, and only teaching that which could be directly applied to one's life situations. Others believed it should be more academic with strong content to support the learning of algebra and geometry. If the focus is on student centered learning, the amount of content that can be covered is greatly diminished leaving little ability to build foundations to support rigorous college level math. If the focus is aiming toward college level learning, then the amount of content that must be covered is vast and takes more time to get to the needed level of achievement. Regardless of many varying beliefs, studies show that to be successful in college students must be successful in algebra. The current goal of the public education system is to prepare every student, so they have the opportunity to be successful in college, whether they plan to attend college or not. The many national education acts sought to close the education gaps that existed due to poverty by providing resources to make sure every student regardless of race, socioeconomic status, location, or any other existing factors would be able to attend college to better themselves. For this reason, algebra is a requirement in most high schools.

A Nation at Risk cited that when comparing late 1960's the late 1970's curriculum, "Students have migrated from vocational and college preparatory programs to "general track" courses in large numbers" (*A Nation at Risk: The Imperative for Educational Reform a Report to the Nation and the Secretary of Education United States Department of Education by The National Commission on Excellence in Education,* 1983). These students were selecting easier courses thus creating much lower enrolment in higher level math and science courses overall. Compared to other countries our high school programs were much less rigorous and had significantly less content. If the United States were to compete in the global arena in the space race, or anywhere else, more students needed to be in higher level math and sciences. Giving every student the opportunity to reach higher levels began the push for more rigorous standards and less "tracking." It was believed that even students that planned to attend a vocational program should have the background that would enable them to pursue college if they were to change their plans. This, along with many other reports and studies done in the 1980's and 1990's, would contribute to the No Child Left Behind Act (NCLB) of 2001. NCLB was an amendment of the Elementary and Secondary Education act of 1965 that focused on accountability. Schools would be given "report cards" based on student learning that would be measured by standardized tests. The idea behind this act was that every student would leave high school prepared for college, whether they planned to attend or not. Algebra had long been considered a need for college bound students but was now considered a need for all high school students.

Many who are against the teaching of algebra to all students say that not all students will go to college and never have a need for algebra. If students are assumed to not attend college, then it would be impossible for them to change their minds, or, at the very least, make it very difficult to "change tracks" if they decide to attend college in the future. A study done by Gamoran, and Hannigan compared 10th grade math achievement among students who took algebra and those who did not. The students who took algebra had significantly greater growth than those who did not. Lower achieving students had less growth overall as would be expected, but still had statistically significant growth compared to those who took no algebra in high school (2000).   Similarly, Huffman, Stromberg, and Tunks found that access to algebra I in 8th grade can increase the likelihood of taking more math courses in high school and can also contribute to being more college ready at graduation (Huffman et al., 2009). Therefore, these and many other studies show that students who succeed in algebra are much more likely to be successful in higher level and college level math. In today's technological times, with much emphasis on economics, the need for math fluency is increasing. While there are still many careers that do not require college level math, algebra skills contribute to higher achievement while also providing the option of college if a change is desired.

In addition to the fact that algebra is a key to college success, algebra is the first area where students are introduced to abstract reasoning. Using a letter to represent a number makes little sense to a student who has never seen that. However, when students use algorithms, extrapolations, step-by-step analysis, and problem-solving skills, they are exposed to logic and reasoning skills that can be applied in real-life situations. It might be argued that there are better ways to teach logic and reasoning skills, but with the other added benefits algebra is considered a powerful addition to these attributes. These skills are carried over into many other areas, most specifically in many of the sciences. Any student interested in nursing, medical fields, biology, earth studies, physics, chemistry, computer sciences, etc. will need at the very least basic algebra skills. Most areas will require much higher levels of mathematics such as statistics, algebra II, and calculus, which all require algebra as a foundation. Even though a student who does not plan to go into a career immediately where there is a need for algebra, many people change careers over the course of their lives. What does not seem interesting to someone now may become an interest later, and if you did not build a foundation to prepare you for the education needed it can be difficult and costly to take the remedial courses necessary to pursue a new career later in life.

The Role of Literacy and Language in the Study of Mathematics

Mathematics and reading are two foundational skills linked to long-term academic and career success (Purpura et al.,2019). Additionally, a rising correlation between education and income has been found as a result of the increasing literacy requirements of many workplaces (Shanahan & Shanahan, 2008).

Within the realm of reading, children must master the skills of language and literacy. According to the American Speech-Language-Hearing Association (ASHA) (ASHA, n.d.), the definition of language is “The words we use and how we use them to share ideas and get what we want.” Literacy is defined by the National Council of Teachers of English (NCTE), as “The way that we interact with the world around us, how we shape it and are shaped by it. It is how we communicate with others via reading and writing, but also by speaking, listening, and creating. It is how we articulate our experience in the world and declare, ‘We Are Here!’” (Peterson, 2020).

As previously discussed from the work of constructivist theories, not all knowledge is taught, but rather learned from social and cultural experiences. According to Dawn Betts Ph. D, just like language, reading is a consequence of living in a literate society (2008, p. 28). Furthermore, from a constructivist perspective, Betts suggests that reading is something that is learned from the practices and beliefs of one’s environment, and not just explicitly taught. Therefore, cultural, and social contexts should not be dismissed when considering the developmental process of language and literacy. However, the belief that basic reading skills continue to evolve and advance as one continues their literacy learning is only partially correct (Shanahan, 2008).

Language and Literacy Deficits

Understanding that language and literacy are extraordinarily intertwined, research suggests that deficits in language are related to deficits in literacy and vice versa. According to Betts (2008) deficits in language skills during preschool and early childhood tend to, and continue to have difficulties with language, more specifically literacy skills throughout adolescence. Bernhardt and Major (2005) studied preschoolers three years after having taken an initial language assessment. After reevaluating the preschoolers, their findings suggest that those preschoolers who exhibited difficulties with verbal memory and language production on their initial assessment were more likely to struggle with literacy skills compared to their peers.

Similarly, David Purpura et al. (2019) states, “Mathematics and reading disorders have a high comorbidity.” It follows children who struggle with reading also have a greater risk of experiencing struggles in mathematics in later grades (Purpura et al., 2019; Jordan et al., 2003). In fact, recent statistics show that of the 7% of children that experience a mathematics disorder, 17%-66% will experience a comorbid disorder in reading (Koepke & Miller, 2013; Purpura et al., 2019). Therefore, it is of utmost importance to address the needs of struggling readers, especially at an early age, in order to prevent later difficulties in both reading and mathematics.

Third Grade Reading Guarantee

Seeing that mastery of and fluency in language and literacy at an early age is so crucial, it comes as no surprise that these two skills are an integral part of a student's curriculum during the early elementary years. Beginning in kindergarten, children have on average 720 school days to achieve fluency in reading by the end of third grade (Logan et al, 2019). When a student enters fourth grade, instruction shifts from "learning to read" to "reading to learn" (Logan et al., 2019; Adams, 1994). That said, there is a significant transition from just being able to read and recognize words, to being able to read while also comprehending the text.

Due to the importance of a child's ability to read fluently by the fourth grade, many initiatives, grant-money, and legislation has been put into effect in order to address a lack of literacy achievement. As of 2019, 16 states and DC have put into place a third-grade reading guarantee. Ohio is included in this guarantee that requires retention for students that do not show reading proficiency by the end of third grade (Logan et al., 2019). In June 2012, Governor John Kasich signed Senate Bill 316 (SB 316) which mandated Ohio public schools to retain all non-proficient readers (Logan et al. 2019). In addition to retention, SB 316 also allowed the State Board of Education to determine cut off scores that deem a student as proficient or not proficient and provided more support for students in grades K-3 by requiring schools to identify students as below grade level. Those students identified were to be part of a reading improvement plan that is then reported to the department of education, governor, and general assembly. Finally, this legislation ensured that students identified as underperforming are taught by “qualified teachers,” and parents are to be notified if their child is identified as underperforming (Logan et al, 2019, p. 3).

As found by Denti and Guerin (1999), a strong correlation with R-value .80 exists between third-grade reading and eleventh grade success (Betts, 2008, p. 43). Although the goal of the third-grade guarantee is not specific to eleventh grade, it is apparent that Ohio recognizes the importance of improving children’s reading abilities before they enter the fourth grade in order to create literacy/reading skills that will last to help them throughout the rest of their educational career. That said, according to the study by Logan et al. from The Ohio State University (2019) it is unclear if the third grade reading guarantee has made any progress in meeting this goal. Their work found that Ohio’s fourth-grade reading National Assessment of Educational Progress (NAEP) scores showed no meaningful change from 2002 through 2017, five years after the implementation of the guarantee. Their findings also show that one in three children score below basic on the NAEP, which has not changed for the last 15 years, and state test scores do not show much difference either (Logan et al., 2019; McFarland et al., 2017). Ultimately, even though the state is showing a significant improvement in passage rates for the third-grade reading guarantee, Logan et al. states “Our findings demonstrate that this does not reflect the reality, which is that significant percentages of third and fourth graders are not reading proficiently” (2019).

Reading and Mathematics

It may sound counterintuitive that reading and math are highly correlated, but according to the work of Walkington, “many mathematics problems involve considerable reading demands" (2018). Both mathematics and reading require the use and understanding of a symbolic code, be it numbers or letters (Purpura et al., 2019). Therefore, phonological processing, language comprehension, reading comprehension, and problem translation are all factors that impact a student’s mathematical ability (Gomez et al.; 2020). Students must be able to understand the language of mathematics, but also comprehend what is being asked of them within a problem. If a student struggles with any of the aforementioned factors, word problems automatically become an obstacle for a student even if they understand the mathematics necessary to solve the problem.

When it comes to mathematics, once problems are taken out of their symbolic form and put into real-life applications, comprehension of these word problems is crucial for student success (Gomez et, al, 2020; Macdonald and Banes, 2017). When students are given mathematical information presented in a verbal context instead of symbolic form, this requires the reader to interpret the language and extract meaning; a more rigorous skill than simply completing an exercise problem alone. Therefore, language and vocabulary choice, as well as student experiences play a factor in what students are able to comprehend and or successfully complete.

Even though teachers can control the number and type of word problems or application problems they use in their classrooms, the issue lies in state- and nationallymandated assessments. Given a wide range of student language abilities, literacy levels, and social experiences, it is “academically irresponsible to assume that state and national assessments are created to fit the linguistic needs of all students” (Gomez et. al, 2020 p. 1347) Trakulphadetkrai et al. (2020) found that standardized assessments around the world have shifted towards the use of mathematical word problems to assess a student’s mathematical ability. The findings of this study are relevant as this type of testing model requires children to not only think mathematically, but also make sense of and interpret the word problems. This type of assessment assesses not only a student’s mathematical ability but also brings into consideration their language and literacy skills. Therefore, with this shift, teachers must consider how to address the literacy and language needs of their students in order to be successful.

Implications of Reading for Mathematics Teachers

Currently, very little policy has been created to help remedy and provide support to struggling adolescent readers. Literacy at the secondary level is often neglected and underfunded primarily due to a lack of research and limited resources (Betts, 2008, pg. 43). The Shanahan’s also agree, saying “There is a clear need to expand literacy instruction upward through the grades to better support the reading of older students" (2008). He continues on to suggest that new demands for literacy need to focus on not just the lowest achieving students, but all students, and an advanced literacy program needs to be developed and implemented at the secondary level. Therefore, as the research shows, since there is a clear connection between reading and mathematics performance, it is pertinent that mathematics teachers are incorporating literacy skills within their classes. Since reading and mathematics are not typically taught by the same teacher, understanding how to address struggling reader's needs and provide reading comprehension strategies to assist all students' needs is of foremost importance.

According to Gomez (2020), teachers must provide their students with strategies "to help lessen the cognitive demand of word problems." Takulphadetkrai et al. (2020) also suggests that students need to have a "good knowledge of everyday vocabulary" as mathematical modeling, or real-life application and context, has become the preferred method of problem solving. It is in the intersection of mathematical language and everyday language where confusion creeps in, and student understanding is convoluted.

One strategy recommended to content area teachers is disciplinary literacy. Compared to content reading which has been around for over a century, disciplinary literacy is a relatively new buzzword stemming from the 1990's (Hynd-Shanahan, 2013). With content area reading, the idea is that students can develop skills that apply to any field of reading to help comprehend the text. Disciplinary literacy focuses on the discipline itself (in this case mathematics) and knowing how to read and interpret a text written from this view. For example, according to a research study by Tim and Cynthia Shanahan, two educational researchers and policy makers, found that the group of mathematicians expressed that when practicing disciplinary reading, the two most important skills were rereading the text and close reading (Shanahan & Shanahan, 2008). They were identified as the most important because mathematical reading requires precision of word meaning, and unlike other disciplines, function words like "a" and "the" can express different meanings based on their use within the context of a proof or problem. Therefore, instead of teaching a specific reading strategy or strategies to students, teachers should focus on teaching their students to be disciplinary readers where they read the text based on its discipline. In essence, students should read a historical text like a historian, a scientific text like a scientist, and a mathematical text like a mathematician. In doing this, students are better suited to interpret and comprehend the specific word meanings within a text and are more likely to understand the intended purpose of the text. (Hynd-Shanahan, 2013).

Ultimately, when it comes to student literacy at the secondary level, the Shanahan's believes that in order to address the nations long-term literacy needs in adolescents begins with teacher preparation and education (2008). Many programs for content teachers at the secondary level do not integrate literacy courses into their curriculum (Hynd-Shanahan, 2013; Shanahan, 2008). Therefore, educators are not properly equipped to tackle literacy deficits/topics within their classrooms despite being asked to incorporate these skills into their courses. There is a clear need for literacy certification standards for all teachers, including those in the various disciplines (Shanahan, 2008). Until changes are made within educator preparation programs, teachers are able to utilize strategies within their classrooms, and reading is not seen as a separate domain from the disciplines, it is likely literacy scores, and success in mathematic will remain the same for years to come (Purpura et al., 2019; Shanahan, 2008)

History and Role of Standardized Testing

In the early days of public education in the United States there was little guidance as to what to teach and even less information on how to teach it. In the 1800's the only students that studied algebra, geometry and higher-level math were students that planned to study math in college. At that time this was a small select group of white males. A study in 1908 by the International Commission on the Teaching of Mathematics found that “almost all secondary schools in the U.S. provided at least one year of algebra and geometry, that 50% of schools had one more semester of algebra, and that less than 20% of schools offered any higher mathematics (Willoughby, p.7)” (Furr(Waggener), 1996). Through the World War 1 era there was decreased emphasis and requirement for math education. Many believed that nothing more than basic calculations should be taught.

In the late 1800’s colleges began placing more interest in teacher education. Colleges also began increasing mathematical requirements for college entrance. In the early 1900’s the College Entrance Examination Board (CEEB) was formed, and the first college entrance exams were created. In 1926 the Scholastic Aptitude Test (SAT) was first given and by 1930 it very closely resembled its current format. Around this same time standardized intelligence tests and military aptitude tests were beginning to be used. Also, during this era, the University of Iowa began development and use of high school standardized tests. The Iowa tests would later contribute to the development of the American College Test (ACT). (*History of Standardized Testing in the United States* | *NEA*, n.d.)

The forerunner to national standards was perhaps the National Committee on Mathematical Requirements, under the Mathematical Association of America, bulletin “The Reorganization of Mathematics in Secondary Education ". Colleges were beginning to introduce entrance exams which brought high school math education into consideration. This bulletin called for reform in secondary classrooms and suggested what should be taught at various levels (The National Committee on Mathematical Requirements, 1922). The purpose of the committee was to give "national expression to the movement for reform in the teaching of mathematics, which had gained considerable headway in various parts of the country” (Boyer et al., 1972). Despite continued efforts to increase mathematical requirements, the 1930’s saw increased enrollment in secondary schools but “the vast extension of compulsory education had changed its purpose from preparation for college to "life adjustment."’ (Boyer et al., 1972). During this time standardized testing was becoming increasingly prevalent in many aspects of education.

World War II revealed a need for increased emphasis on mathematical learning. However, the ways to implement the reform were very much disputed. “New math” was introduced and hotly debated as a means for improving mathematical competency. New math was the idea that students would perform better if they understood the algorithms behind the computations rather than memorizing steps and patterns. While not a new idea, it was different from traditional memorization and practice methods. New math implemented discovery learning which was backed by constructivist theorists and while the learning is much more “permanent,” it takes much longer to cover material so the number of topics or standards that can be taught decreases drastically. Then with Russia launching Sputnik in 1957 there was a new drive for greater math proficiency and competition in the space race. Controversy and debate over what to teach and how to teach it were constantly at the forefront of math education for the next several decades. In 1983 “A Nation at Risk" was a study done for the US Department of Education that made recommendations for reforms needed and how to implement them. The study was done by The National Commission on Excellence in Education and found that curriculums across the US were diluted, not rigorous and with decreased expectations on grades and time. Among the findings, a 1980 survey found that thirty-five states require only 1 year of mathematics for graduation (A Nation at Risk, 1983). In 1989 the NCTM published the first voluntary national content standards in math. These standards were debated and reconstructed several times but laid the foundations that would later help states to develop their own content standards for mathematics.

It was during this time, approximately 1987, that Ohio began to pursue a testing requirement for high school graduation. The ninth-grade proficiency test was the first standardized test that would be the requirement for graduation beginning in 1994 (Background/History of Ohio Proficiency Tests, 1998). The state also developed and administered proficiency tests at the fourth, sixth, and twelfth grade levels in reading, writing, math, science, and citizenship.

Between 1990-2000 states began developing their own content standards. The 2001 No Child Left Behind Act required state standards and assessment in English Language Arts (ELA), Math, and later science. The following years found many issues with the standards adopted and by the late 2000's 48 of the 50 states decided to collaborate to develop "common" standards. In 2010 the common core standards were released and Ohio, along with 45 other states, adopted them as the states learning standards. In response to the No Child Left Behind Act (NCLB) of 2001, in 2005 the Ohio Achievement Assessment (OAA) and Ohio Graduation Test (OGT) were developed to replace the proficiency tests and the OGT was added as a graduation requirement. The

OGT measured achievement in 10th grade level reading, writing, math, science, and history. In 2010 Ohio adopted the Common Core Standards that were developed by a committee made up of educators and representatives from several states (Findell & Roget, 2015). Ohio only required two math credits for graduations until 2004 when the number of math credits increased to three (State Requirements for High School Graduation, in Carnegie Units: 2001). Later, Ohio would introduce the third grade reading guarantee which meant that students were required to score a proficient score on a reading test at the end of third grade to ensure they were proficient readers and ready to progress. Around the same time, Ohio began to use standardized tests along with Student Learning Objectives (SLO's) not only to measure student growth but to evaluate teachers. In 2014 Ohio added Algebra 2 as a graduation requirement and increased math credits required for graduation to four.

Ohio EOC Assessments and Graduation Requirements

In 2015 Ohio again changed testing requirements. Third grade through eighth grade were tested in English language arts and math. Science was tested in fifth and seventh grades. Social studies were tested in fourth and sixth grades. At the high school level, end-of-course exams would be given in ninth grade in English I and algebra I (or integrated math). In tenth grade, end-of-course exams were given in English II, geometry (or integrated math II), biology and American History. Finally, an end-of-course exam in American Government was given in eleventh grade. Along with the roll out of the new tests in 2015, the graduation requirement for the class of 2018 (the class entering the ninth grade the first year of test administration) were to earn 18 points among the 7 tests issued. Each test had a maximum of 5 points available: 1-limited, 2 – basic, 3- proficient, 4- accelerated, and 5- advanced. In addition, a student must earn at least 4 points in English, at least 4 points in math, and a minimum of 6 points across science and history. From 2018 through 2022 this was the suggested graduation requirements, however there were alternative pathways to graduate. For the class of 2023 and beyond, the testing requirement was decreased. The class of 2023 still needs to take end-of-course exams in English II, algebra I, geometry, biology, American history, and American government. The only tests that require a proficient score to graduate are English II and Algebra I (Department of Education, n.d.). With the current graduation testing requirement being reduced to just algebra and ELA, again there is a clear emphasis on algebra and reading ability being perceived as the most key factors for success.

This study hopes to explore the link between reading skills and success on the algebra I end-of-course assessment while examining other factors that could potentially be predictors of success. One of the factors to be examined are STAR reading assessment scores. While Betts found a direct relationship to success on the OGT and reading comprehension scores, most studies found previous year end-of-course tests, grades, socioeconomic status (free lunch), and minority status to be major predictors (2008).

Summary

Chapter 2 presented and summarized literature and research that is similar and relevant to this study; that is, how students learn, why algebra is important, the role of literacy in mathematics, the history of standardized testing, and Ohio's current EOC testing and graduation requirements. To the knowledge of the researchers, there are no studies that consider the relationships between reading/language and literacy and the Ohio end-of-course exam for algebra 1. Therefore, the purpose of this study is to identify statistically significant predictors of success that might help similar schools in order to provide interventions to appropriate students.

CHAPTER III: METHODOLOGY

Introduction

Chapter 3 will provide a quantitative and demographic overview of the two schools selected for this study, and how participants for this study were chosen. This chapter will then provide a description for each of the assessment tools included in the data set, followed by how both of the researchers collected data to ensure anonymity and no risk to the participants. This chapter will describe in detail each step of the process that the researchers will take to examine the relationships between the variables. Finally, Chapter 3 will conclude with the research hypotheses, and an explanation of how the data is to be analyzed. All data used in this study was collected in 2022 but uses results from the 2017-2018 (eighth-grade) and 2018-2019 (freshman) academic school years.

Setting and Participants

The participants in this study are students from two rural, public Ohio high schools. Both schools have very little diversity and similar gender distribution. Additionally, the two schools are considered to be of low socioeconomic status. The first high school is located in North-West Ohio and has a total enrollment of 366 students according to the 2020-2021 Ohio School Report Card (*Ohio School Report Cards*, n.d.). The second high school is located in Mid-East Ohio and has a total of 423 students according to the 2020-2021 Ohio School Report Card (*Ohio School Report Cards*, n.d.). The participants chosen attended the two previously mentioned schools and are students of their respective 2022 graduating class. Although the researchers would have liked to include more classes to increase the sample size, unfortunately the Covid-19 pandemic caused an interruption in state testing during the 2019-2020 school year creating incomplete data sets for the class of 2023 (no algebra 1 EOC score) and class of 2024 (no eight-grade EOC scores). The next graduating class to have complete data for this particular study will be from the class of 2025. Due to the time constraints for this study, the 2025 data set will be available after the completion of this study. Therefore, the only complete set of available data to the researchers is that from the class of 2022.

Since both schools offer an advanced track for algebra in eighth grade, the researchers had to specify which students should be included in the study. Therefore, not all members of the 2022 graduating class are included in this study. To clarify, aside from being part of the 2022 graduating class, other qualifications considered were,

Participant of this study are to,

1. Be enrolled in an eighth-grade math and language arts course during the 2017-2018 academic school year.
2. Take the eighth-grade math and ELA EOC exams during the spring 2018 administration.
3. Be enrolled in an algebra 1 course during the 2018-2019 academic school year.
4. Take the EOC during the spring 2019 administration.

This decision was made so that the researchers can compare EOC results from the same test instead of comparing results from two different versions of the test. Although this removes the typically highest achieving students from the sample set, this provides consistency amongst the predictors chosen.

The overall demographics of the first school include 3.8% Hispanic, 3% multiracial, 89.6% white, with 9.3% of students identified as having disabilities and 44.5% of students as economically disadvantaged. After students with missing data were removed, school one had 41 students included in the study. Of the final data, there were 19 females, 22 males, 0 students with 504 plans, and 2 students with IEP's.

The overall demographics of the second school were 4.2% multiracial, 94.2% white, with 10.5% of students with disabilities and 32.6% of students economically disadvantaged. The data for the second school was provided by administration with identifiers removed. After removing students with missing data there were 82 students included in the study. Of the final data, there were 47 females, 35 males, 2 students with 504 plans, and 6 students with IEP's.

The multiple regression test was chosen as it allows us to assess the strength of the relationship between the dependent variable and the predictor variable(s). This also allows us to identify the significance of each predictor as well. In terms of effect size, since we are working with relatively small schools instead of large districts, we chose a medium sized effect. Finally, for our alpha level, we decided to just stick with the standard alpha of .05 to have a 95% confidence interval.

Question 1: Is there a statistically significant correlation between a student's STAR Reading test score and the algebra 1 EOC score? This question requires 1 tested predictor with 2 total predictors. Using G-Power for Linear Multiple Regression (F-Tests), with an effect size of 0.15, alpha level of 0.05 to obtain a 95% confidence in the accuracy of our test, the suggested sample size is 89.

Question 2 & Question3: Are eighth grade demographics (District/SWD/Gender), Star instructional reading level, mathematics and English course grades, and end-of-course exam scores (mathematics and English Language Arts, ELA) significant predictors of a student's score on the Ohio algebra 1 EOC?/ Are eighth grade demographics (District/SWD/Gender), Star instructional reading level, mathematics and English course grades, and end-of-course exam scores (mathematics and English Language Arts, ELA) significant predictors of a student's success (Pass/Fail) on the Ohio algebra 1 EOC? The remaining two hypotheses require 8 tested predictors with 9 total predictors. Using G-Power for Linear Multiple Regression (F-Tests), with an effect size of 0.15, alpha level = 0.05 to obtain a 95% confidence level, the suggested sample size is 129.

Instrumentation

The STAR reading assessment, produced by Renaissance Learning, Inc., is a commonly used tool for measuring reading ability. According to Renaissance Learning, the STAR reading assessment has a high level of reliability and reports a .97 reliability coefficient from a sample of 1,227,915 students grades 1-12 (2013). The STAR reading assessment measures a student's reading skills and identifies the instructional reading level (IRL) for each student.

The Ohio Department of Education, ODE, along with Cambium Assessment developed the eighth-grade English Language Arts, eighth-grade Mathematics, and the Algebra I end-of-course assessments. The eighth-grade math EOC exam administered to these students in 2018 contained 14 points for expressions and equations, 11 points for functions, 16 points for geometry, 12 points for the number system, and of the 53 points available, 26 also measured modeling and reasoning. The eighth-grade ELA EOC exam contained 23 points measuring reading for information, 19 points for reading for literature and 20 points for writing. The 2019 Algebra I EOC exam included 24 points for functions, 20 points for Number Quantities, Equations, and Expressions, 10 points for statistics, and of the 54 points, 27 measured modeling and reasoning. The levels of scoring are listed in Tables 1-3 below.

OHIO'S STATE TESTS Spring 2018 Administration Raw Score Subscale Ranges

Table 1. Grade 8 English Language Arts Raw Score Subscale Ranges

	Below Standard	At or near Standard	Above Standard
Reading for Information	0-8	9-13	14-23
Reading for Literature	0-8	9-12	13-19
Writing	0-7	8-11	12-20

Table 2. Grade 8 Mathematics Raw Score Subscale Ranges

	Below Standard	At or near Standard	Above Standard
Expressions and Equations	0-3	4-7	8-14
Functions	0-4	5-6	7-11
Geometry	0-6	7-9	10-16
The Number System	0-3	4-6	7-12
Modeling and Reasoning	0-6	7-10	11-26

OHIO'S STATE TESTS Spring 2019 Administration Raw Score Subscale Ranges

Table 3. Algebra Raw Score Subscale Ranges

	Below Standard	At or near Standard	Above Standard
Functions	0-6	7-10	11-24
Number Quantities, Equations, and Expressions	0-6	7-9	10-20
Statistics	0-2	3-5	6-10
Modeling and Reasoning	0-7	8-11	12-27

(*Statistical Summaries and Item Analysis Reports | Ohio Department of Education*, n.d.)

Procedure

Data required for this study was easily accessible and readily available to building administrators. Upon approval from the IRB, data was requested and provided to the researchers by administrators from each school district. The administrators compiled all the data set into a spreadsheet then removed students' names and school ID numbers. Due to the age of the students, all identifiable information was removed before the data was released to the researchers, thus removing all risks of a participant being identified. In addition, because there is no identifiable information linked to the data, the researchers did not need to obtain permission from the participants. As all identifiers were removed from the data before being released to the researchers an exempt IRB application was filed and approved.   The compiled data sets are attached in appendix A. The IRB approval is also attached in appendix B.

All students who were missing any piece of the data were removed. The remaining students had both eighth-grade math and English course grades, EOC scores for eighth-grade math and ELA, an eighth-grade STAR assessment score, and a ninth-grade algebra I EOC score. The data for the two schools was combined into a shared document so both researchers had access to the combined data.

Data Processing and Analysis

The data was combined into a spreadsheet with the two districts being marked respectively (See appendix A). Once all the data was organized, it was cleansed by removing all students with incomplete data. The finished data set was then entered into the statistical computing package, R (v4.0.2; R Core Team 2022). Table 4 provides a detailed and descriptive list of all the variables used by the researchers throughout the study. This table will be useful while interpreting the results found in chapter 4.

Table 4. Description of Variables Used

Name	Label	Value	Measure
District	School district	[A, SE dist.] [B, NW dist.]	Categorical
StudentID	Student ID	None	Nominal
ALGEBRA	Student’s scale score on the Alg. 1 EOC exam	None	Scale

Table 4. Cont. Description of Variables Used

Name	**Label**	**Value**	**Measure**
STAR	Instructional Reading Level from spring 2018 STAR testing. See value for interpretation.	[ex: 8.7,8th grade 7th month]	Scale
MATH_Grade	Student’s 8th grade mathematics course grade	[4,A] [3,B] [2,C] [1,D] [0,F]	Nominal
ENGLISH_Grade	Student’s 8th grade English course grade	[4,A] [3,B] [2,C] [1,D] [0,F]	Nominal
MATH_EOC	Student’s scale score on the 8th-grade Math EOC exam	None	Scale
ELA_EOC	Student’s scale score on the 8th-grade ELA EOC exam	None	Scale
SUCCESS	Students pass the Algebra 1EOC by earning a score of 684	[0,Pass] [1,Fail]	Nominal
SWD	Students with individualized education plan (IEP) or 504 plan	[Y, Yes] [N, No]	Categorical
GENDER	Student’s gender	[M, Male] [F, Female]	Categorical

This research is closely related to the work of other similar studies and their analysis models. The study conducted by Henry et. al used regression techniques to consider the relationship between English language proficiency and mathematics scores using multiple predictors and ANOVA to compare the difference between grade levels (2014). Additionally, from the work of Betts Ph.D., who considered reading ability and success on the Ohio Graduation Test, or OGT, used regression analysis techniques to predict a student's performance outcome of pass or fail (2008). Finally, the studies that were most similar in design and variable choice are those from Susan Hickey Ph.D. and Brian Pollitt Ph. D (2009; 2018). Susan Hickey considered success on the Oklahoma Algebra 1 EOC exam by using multiple regression techniques and predictors such as eighth-grade math course grade and eighth-grade mathematics EOC exam (Hickey, 2009). The work of Pollitt also considered success on the Algebra 1 EOC exam but emphasized the use of the ANOVA to consider the statistical significance of each individual variable (Pollitt, 2018). Therefore, considering the work of each of these studies, the researchers have utilized a similar structure in choosing variables for this study and selecting the appropriate models for analyzing the data.

Research Question 1: Is there a statistically significant correlation between a student's STAR Reading test score and the algebra 1 EOC score?

This question had two variables, Star instructional reading level score (STAR) as the independent predictor variable, and the dependent variable being the student's algebra 1 EOC score (ALGEBRA). Therefore, since question 1 is correlational, simple linear regression analysis was the chosen method (Hickey, 2009; Pollitt, 2018). Before beginning the statistical analysis, intercept only models and random intercept only models will be examined to determine if a mixed model method should be used in the regression. AIC and BIC will be compared to determine which model gives the best fit. To check the assumptions, first the graphs will be examined to determine if there is a linear relationship between STAR and ALGEBRA. Next the scatterplot of the residuals will be examined for randomness to verify independence and to inspect homogeneity of variances. The final assumption to be checked is normality, this will include inspecting histograms of residuals and normal qq-plots. Once assumptions have been checked and no major violations are found, aside from independence, the descriptive statistics will be examined, and linear regression will be performed. The test statistic, p-value, confidence intervals, correlation coefficient, and the adjusted R2 will be examined to determine the strength of the relationship between the predictors.

Research Question 2: Are eighth grade demographics (District/SWD/Gender), Star instructional reading level, mathematics and English course grades, and end-of-course exam scores (mathematics and English Language Arts, ELA) significant predictors of a student's score on the Ohio algebra 1 EOC?

This question is also correlational, and the researchers are using several independent variables to predict a student’s score. Therefore, a multiple regression analysis was chosen as the method to answer research question 2 (Hickey, 2009; Pollitt, 2018). There were 9 predictor variables; 8 tested predictor (independent) variables, District, Star instructional reading level score (STAR), eighth-grade math course grade (MATH_Grade), eighth-grade English course grade (ENGLISH_Grade), eighth-grade MATH EOC score (MATH_EOC), eighth-grade ELA EOC score (ELA_EOC), identified with a learning disability (SWD), and gender (GENDER), and the dependent variable being the student’s algebra 1 EOC score (ALGEBRA). STAR, MATH_Grade, ENGLISH_Grade, MATH_EOC, ELA_EOC, and ALGEBRA are all quantitative variables, and District, SWD, and GENDER are categorical variables.

After determining if a mixed model approach was appropriate, the analysis will proceed accordingly using mixed models or multiple regression. Assumptions of linearity, independence, homogeneity of variances and normality will be checked using scatterplots of independent and dependent variables, residuals, and normal qq-plots. Descriptive statistics will be measured, examined, and tables will be included. Simple linear regression techniques will be used with the individual predictors to check for statistical significance with independent ANOVA tests. Multiple regression applications will be completed using a backward step method until all predictors are considered statistically significant at the .01 level to identify the best model. AIC and BIC will be compared to find the best model to use for predicting success on the algebra EOC.

Research Question 3: Are eighth grade demographics (District/SWD/Gender), Star instructional reading level, mathematics and English course grades, and end-of-course exam scores (mathematics and English Language Arts, ELA) significant predictors of a student's success (Pass/Fail) on the Ohio algebra 1 EOC?

As the researchers are predicting success or failure using quantitative and categorical variables, logistic regression analysis was chosen as the method to answer research question 3. The third research question had 9 predictor variables; 8 tested predictor (independent) variables, school district (District), Star instructional reading level score (STAR), eighth-grade math and English course grades (MATH_Grade, ENGLISH_Grade), eighth-grade MATH EOC score (MATH_EOC), eighth-grade ELA EOC score (ELA_EOC), identified with a learning disability (SWD), and gender (GENDER), and the dependent variable being the student’s algebra 1 EOC success or failure (SUCCESS). In this situation the quantitative variables are STAR, MATH_EOC, ELA_EOC, ENGLISH_Grade, and MATH_Grade and District, SWD, GENDER, and SUCCESS will be categorical variables.

The first step again will be to determine if a mixed model application should be applied. After proceeding with mixed models or logistic regression techniques, assumptions will be checked as mentioned previously. Backward step logistic regression applications will be completed to find the best set of predictors. AIC and BIC will be compared to find the best model to use for predicting success on the algebra EOC.

Summary

This study examined different variables with the intention of predicting success on the Algebra I end-of-course state assessment. The primary focus of this study is correlation, specifically the relationship between various predictors and success on the Ohio Algebra I end-of-course exam. A multiple regression design was used to evaluate the data and to determine the strength of the various predictor variables. A one-way analysis of variance (ANOVA), descriptive statistics on all variables, correlations between independent and dependent variables, and a stepwise multiple regression analysis were all computed to determine the best model to predict success.

CHAPTER IV: RESULTS

Introduction

This chapter includes the results from a completed data analysis. All results from this study will be discussed and described in detail within chapter 4. The purpose for this study is to determine the relationship between different variables, and the role they contribute to predicting high school students’ scores and success on the algebra I end-of-course assessment administered by the state of Ohio. By predicting EOC scores, educators are then better able to determine which students are more likely to pass or fail the end-of-course exam for algebra 1. In return, this ability enables educators to provide and implement intervention strategies preemptively to better guide students towards success.

Data was collected from high school seniors at two, low-socioeconomic, rural high schools in Ohio. High school seniors of the class of 2022 were chosen to avoid years that testing was interrupted by Covid-19 closings and restrictions. The data examined were the students' school district, gender, IEP/504 status, and scores and grades consisting of: algebra 1 state EOC score, 8th grade EOC results in math and ELA, 8th grade course grades in math and English, and Star reading assessment levels.

Study Participants

The study includes data for 123 high school students from two high schools. The students selected for this study are 2022 graduates who took eighth grade math during the 2017-2018 school year, and algebra 1 during the 2018-2019 school year.

Table 5 displays the total number of students across each district by gender and disability. In this study, there were a total of 57 male and 66 female students. Of the 123 students, 2 had a 504 plan, and 8 had an individualized education plan, IEP.

Table 5. Sample by Gender and Disability

	District A	District B	Total
GENDER - Male	35	22	57
Female	47	19	66
SWD - 504	2	0	2
IEP	6	2	8

Table 6 displays the means and standard deviations for each variable used within this study. Variables include algebra 1 state EOC score (ALGEBRA), star reading level (STAR), eighth grade math and English grades (MATH_Grade, ENGLISH_Grade), eighth grade math and ELA EOC scores (MATH_EOC, ELA_EOC), and success (pass/fail) on the algebra 1 state EOC (SUCCESS). For a more detailed description of each variable, consult Table 4 from Chapter 3.

Table 6. Means and standard deviations of each variable

	District A	District B	Total
ALGEBRA - mean	710.39	711.37	710.72
std dev	25.31	16.46	22.68
STAR - mean	6.42	8.15	6.99
std dev	2.23	2.10	2.33
MATH_Grade - mean	2.37	2.68	2.47
std dev	1.16	1.17	1.17
A (4)	15 (18%)	12 (29%)	27 (22%)
B (3)	24 (29%)	13 (32%)	37 (30%)
C (2)	25 (30%)	9 (22%)	34 (28%)
D (1)	12 (15%)	5 (12%)	17 (14%)
F (0)	6 (7%)	2 (5%)	8 (7%)

Table 6. Cont. Means and standard deviations of each variable

	District A	District B	Total
ENGLISH_Grade - mean	2.98	3.22	3.06
std dev	.90	.94	.92
A (4)	26 (32%)	21 (51%)	47 (38%)
B (3)	33 (40%)	10 (24%)	43 (35%)
C (2)	19 (23%)	8 (20%)	27 (22%)
D (1)	3 (4%)	2 (5%)	5 (4%)
F (0)	1 (1%)	0 (0%)	1 (1%)
MATH_EOC - mean	702.01	717.51	707.18
std dev	22.73	15.93	21.91
ELA_EOC - mean	696.90	702.98	698.93
std dev	22.25	17.99	21.05
SUCCESS -Pass	72 (88%)	39 (95%)	111 (90%)
Fail	10 (12%)	2 (5%)	12 (10%)

Data Analysis

By allowing ALGEBRA to vary across districts the AIC increased from 1119.96 for the intercept only model to 1121.96 for random intercept only model, and BIC increased from 1125.58 for the intercept only model to 1130.40 for the random intercept only model, $X^2(2) = 1.53e-07$, $p = .9997$, indicating that adding random slopes to the model does not significantly improve the fit. This means that there is not significant variation in the effect of ALGEBRA scores across districts, so a mixed model is not needed.

Research Question 1: Is there a statistically significant correlation between a student's STAR Reading test score and the algebra 1 EOC score?

For question 1, a linear regression model was created, and a one-way ANOVA was conducted to assess if the STAR reading test was statistically significant to predict a student's algebra 1 EOC score. The assumptions of linearity, independence, homogeneity of variance, and normality were all tested as show in Appendix C. The plot of the residuals to the fitted values does not show any pattern and appears random so linearity and homogeneity of variance can be assumed. The histograms and normal QQ plot indicate normality. Independence is violated because we do not have a random sample. A convenient sample of easily accessed data was used, so the results of this study can only represent and be indicative for the observed districts.

The results of the ANOVA were significant, meaning that it successfully predicted algebra 1 EOC scores (F (1,121) = 46.006 and p < .001), with an of .270, indicating there was a significant relationship between algebra 1 EOC scores and Star reading assessment levels. The results of the ANOVA are displayed in Table 7. The linear regression model (Table 8) explained 27% of the variance in algebra 1 EOC scores. Students' algebra 1 EOC scores were predicted by their Star reading level (β = 5.11, t = 6.78, p < .001). For every increase in Star reading level by 1 grade, algebra 1 EOC score increased by 5.11 points. Therefore, using the Star reading level as the only variable, the following equation can be used to predict a student's score on the algebra 1 EOC.

$$ALGEBRA = 674.96 + 5.11(STAR)$$

With a total of 123 students, G-Power, given an effect size of 0.15, alpha of 0.05, gives a post hoc achieved power of 0.99 for the first research question measuring two total predictors.

Table 7. ANOVA for Star Reading Level

Term	df	SS	MS	F	p
STAR	1	179290	17290.2	46.006	4.613e-10 ***
Residuals	121	45475	375.8		
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					

Table 8: Coefficients of Linear Regression Model

Model	Estimate Std.	Error	t	P(significance)
(intercept)	674.96	5.55	121.528	< 2e-16 ***
STAR	5.11	0.75	6.783	4.61e-10 ***
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

Question 2: Are eighth grade demographics (District/SWD/Gender), Star instructional reading level, mathematics and English course grades, and end-of-course exam scores (mathematics and English Language Arts, ELA) significant predictors of a student's score on the Ohio algebra 1 EOC?

As previously noted with question 1, mixed models were not needed for this regression. Similarly, for question 2, a linear regression model and a one-way ANOVA was conducted for each individual predictor. All but District and GENDER were found to be statistically significant to predict a student’s algebra 1 EOC score at $p<.01$. Multiple regression techniques were used to test the assumptions of linearity, independence, homogeneity of variance, and normality were all tested as shown in Appendix C. The plot of the residuals to the fitted values does not show any pattern and appears random so linearity and homogeneity of variance can be assumed. The histograms and normal QQ plot indicate normality. Shapiro’s test for normality did not reveal any concerns; $W = 0.987$, $p = 0.319$. Multicollinearity was examined with vif, Variance Inflation Factors, ranging from 1.24 (gender) to 2.98 (ELA EOC). Independence is violated because we do not have a random sample. A convenient sample of easily accessed data was used, so the results of this study can only represent and be indicative for the observed districts.

Using the statistical package R (R Core team, 2021), a full linear model was created with all predictors (Table 9).

Table 9: Summary of Full Multiple Regression Model

Full Model	Estimate Std.	Error	t	P(significance)
(intercept)	293.76	81.10	3.62	0.000438***
DistrictB	-12.59	3.29	-3.83	0.000210***
STAR	1.91	0.95	2.01	0.046867 *
MATH Grade	2.67	1.95	1.37	0.173931
ENGLISH Grade	2.25	2.17	1.04	0.301496
MATH_EOC	.54	.11	5.06	1.6e-06 ***
ELA_EOC	.02	.11	0.16	0.876391
SWDY	-3.58	5.64	-0.64	0.5267
GenderM	2.03	3.04	-0.67	.504363
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

Multiple linear regression analysis was done to evaluate the prediction of algebra 1 EOC scores from District, Star scores, 8th grade math and English grades, 8th grade math and ELA EOC scores, students with disabilities, and gender. The regression showed eighth-grade math and English course grades, eighth grade ELA EOC, students with disability, and gender were not statistically significant. The regression showed a statistically significant relation with school district and eighth grade math EOC at $p < .001$. The regression also showed the Star reading level is significant at a level of $p < .05$. The model reached significance and successfully predicts algebra 1 EOC scores ($F(8,114) = 20.08$, $p < .001$). The model explained 55.58% of variance in algebra 1 EOC scores.

Algebra 1 EOC scores were predicted by school district ($\beta = -12.59$, $t = -3.830$, $p < 0.001$). Students who attend district B have a decrease in their algebra 1 EOC score by 12.59 points. Algebra 1 EOC scores were then predicted by Star reading level ($\beta = 1.91$, $t =2.01$, $p < 0.05$). For every increase in Star reading level by 1 grade, the algebra 1 score increased by 1.91 points. Algebra 1 EOC scores were also predicted by 8th grade math grades (β = 2.67, t = 1.37, p = 0.17). For every increase in letter grade, the algebra 1 score increased by 2.67 points. Algebra 1 EOC scores were also predicted by 8th grade English grades (β = 2.25, t = 1.37, p =.301). For every increase in letter grade, the algebra 1 score increased by 2.25 points. Algebra 1 EOC scores were also predicted by 8th grade math EOC (β = 0.54, t = 5.064, p < .001). For every point increase on the 8th grade math EOC, the algebra 1 score increased by 0.54 points. Algebra 1 EOC scores were also predicted by 8th grade ELA EOC (β = 0.02, t = .156, p = .876). For every point increase on the ELA EOC, the algebra 1 score increased by 0.02 points. Next, Algebra 1 EOC scores were predicted by disability (IEP/504) (β = -3.58, t = -0.635, p = .527). If a student is identified with having a learning disability, the algebra 1 score decreases by 3.58 points.

This regression results in the following equation. Finally, algebra 1 EOC scores were also predicted by gender (β = 2.03, t = 0.67, p = 0.50). For male students, the algebra 1 score increased by 2.03.

Therefore, using the full model, the following equation can be used to predict a student's potential score on the algebra 1 EOC.

$$\begin{aligned} ALGEBRA = 293.76 - 12.59(District) + 1.91(STAR) + 2.67(MATHGrade) \\ + 2.25(ENGLISHGrade) + 0.54(MATHEOC) + 0.02(ELAEOC) \\ - 3.58(SWD) + 2.03(GENDER) \end{aligned}$$

Note: District: [0, District A] [1, District B]; SWD: [0, No], [1, Yes]; GENDER: [0, F], [1, M]

With a total of 123 students, given an effect size of 0.15, alpha of 0.05, G-Power gives a post hoc achieved power of 0.86 for the full model measuring nine total predictors.

Using R to do a backward step regression analysis, (See Tables 10-11 and Appendix D), a best fit was found using only school district, Star instructional reading level, 8th grade math course grade, and 8th grade math EOC score to predict algebra 1 EOC scores. The new model had an AIC of 1022 and BIC of 1038, compared to the full model with an AIC of 1028 and BIC of 1056. Both AIC and BIC decreased with the new model indicating a better fit. The new model significantly predicted the algebra 1 EOC scores (F (4,118) = 40.6, p < .001). The model explained 56.49 % of variance in algebra 1 EOC scores. Algebra 1 EOC scores were predicted by using school district to predict algebra EOC scores (β = -12.42, t = 3.11, p < 0.001). For students who attend district B, the algebra 1 score decreases by 12.42 points. Star instructional reading level was also used to predict the algebra 1 EOC score (β = 2.22, t = 2.95, p < 0.01). For every increase in Star reading level by 1 grade, the algebra 1 score increased by 2.22 points. Additionally, Algebra 1 EOC scores were also predicted by 8th grade math course grades (β = 3.58, t = 2.428, p < 0.05). For every increase in letter grade, the algebra 1 score increased by 3.58 points. Finally, algebra 1 EOC scores were predicted by eighth-grade math EOC scores (β = 0.54, t = 5.734, p < 0.001). For every point increase in math EOC score, the algebra 1 score increased by 0.54 points. Therefore, the following equation can be used to predict a student’s potential score on the Ohio Algebra EOC exam.

$$ALGEBRA = 306.41 - 12.42(District) + 2.22(STAR) + 3.58(MATHGrade) \\ + .54(MATHEOC)$$

Note: District: [0, District A] [1, District B]

With a total of 123 students, given an effect size of 0.15, alpha of 0.05, G-Power gives a post hoc achieved power of 0.94 for the best model measuring five total predictors.

Table 10: Backward Step Multiple Regression Model (Best Model)

Model	Estimate Std.	Error	t	P(significance)
(intercept)	306.41	62.42	4.909	2.97e-06 ***
DistrictB	-12.42	3.11	-3.990	0.000115 ***
STAR	2.22	0.75	2.950	0.003835 **
MATH Grade	3.58	1.48	2.428	0.016673 *
MATH_EOC	0.54	0.09	5.734	7.68e-08 ***
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1				

Table 11: Summary and ANOVA of each MR Model

Model	R^2	Adjusted R^2	Std. error of the estimate	AIC	BIC	Statistic and p-value
1 (Full)	0.585	0.5558	15.12	1027.798	1055.92	F (8,114) = 20.08, p < 2.2e-16
2	0.5835	0.5581	15.08	1026.232	1051.542	F (7,115) = 23.01, p < 2.2e-16
3	0.5831	0.5616	15.02	1024.336	1046.833	F (6,116) = 27.04, p < 2.2e-16
4	0.5818	0.564	14.98	1022.72	1042.405	F (5,117) = 32.56, p < 2.2e-16
5 (Best)	**0.5792**	**0.5649**	**14.96**	**1021.501**	**1038.374**	**F (4,118) = 40.6, p < 2.2e-16**
6	0.5581	0.547	15.27	1025.5	1039.561	F (3,119) = 50.1, p < 2.2e-16

Question 3: Are eighth grade demographics (District/SWD/Gender), Star instructional reading level, mathematics and English course grades, and end-of-course exam scores (mathematics and English Language Arts, ELA) significant predictors of a student's success (Pass/Fail) on the Ohio algebra 1 EOC?

A logistic regression analysis was performed on obtaining a passing score (greater than 684) on the algebra 1 EOC state test and eight predictors: school district A or B (District), eighth grade Star IRL reading level (STAR), eighth grade math grade (MATH Grade), eighth grade English grade (English Grade), eighth grade math EOC (MATH_EOC), eighth grade ELA EOC (ELA_EOC), students with disabilities (SWD), and gender (GENDER). Data for n=123 students were available for analysis: 111 passing. Analysis was performed using R (R Core Team,2021).

A test of the full model with eight predictors against a constant-only model was statistically reliable. (8, N=123) = 25.219, $p < 0.01$, indicating that the set of predictors reliably distinguished between passing and failing. The variance in success is acceptable with McFadden’s rho = 0.321, df = 8. The AIC for the full model (71.4) was lower than the constant-only model (80.6), indicating a slightly better fit.

Predicting success (using 0.5 as the threshold) was fairly reliable with 112 out of 123(91%) accurately classified or predicted correctly. Sensitivity and specificity values were 0.973 and 0.333, respectively.

Table 12 displays the regression coefficients, Wald statistics, odds ratios, and 95% confidence intervals for odds ratios for the 8 predictors. According to the Wald criterion, none of the predictors reliably predict success, $z < 1.1$, $p > 0.0790$ for all predictors. A backward regression model was done later to identify significant predictors to follow.

Variance Inflation Factors (VIF) values ranged from 1.16(GENDER) to 2.51(STAR) indicating that multicollinearity is not a problem. Examination of the significance levels of the interaction between each predictor and the log of itself (Hosmer & Lemeshow, 1989) indicates that linearity between each predictor and the logit of itself may be assumed.

Table 12: Logistic Regression Analysis of Passing the Algebra 1 EOC

Variables	**B**	**Wald (z-ratio)**	**p-value**	**Odds Ratio (OR)**	**95% CI Lower, OR**	**95% CI Upper, OR**
District	0.208	0.197	0.8442	1.23	.166	1.24
STAR	-0.167	-0.559	0.5759	0.85	0.47	1.53
Math Grade	-0.094	-0.211	0.8328	0.91	0.36	2.16
English Grade	0.908	1.756	0.0790	2.48	0.95	7.59
Math EOC	0.042	1.439	0.1502	1.04	0.99	1.11
ELA EOC	0.041	1.540	0.1237	1.04	0.99	1.10
SWD	-0.782	-0.775	0.4385	0.45	0.06	3.69
GenderM	1.394	1.743	0.0814	4.03	0.91	2.24
(Intercept)	-57.282	-2.533	0.0113	1.32e-25	3.73e-47	9.11e-08

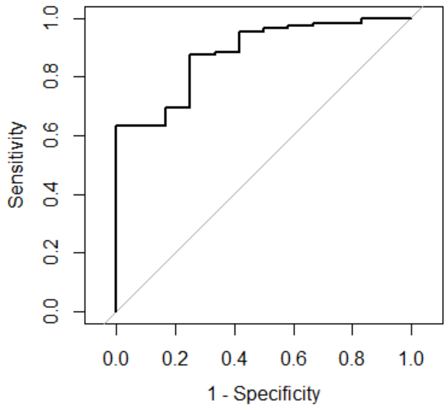
Therefore, using the full model, the following equation can be used to predict a student's potential success(pass/fail) on the algebra 1 EOC.

$$
\begin{aligned}
SUCCESS = -57.28 + .021(District) - 0.17(STAR) - 0.09(MATHGrade) \\
+ 0.91(ENGLISHGrade) + 0.04(MATHEOC) + 0.04(ELAEOC) \\
- 0.78(SWD) + 1.39(GENDER)
\end{aligned}
$$

Note: District: [0, District A] [1, District B]; SWD: [0, No], [1, Yes]; GENDER: [0, F], [1, M]

Using the eight-predictor model a receiver operating characteristic curve (ROC) is presented in Figure 1. Receiver operating characteristics graphs (ROC) have been shown to be a reliable technique for visualizing, organizing, and selecting classifications (Tape, 2015). The area under the curve (AUC) determines that we have very good accuracy, with AUC = 0.88.

Figure 1: ROC Curve - Algebra 1 EOC Success (Full Model)



A backward step logistic regression analysis was performed on our full model to determine the best model to fit our data. Using R to complete the backward step regression, the variables for District, STAR, MATH Grade, and SWD were removed from the model, leaving a new four-predictor model.

A test of the new model with four predictors against a constant-only model was statistically reliable. (4, N=123) = 24.39, $p < 0.001$, indicating that the set of predictors reliably distinguished between passing and failing. The variance in success is acceptable with McFadden's rho = 0.310, df = 4. The AIC for the new model (64.3) was lower than the constant-only model (80.6), indicating a better fit. Predicting success (using 0.5 as the threshold) was fairly reliable with 113 of 123(92%) accurately classified or predicted correctly. Sensitivity and specificity values were 0.982 and 0.333, respectively.

Table 13 displays the regression coefficients, Wald statistics, odds ratios, and 95% confidence intervals for odds ratios for the 4 predictors. According to the Wald criterion, none of the predictors reliably predict success, $z < 1.95$, $p > 0.05$ for all predictors. A backward regression model was done later to identify significant predictors to follow.

Variance Inflation Factors (VIF) values ranged from 1.13(ENGLISH Grade) to 1.32(ELA_EOC) indicating that multicollinearity is not a problem. Examination of the significance levels of the interaction between each predictor and the log of itself (Hosmer & Lemeshow, 1989) indicates that linearity between each predictor and the logit of itself may be assumed.

Table 13: Backward Step Logistic Regression Model of Passing the Algebra 1 EOC

Variables	B	Wald (z-ratio)	p-value	Odds Ratio (OR)	95% CI Lower, OR	95% CI Upper, OR
English Grade	0.750	1.953	0.051	2.12	1.02	4.79
Math EOC	0.036	1.476	0.1401	1.04	0.99	1.09
ELA EOC	0.039	1.883	0.0598	1.04	0.99	1.09
GenderM	1.313	1.665	0.096	3.72	0.86	1.09
(intercept)	-52.509	-3.274	0.0011	1.57e-23	2.57e-39	3.05e-11

Therefore, using the new model, the following equation can be used to predict a student's potential success(pass=1/fail=0) on the algebra 1 EOC.

$$SUCCESS = -52.51 + .75(ENGLISHGrade) + 0.04(MATHEOC) + 0.04(ELAEOC) + 1.31(GENDER)$$

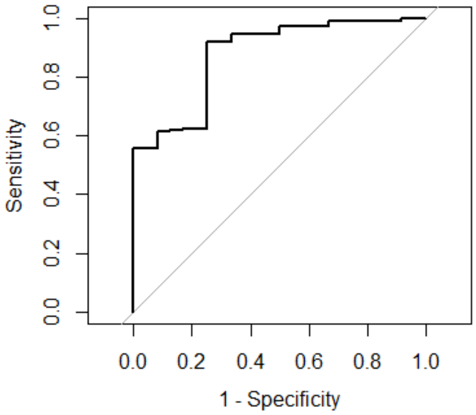
Note: GENDER: [0, F], [1, M]

Interpreting the odds ratios implies that

1. For one grade letter increase in eighth grade English, the odds of passing the algebra 1 EOC increases by a factor of 2.12.
2. For each point increase on the eighth-grade math EOC exam, the odds of passing the algebra 1 EOC increases by a factor of 1.04.
3. For each point increase on the eighth grade ELA EOC exam, the odds of passing the algebra 1 EOC increases by a factor of 1.04.
4. For male students, the odds of passing the algebra 1 EOC increases by a factor of 3.72.

Using the four-predictor model a receiver operating characteristic curve (ROC) is presented in Graph 2. Receiver operating characteristics graphs (ROC) have been shown to be a reliable technique for visualizing, organizing, and selecting classifications (Tape, 2015). The area under the curve (AUC) determines that we have very good accuracy, with AUC = 0.88.

Figure 2: ROC Curve - Algebra 1 EOC Success (4 predictor model)



Summary

Chapter four presented the data and answered each of the research questions by determining there was a statistically significant link between reading scores and success on the algebra 1 EOC exam. The results from question one confirmed that the Star instructional reading level was significantly predictive of an algebra 1 EOC score. Question two found a linear equation useful for predicting an EOC score using a student’s eighth-grade Star reading level, math EOC score, math course grade, and district of enrollment (A or B). Question three utilized logistic regression to predict success, a passing score, on the algebra 1 EOC with very good accuracy by looking at a student’s eighth-grade math EOC, ELA EOC, English course grade, and gender. Instructors at the participating districts can use the formulas found to help determine which students may need additional instruction or differentiation to be successful and obtain a proficient or passing score on the algebra 1 EOC exam.

CHAPTER V: SUMMARY

Introduction

Chapter 5 will begin with a brief summary of the current state testing requirements for the state of Ohio followed by available literature and the purpose of this study. Then, the researchers present a summary of the results from chapter 4 and provide conclusions from these findings. In addition to this summary and conclusion, limitations to this study will be presented, and recommendations will be given for further and continued research.

Background and Purpose of the Study

Ohio has utilized state testing since 1987, but it was not until 1994 that Ohio began using state testing as a graduation requirement (Background/History of Ohio Proficiency Tests, 1998). Beginning in 2016, Ohio switched to its newest version of testing, the AIR test. The AIR test is an End of Course exam provided to assess student understanding for certain subjects, specifically algebra 1. With this added pressure on algebra teachers to ensure their students pass this exam, key factors of student success on the algebra EOC exam must be considered.

Studies by Pollitt, Betts, and Purpura have all suggested that one of these key factors of success is a student’s reading level (2018; 2008; 2019). Each of these studies have found a strong interconnectedness, and comorbidity, with a student’s reading level and their mathematical ability. Further, research by Tim and Cynthia Shanahan suggests that implementing content-specific reading strategies across the curriculum at the secondary level significantly helps to make stronger students (Shanahan & Shanahan, 2008). By continuing to teach students to read in a content-specific manner, they will be better able to interpret and comprehend a text's intended meaning. This skill is especially important when it comes to students struggling with mathematical word problems.

Ultimately, due to the newness of Ohio's EOC exams, there is very little to no research and literature available related to the test. Therefore, to better understand the interconnectedness of students' reading level and their mathematical ability, the researchers used students' eighth-grade Star Instructional Reading Levels (IRL) as one of the major predictors for both student score and success on the EOC exam. Based on the literature, it was suspected that Star IRL would be a significant predictor of both student score and success (pass/fail) on the algebra 1 EOC exam, a measure of a student's mathematical ability. In addition to Star IRL, the researchers also considered previous math and ELA course grades and EOC scores, school district, gender, and disability status.

The purpose of this study was to determine if a student's eighth-grade reading level and other chosen eighth-grade measures can predict a student's score and success (pass/fail) on the algebra 1 end-of-course exam administered by the state of Ohio. The data collected is of students of the graduating class of 2022 from two rural, low-socioeconomic status schools in Ohio. This class was chosen as they were the only class with uninterrupted data due to the Covid-19 pandemic. The only requirement for these participants is they must have taken algebra as a freshman during the 2018-2019 school year and eighth grade math during the 2017-2018 school year. The data consists of 123 students, 57 males and 66 females. School district A represents 82 of the participants and school district B represents 41 of the participants.

Summary of Findings

The findings of this study as follows represent a summarization of the statement of the problem as presented in Chapter 1.

Research Question 1. Is there a statistically significant correlation between a student’s STAR Reading test score and the algebra 1 EOC score?

For this question, the Star instructional reading level, Star IRL, (STAR) was the only independent variable used to predict the algebra 1 EOC. The mean reading level for both districts was at a seventh-grade level by the end of eighth grade, sixth grade fourth month for District A, and eighth grade second month for District B. Given that these students were assessed at the end of eighth-grade, it is fair to assume that the two schools, both individually and combined, show an average student reading level that is lower than expected. Despite this discrepancy, Star IRL had a large effect size on the algebra 1 EOC score (ALGEBRA). Therefore, Star IRL is a strong predictor of a student’s score on the algebra 1 EOC, and the higher a student’s reading level is, the more likely they are to earn a higher algebra score than peers with a lower reading level.

From these findings, it can be assumed that a student’s reading level is a significant and important predictor of a student’s score on the algebra 1 EOC exam. Thus, literacy plays an important part of a student’s score on the algebra 1 EOC exam. This follows with the studies of Dawn Betts Ph.D. and David Purpura which suggest reading ability and mathematics success are interconnected (2008; 2019).

Furthermore, based on the model, a student reading at grade level while taking a freshmen level algebra course should receive a passing score of 721. In order to pass the exam, a score of 684, a student would only be required to have a 2nd grade reading level to result in a score of 685. That said, this may imply that the algebra EOC exam may not be rooted in literacy and reading as much as expected. This may also be due to questions being computational or questions on the test are written at lower reading levels. Also, a passing score is not necessarily a proficient score. In order to guarantee a student's best chance at passing the algebra 1 EOC exam, it is imperative that teachers work to improve student literacy levels if they expect to see scores above the proficient level. Overall, based on the model, it is the researchers' recommendation that teachers should identify students with low reading levels and provide reading intervention strategies to better equip their students for taking the algebra end-of-course exam.

Research Question 2. Are eighth grade demographics (District/SWD/Gender), Star instructional reading level, mathematics and English course grades, and end-of-course exam scores (mathematics and English Language Arts, ELA) significant predictors of a student's score on the Ohio algebra 1 EOC?

The full model for the second research question included District, Star IRL, eighth-grade math and English course grades, eighth-grade math and ELA EOC scores, disability identification and gender. In this model, only variables District, STAR, and MATH_EOC were considered statistically significant. Math EOC score had a large effect size in this model, and District a medium effect size with Star IRL, math grade and English grade having a small effect size.

A better model was determined that only included District, Star IRL, and eighth grade math course grade and EOC score. In this model, all of the variables were considered statistically significant, $p < .05$. Focusing on the best model, each variable, both individually and combined, had a unique impact on a student's predicted score for the algebra 1 end-of-course exam.

District: There was a significant difference in the amount of data collected from each school district. For this study, there was a 2:1 ratio of students from each district. Despite having very little difference between district mean scores for the algebra EOC, the variable District had a medium effect size on the algebra 1 EOC score (ALGEBRA). Thus, alone, District is a fairly strong enough variable to predict a student's score on the algebra 1 EOC. When combined with the other variables, controlling for District B, District implied that students who attend District B should expect a slightly lower than students who attend District A.

STAR: As explained with the first research question, the mean reading level was lower than expected for students testing at the end of their eighth-grade year. Star IRL had a medium effect size on the algebra 1 EOC score (ALGEBRA). Therefore, Star IRL alone is a fair predictor of a student's score on the algebra 1 EOC. When combined with the other variables STAR had a positive contribution to the overall algebra 1 EOC score. Therefore, once again, the higher a student's reading level, the more likely a student is to earn a higher algebra score than peers with a lower reading level.

MATH_Grade: Both districts had a combined C-average course grade. Eighth-grade math course grade had the lowest effect of the four predictors. Even though it has a small effect, the variable was statistically significant for the model. Alone, a student's eighth-grade math course grade is not a strong predictor of a student's score on the algebra 1 EOC, but when combined with the other variables, the beta value from the regression model had a positive effect on the student's score. Therefore, the higher the eighth-grade math course grade a student earns, the more likely they are to see a higher algebra 1 EOC score.

MATH_EOC: The eighth-grade math EOC exam had a possible score ranging from 559 to perfect score of 845. Eighth-grade math EOC had the biggest effect of the four predictors with a large effect size. Thus, alone, MATH_EOC is a very strong predictor of a student's score on the algebra 1 EOC. When combined with the other variables, students should expect to see an increase in their algebra EOC score for each point earned on the eighth-grade math EOC exam. Therefore, the higher the eighth-grade math EOC score, the more likely a student is to see a higher algebra 1 EOC score.

As found from research question one, using Star IRL as the only predictor, 27% of the variation on the algebra 1 EOC exam can be explained. Using a multiple linear regression analysis between the algebra 1 EOC exam and school district, Star IRL, eighth-grade math course grades, and eighth-grade math EOC score resulted in 56.5% of the variation explained. This is nearly a 30% increase, thus providing a more accurate prediction of a student's projected score.

Although the full model was better than Star IRL model alone, the reduced model explains 1% more variance and shows that a student's disability, gender, and success in their eighth-grade English course and ELA EOC have very little to no effect on a student's algebra 1 score. This finding confirms the work of Pollitt who reported that gender and disability have weak contributions in predicting students' algebra scores (2018).

Overall, the findings for the second research question confirm that a student's Star reading level does play a significant role in a student's score on the Ohio algebra 1 EOC exam. This is consistent with the work of the studies utilized in the literature review (Pollitt, 2008: Betts, 2008; Purpura, 2019). Overall, Star IRL, along with district, eighth-grade math course grade and math EOC are variables that should be considered to best predict a student's algebra 1 EOC exam score.

Research Question 3: Are eighth grade demographics (District/SWD/Gender), Star instructional reading level, mathematics and English course grades, and end-of-course exam scores (mathematics and English Language Arts, ELA) significant predictors of a student's success (Pass/Fail) on the Ohio algebra 1 EOC?

The full model for the final research question included District, Star IRL, eighth-grade math and English course grades, eighth-grade math and ELA EOC scores, disability identification and gender. Although the model was statistically significant compared to the constant-only model, none of the individual variables were considered statistically significant. A better model was found that also was statistically significant. This model included English course grade, math and ELA EOC scores, and gender, but none of the individual variables were statistically significant.

Focusing on the best model, each variable, both individually and combined, had a unique impact on a student's predicted score for the algebra 1 end-of-course exam. Using the odds ratio to determine effect size for the new model, gender had a large effect size, English grade a medium effect size, and math and ELA EOC scores had a small effect size.

Using a logistic regression analysis between the algebra 1 EOC exam and all predictor variables, the model reliably predicts success in 91% of the cases, while the improved model accurately predicts success in 92% of the cases. Both models have high AUC values indicating they can both predict success with high accuracy.

Overall, the findings for research question three confirms that a student's reading level does play a significant role in a student's ability to pass the Ohio algebra 1 EOC exam. This once again is consistent with the work of the previously mentioned studies. Therefore, the student's gender, eighth-grade English course grade, math and ELA EOC scores should be considered to best predict a student's odds of passing the algebra 1 EOC exam.

Limitations

When considering the findings of this research, these results can only be applied to students from the two districts within the study. Educators from other schools can use these models as a means to predict how their students may perform on the algebra 1 EOC exam, but it is simply that, a prediction based on limited data. The results of this study are merely a regression of the results from the graduating class of 2022. Results may vary per class and district, and until further research is completed with other classes, districts, and/or a larger sample, it is uncertain the reliability and validity of these models for predicting scores and student success on Ohio's algebra 1 EOC exam.

Recommendations

Seeing that one of the biggest limitations to this study is the lack of data over a span of years, the best recommendation is to repeat the analysis for a minimum of four consecutive years. By doing this analysis both individually by grade, and as a collective sample, it would be possible to see similarities from year to year and look for an even better model to predict scores for students at each of these districts. Additionally, by expanding the research from just the two school districts available to the researchers, by collecting data from each of the schools in the respective counties, it would be possible to then start looking at larger scale assumptions and a model for a larger population.

As math teachers are aware, mathematical models do not, and cannot predict reality, but rather explain a set of data's behavior. Attempting to create a state-wide model(s) that works for the majority of students across Ohio would be beneficial for identifying students who would benefit from early intervention. As of the most recent spring 2022 administration of the algebra 1 EOC exam, only 45% of the students tested in the state of Ohio received a proficient score, 700 or higher. This number is astonishingly low, thus showing a need to support algebra aged students across the state. It is seen with the results of this study that there is a clear relationship between student reading level and their performance in algebra. Perhaps it is time something is done to remedy high school student's reading skills or reevaluate the design of the algebra test to ensure that the test is truly assessing a student's mathematical ability and not their reading ability.

Conclusion

This study looked at determining which of the chosen variables could be used to determine both score and success on the end of course algebra 1 exam for the state of Ohio. After having collected data from both school districts, an analysis of the data was conducted and Star IRL alone was found to be statistically significant to predict algebra score. When the other variables were introduced, several were found to be statistically significant to predict both algebra score and success.

Mathematics and reading are two unique and vastly different skills taught to students beginning at an early age. Although the two skills include completely different concepts and applications, from the work of both this study and previous studies, there is found to be a significant correlation between a student's reading level or ability and their mathematics performance. Knowing this connection and given that algebra requires a passing score on an end-of-course exam attached to graduation, mathematics educators across the state of Ohio should work closely with their school's English teachers to be made aware of their student's reading levels. Further, for the algebra teachers at both districts in this study, to predict a student's score, the following factors should be considered: school district, Star IRL, eighth grade math course grade and math EOC score. To predict success or ability to pass the exam, the following factors should be considered: eighth-grade English course grade, math and ELA EOC scores, and gender.

While this study only looks at two small rural districts, if the data were expanded to include more diverse districts, a greater amount of data, and continue over subsequent years, a greater understanding of what makes students successful could be better estimated. Repeating this study with students from a diverse urban setting where there are students with English as a second language would be assumed to have an even greater learning gap. Likewise, students who live in poverty already suffer from greater learning gaps in many subjects. Conversely, based on previous studies, one could assume a much higher scoring and passing ability in areas of higher economic advantages with educated parents in the household. Many students could benefit from interventions prior to testing that would afford them a better chance of success on the algebra 1 EOC thus graduating.

Though not addressed in this study, the makeup of the test being administered could also be a focus of additional studies. Implementing a focus on students whose first language is not English could reveal a large gap in success for those students. Writing the test at a lower reading level, offering tests in alternate languages, or simply including more computation than comprehension style questions could be included in future studies.

Although reading ability can provide ideas on what might predict a student’s score/success on the state test, teachers and administrators must consider that a combination of previous test scores, course grades, and other demographic variables also play a significant role in the algebra 1 EOC exam. All things considered; these predictors should not be used to dictate a student's high school mathematics pathway as some of the factors are outside of a student’s control. That said, what can be done, is using these predictors to provide interventions for students to increase their chances of success.

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Appendix A

The following table represents the set of data used for this study. Each column is labeled with the corresponding labels as stated in chapter 3.

Table 14. Data Set for Study

District	StudentID	ALGEBRA	STAR	MATH_ Grade	ENGLISH _Grade	MATH_ EOC	ELA_EOC	SUCCESS	SWD	GENDER
A	1	708	6.2	3	4	708	702	1	N	M
A	2	759	6.4	4	4	714	700	1	N	F
A	3	719	5.2	3	4	714	695	1	N	F
A	4	719	6.2	2	2	730	712	1	N	M
A	5	685	5.6	2	4	668	669	1	N	F
A	6	700	6.7	2	2	684	707	1	N	F
A	7	755	6.5	2	3	728	717	1	N	F
A	8	742	11.4	4	4	719	752	1	N	F
A	9	716	9.4	4	4	710	714	1	N	F
A	10	685	6.5	2	4	687	700	1	N	F
A	11	752	6.9	4	3	744	697	1	N	M
A	12	672	1.3	3	4	687	657	0	Y	F
A	13	691	4.4	3	3	679	675	1	Y	M
A	14	719	4.4	2	3	692	654	1	N	M
A	15	700	6.5	1	3	687	704	1	N	F
A	16	705	5.5	2	3	676	700	1	N	F
A	17	716	8.6	3	3	719	707	1	N	F
A	18	697	5.5	3	4	682	664	1	N	M
A	19	703	6.1	2	2	694	692	1	N	F
A	20	736	8.7	2	1	730	712	1	N	M
A	21	703	6.3	1	2	692	657	1	N	F
A	22	685	6.3	3	3	684	669	1	N	M
A	23	708	7.2	2	2	728	714	1	N	M
A	24	675	3.1	3	4	674	669	0	N	F
A	25	711	8.4	3	2	717	707	1	N	M
A	26	711	6.9	2	3	682	712	1	N	M
A	27	700	3	1	2	649	651	1	N	M
A	28	694	5.7	3	3	714	695	1	N	M
A	29	736	6.3	4	3	741	704	1	N	M
A	30	725	6.8	2	4	719	722	1	N	F
A	31	664	5.1	2	3	665	661	0	N	F
A	32	705	5.4	4	3	692	695	1	Y	F

A	33	700	5.3	2	4	692	702	1	N	F
A	34	725	6.2	4	4	733	714	1	N	F
A	35	654	3.5	0	2	684	682	0	N	F
A	36	719	5.3	3	3	708	704	1	N	M
A	37	711	6.6	2	3	676	690	1	N	M
A	38	742	11.2	3	3	733	712	1	N	F
A	39	703	7.7	1	3	690	697	1	N	F
A	40	730	4.9	4	4	735	690	1	N	F
A	41	668	2.3	3	3	668	654	0	Y	F
A	42	675	4.3	0	2	661	692	0	N	M
A	43	722	6.4	1	2	719	704	1	N	M
A	44	697	4.8	1	3	694	692	1	N	F
A	45	752	11.5	4	4	735	731	1	N	F
A	46	679	4.6	0	0	687	664	0	N	M
A	47	685	5.9	0	1	694	700	1	N	M
A	48	675	4.7	1	3	684	669	0	Y	F
A	49	714	6.1	4	4	728	704	1	N	F
A	50	763	11.4	4	4	733	714	1	N	M
A	51	736	6.8	4	4	723	709	1	N	F
A	52	708	6.1	3	3	674	680	1	Y	M
A	53	703	3.8	2	3	676	685	1	N	M
A	54	789	11.9	4	4	750	737	1	N	F
A	55	675	8.8	2	3	696	728	0	N	F
A	56	714	11	3	4	708	731	1	N	F
A	57	725	5.3	2	4	687	692	1	N	F
A	58	700	6.1	1	3	687	704	1	N	F
A	59	722	6.1	3	3	701	666	1	N	M
A	60	708	4.9	1	2	708	687	1	Y	M
A	61	749	11.1	3	4	733	741	1	N	F
A	62	705	5.9	2	2	708	697	1	N	M
A	63	719	6.4	3	4	701	702	1	N	F
A	64	725	6.7	3	3	719	720	1	N	F
A	65	733	4.8	2	3	701	690	1	N	M
A	66	708	3.6	0	2	687	697	1	N	F
A	67	733	6.9	2	2	730	695	1	N	M
A	68	742	10.5	3	3	714	725	1	N	M
A	69	697	3.5	1	4	679	647	1	Y	M
A	70	705	6.3	3	2	701	709	1	N	M
A	71	711	6.8	3	4	730	700	1	N	F
A	72	755	10.7	4	4	738	731	1	N	F

A	73	727	6.4	4	3	723	714	1	N	F
A	74	703	6.4	1	2	694	697	1	N	M
A	75	694	9.3	3	3	714	709	1	N	M
A	76	668	3.9	2	1	674	666	0	N	F
A	77	688	3	2	3	692	666	1	N	F
A	78	708	5.5	2	2	701	685	1	N	M
A	79	722	6.5	3	3	712	709	1	N	F
A	80	685	6.9	1	2	671	712	1	N	M
A	81	700	6.5	2	3	699	712	1	N	F
A	82	685	6.7	0	2	671	702	1	N	F
B	83	703	6.6	2	2	714	704	1	N	F
B	84	749	9.8	4	4	741	722	1	N	F
B	85	691	4.8	1	1	690	685	1	N	M
B	86	727	7.1	3	2	723	720	1	N	M
B	87	725	8.1	4	4	730	709	1	N	F
B	88	703	5.7	0	1	694	675	1	N	M
B	89	714	6	3	4	717	704	1	N	F
B	90	708	7.7	3	4	699	695	1	N	M
B	91	694	6.9	3	3	719	725	1	N	F
B	92	733	8.4	4	4	730	714	1	N	M
B	93	685	4.4	1	2	694	664	1	Y	F
B	94	691	6.5	3	4	728	704	1	N	M
B	95	736	12.2	4	4	735	728	1	N	F
B	96	725	6.6	4	4	747	712	1	N	F
B	97	711	5.8	4	4	730	717	1	N	F
B	98	708	7.9	3	4	708	702	1	N	F
B	99	719	4.8	4	4	701	675	1	N	F
B	100	705	7.8	2	3	701	700	1	N	F
B	101	679	8.4	2	2	723	682	0	N	M
B	102	708	8.6	3	4	730	707	1	N	M
B	103	727	9.4	4	4	723	700	1	N	M
B	104	716	11.1	3	4	747	737	1	N	M
B	105	694	8.1	1	2	696	700	1	N	F
B	106	691	9.4	0	3	701	704	1	N	M
B	107	711	10.5	3	4	728	685	1	N	F
B	108	742	9.3	3	4	721	704	1	N	F
B	109	700	6.5	2	3	699	687	1	N	M
B	110	682	11.3	2	2	708	697	0	N	M
B	111	727	10.4	3	3	733	725	1	N	M
B	112	714	11.1	4	4	735	734	1	N	F

B	113	708	4.8	3	4	699	657	1	Y	M
B	114	703	6.3	3	3	735	717	1	N	M
B	115	705	11	4	4	735	714	1	N	M
B	116	722	6.8	4	3	728	704	1	N	F
B	117	714	11.7	1	2	710	717	1	N	M
B	118	711	8.4	1	2	705	682	1	N	M
B	119	700	8.7	2	4	721	700	1	N	M
B	120	730	9.9	4	4	726	702	1	N	F
B	121	736	8.1	2	3	712	695	1	N	M
B	122	703	6.7	2	3	694	695	1	N	F
B	123	716	10.4	2	3	708	722	1	N	M

Appendix B

IRB Approval

CERTIFICATE

OF COMPLETION

PHRP Online Training, Inc. certifies that

Joshua Klein

has successfully completed the web-based course "Protecting Human Research Participants Online Training."

Date Completed: **2021-08-23** Certification Number: **2869738**

PHRP
Protecting Human
Research Participants
Online Training

CERTIFICATE

OF COMPLETION

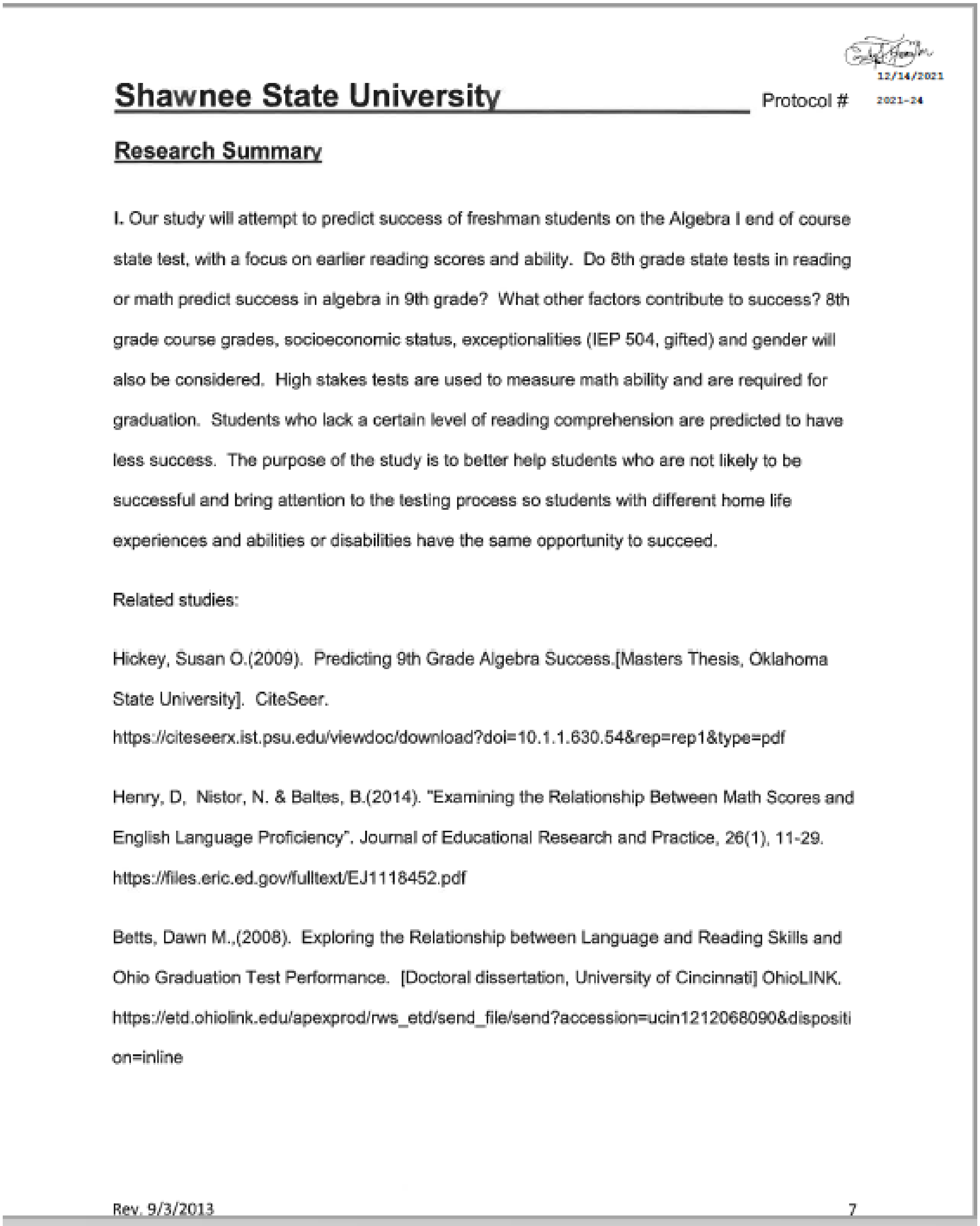
PHRP Online Training, Inc. certifies that

Renee Lambert

has successfully completed the web-based course "Protecting Human Research Participants Online Training."

Date Completed: **2021-08-22** Certification Number: **2869806**

PHRP
Protecting Human
Research Participants
Online Training



12/14/2021

Shawnee State University

Protocol # 2021-24

Research Summary

I. Our study will attempt to predict success of freshman students on the Algebra I end of course state test, with a focus on earlier reading scores and ability. Do 8th grade state tests in reading or math predict success in algebra in 9th grade? What other factors contribute to success? 8th grade course grades, socioeconomic status, exceptionalities (IEP 504, gifted) and gender will also be considered. High stakes tests are used to measure math ability and are required for graduation. Students who lack a certain level of reading comprehension are predicted to have less success. The purpose of the study is to better help students who are not likely to be successful and bring attention to the testing process so students with different home life experiences and abilities or disabilities have the same opportunity to succeed.

Related studies:

Hickey, Susan O.(2009). Predicting 9th Grade Algebra Success.[Masters Thesis, Oklahoma State University]. CiteSeer. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.630.54&rep=rep1&type=pdf

Henry, D, Nistor, N. & Baltes, B.(2014). "Examining the Relationship Between Math Scores and English Language Proficiency". Journal of Educational Research and Practice, 26(1), 11-29. https://files.eric.ed.gov/fulltext/EJ1118452.pdf

Betts, Dawn M.,(2008). Exploring the Relationship between Language and Reading Skills and Ohio Graduation Test Performance. [Doctoral dissertation, University of Cincinnati] OhioLINK. https://etd.ohiolink.edu/apexprod/rws_etd/send_file/send?accession=ucin1212068090&disposition=inline

12/14/2021

Shawnee State University Protocol # 2021-24

Lamie, James M., "Factors Impacting Success in Ninth Grade Algebra I for High School Students" (2014). Electronic Theses and Dissertations. Paper 2427. https://dc.etsu.edu/etd/2427

II. The sample population are 2022 seniors at two high schools in rural Ohio. We will collect the following data about the 2022 graduating class, excluding those students who took algebra 1 as an eighth grader: 8th grade ELA and Mathematics state EOC scores, Algebra 1 state EOC scores, 8th grade STAR Reading score, School year course grades for math and English, Socio-Economic Status, Gifted/504/IEP Status, Gender, ACT Score

All data will be unidentifiable, and will be collected by administrators at each of the respective schools. Once all data is compiled and all identifiable information is removed, the data will be provided to the researchers to conduct their analysis. We will use multiple regression techniques to analyze the data and predict success.

III. The unidentifiable data will be analyzed using multiple regression techniques and reported in a master's thesis to be shared amongst the researchers, research advisors, and any other audiences deemed necessary by the researchers. There will be no risk of privacy or confidentiality break in the reported results as the researchers have no identifiable information about the students, additionally, given the sample size and number of variables, a table of all data collected will not be provided in the thesis, thus eliminating a chance for breach of confidentiality.

IV. Given that all of the information is easily accessible by the school administrators (not accessible to the researchers), data compiling can begin immediately following approval of the IRB, and can easily be collected/compiled within one day, or at the convenience of the administrator.

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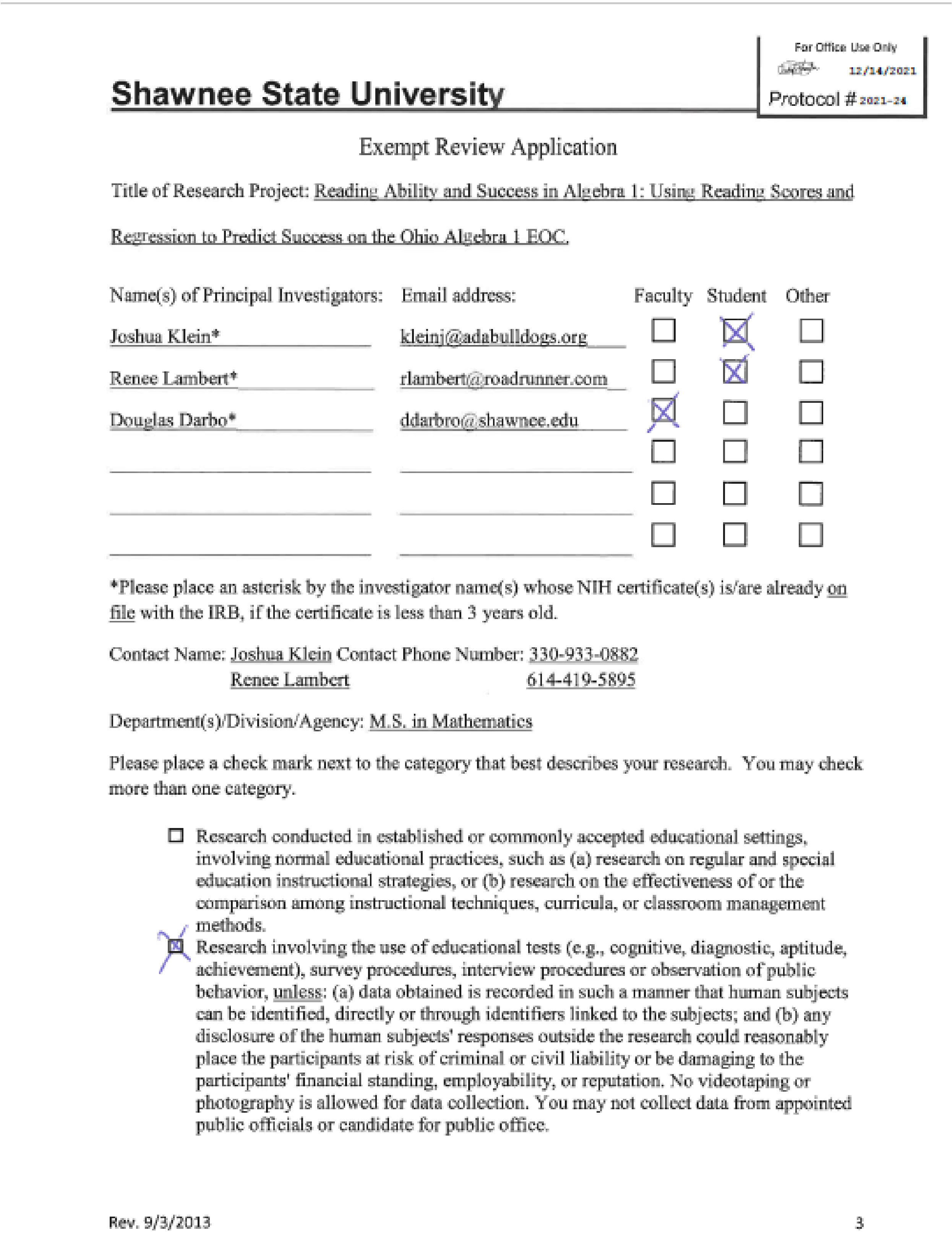

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Protocol # 2021-24

Shawnee State University

Exempt Review Application

Title of Research Project: Reading Ability and Success in Algebra 1: Using Reading Scores and Regression to Predict Success on the Ohio Algebra 1 EOC.

Name(s) of Principal Investigators:	Email address:	Faculty	Student	Other
Joshua Klein*	kleinj@adabulldogs.org	☐	☒	☐
Renee Lambert*	rlambert@roadrunner.com	☐	☒	☐
Douglas Darbo*	ddarbro@shawnee.edu	☒	☐	☐
		☐	☐	☐
		☐	☐	☐
		☐	☐	☐

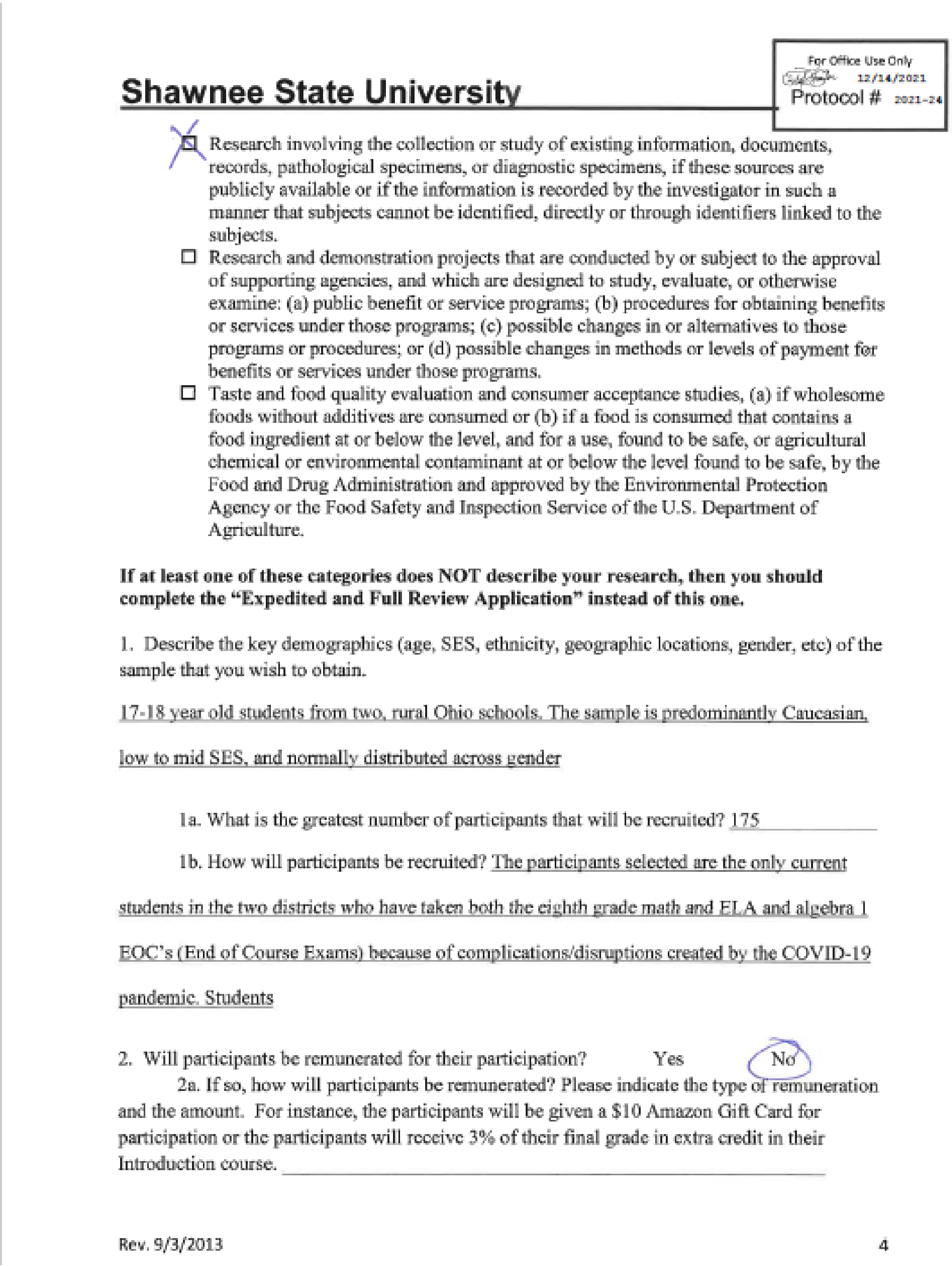
*Please place an asterisk by the investigator name(s) whose NIH certificate(s) is/are already on file with the IRB, if the certificate is less than 3 years old.

Contact Name: Joshua Klein Contact Phone Number: 330-933-0882
Renee Lambert 614-419-5895

Department(s)/Division/Agency: M.S. in Mathematics

Please place a check mark next to the category that best describes your research. You may check more than one category.

- ☐ Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (a) research on regular and special education instructional strategies, or (b) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- ☒ Research involving the use of educational tests (e.g., cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (a) data obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (b) any disclosure of the human subjects' responses outside the research could reasonably place the participants at risk of criminal or civil liability or be damaging to the participants' financial standing, employability, or reputation. No videotaping or photography is allowed for data collection. You may not collect data from appointed public officials or candidate for public office.



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- ☒ Research involving the collection or study of existing information, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.
- ☐ Research and demonstration projects that are conducted by or subject to the approval of supporting agencies, and which are designed to study, evaluate, or otherwise examine: (a) public benefit or service programs; (b) procedures for obtaining benefits or services under those programs; (c) possible changes in or alternatives to those programs or procedures; or (d) possible changes in methods or levels of payment for benefits or services under those programs.
- ☐ Taste and food quality evaluation and consumer acceptance studies, (a) if wholesome foods without additives are consumed or (b) if a food is consumed that contains a food ingredient at or below the level, and for a use, found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the Food and Drug Administration and approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture.

If at least one of these categories does NOT describe your research, then you should complete the "Expedited and Full Review Application" instead of this one.

1. Describe the key demographics (age, SES, ethnicity, geographic locations, gender, etc) of the sample that you wish to obtain.

17-18 year old students from two, rural Ohio schools. The sample is predominantly Caucasian, low to mid SES, and normally distributed across gender

1a. What is the greatest number of participants that will be recruited? 175

1b. How will participants be recruited? The participants selected are the only current students in the two districts who have taken both the eighth grade math and ELA and algebra 1 EOC's (End of Course Exams) because of complications/disruptions created by the COVID-19 pandemic. Students

2. Will participants be remunerated for their participation? Yes [✓ No]

2a. If so, how will participants be remunerated? Please indicate the type of remuneration and the amount. For instance, the participants will be given a $10 Amazon Gift Card for participation or the participants will receive 3% of their final grade in extra credit in their Introduction course. ______________________

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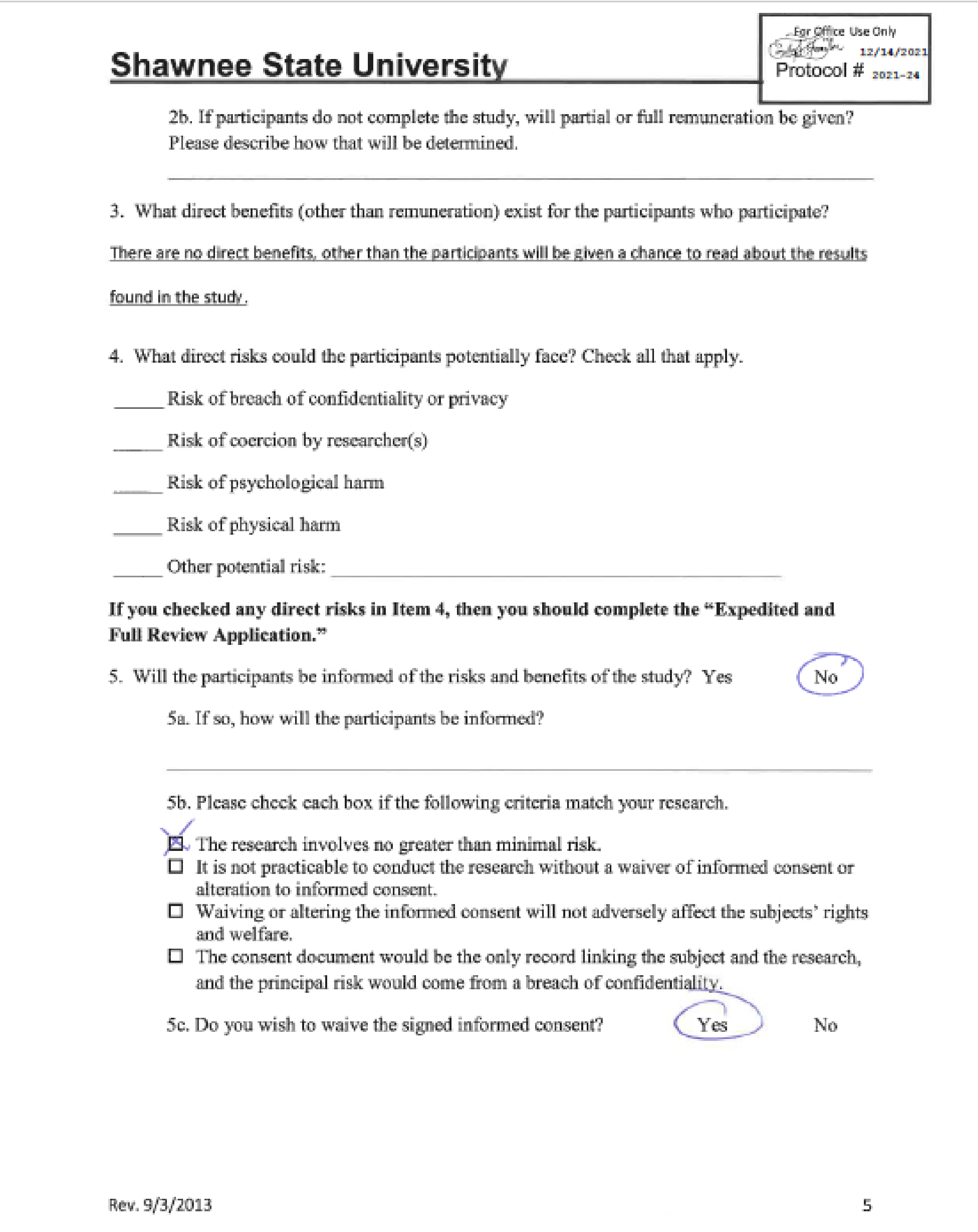

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2b. If participants do not complete the study, will partial or full remuneration be given? Please describe how that will be determined.

____

3. What direct benefits (other than remuneration) exist for the participants who participate?

There are no direct benefits, other than the participants will be given a chance to read about the results found in the study.

4. What direct risks could the participants potentially face? Check all that apply.

_____ Risk of breach of confidentiality or privacy

_____ Risk of coercion by researcher(s)

_____ Risk of psychological harm

_____ Risk of physical harm

_____ Other potential risk: ____

If you checked any direct risks in Item 4, then you should complete the "Expedited and Full Review Application."

5. Will the participants be informed of the risks and benefits of the study? Yes [✓ No]

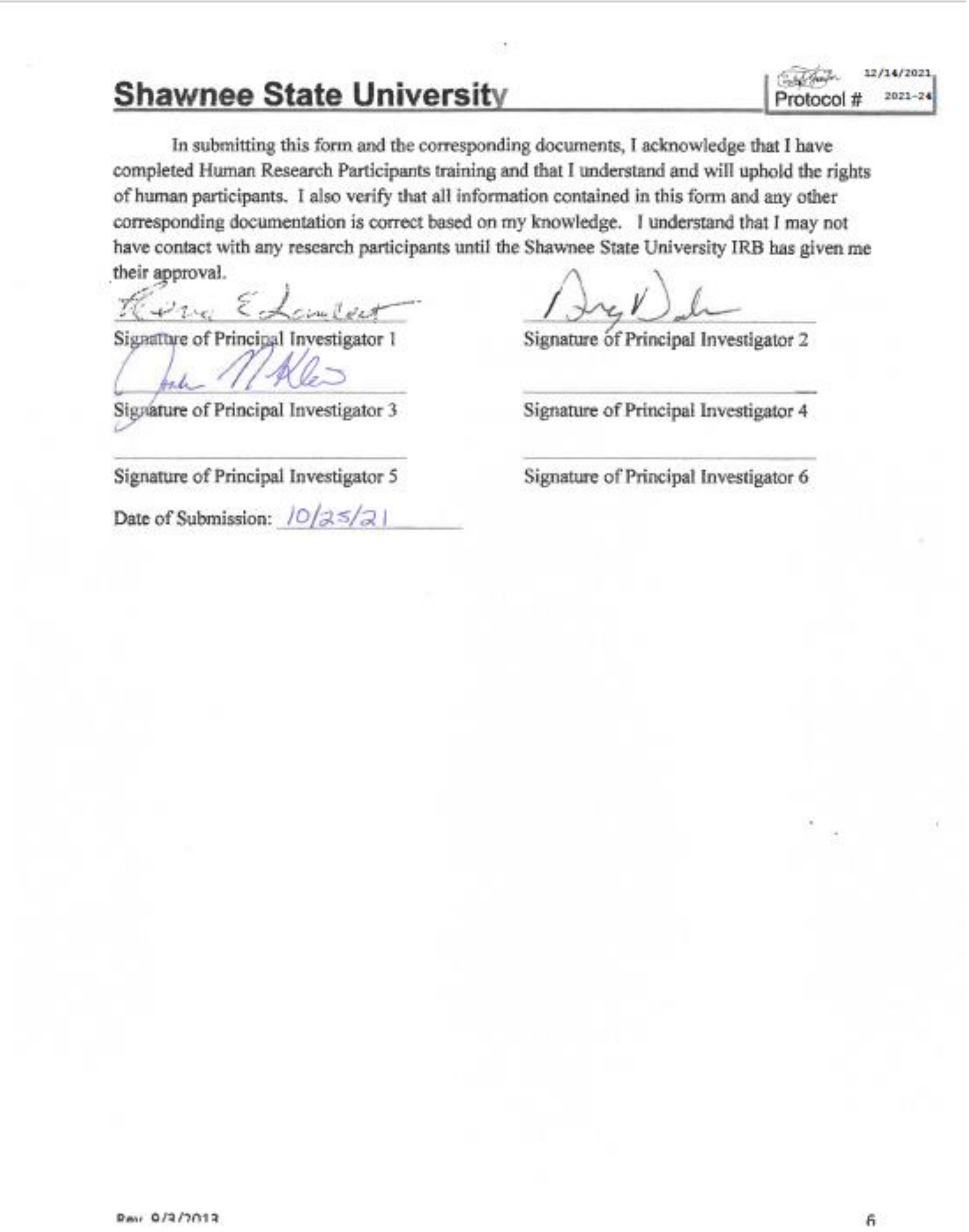
5a. If so, how will the participants be informed?

____

5b. Please check each box if the following criteria match your research.

☒ The research involves no greater than minimal risk.
☐ It is not practicable to conduct the research without a waiver of informed consent or alteration to informed consent.
☐ Waiving or altering the informed consent will not adversely affect the subjects' rights and welfare.
☐ The consent document would be the only record linking the subject and the research, and the principal risk would come from a breach of confidentiality.

5c. Do you wish to waive the signed informed consent? [✓ Yes] No



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Protocol # 2021-24
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In submitting this form and the corresponding documents, I acknowledge that I have completed Human Research Participants training and that I understand and will uphold the rights of human participants. I also verify that all information contained in this form and any other corresponding documentation is correct based on my knowledge. I understand that I may not have contact with any research participants until the Shawnee State University IRB has given me their approval.

Signature of Principal Investigator 1

Signature of Principal Investigator 2

Signature of Principal Investigator 3

Signature of Principal Investigator 4

Signature of Principal Investigator 5

Signature of Principal Investigator 6

Date of Submission: 10/25/21

Rev. 9/3/2013

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Appendix C

Assumptions for Research Questions

Question 1: Linearity

Figure 3: Plot(ALGEBRA,STAR)

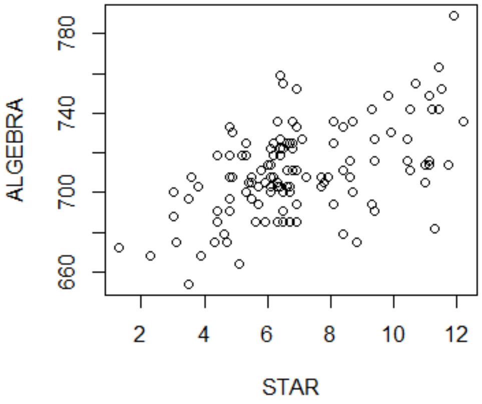
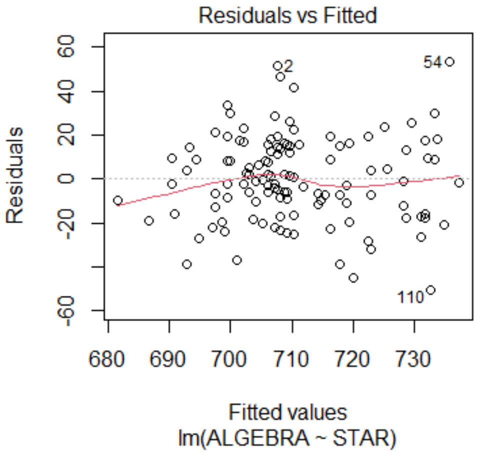


Figure 4: Plot - Residuals vs Fitted



Because there appears to be no pattern in the residual plot, we can assume a linear relationship.

Independence: Independence is violated because this study does not use a random sample. At best results can be generalized to students for the school districts contained within this study. Results cannot be generalized to other districts.

Homogeneity of variances:

Figure 5: Plot(STAR, residual)

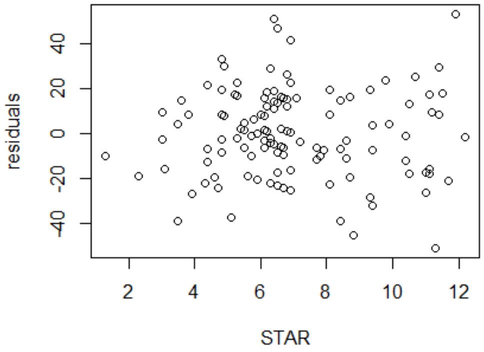
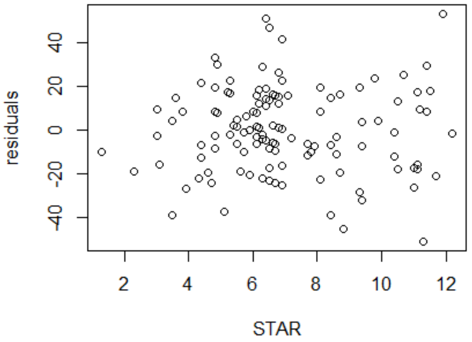


Figure 6: Plot(fitted, residuals)



Normality:

Figure 7: Histogram of ALGEBRA

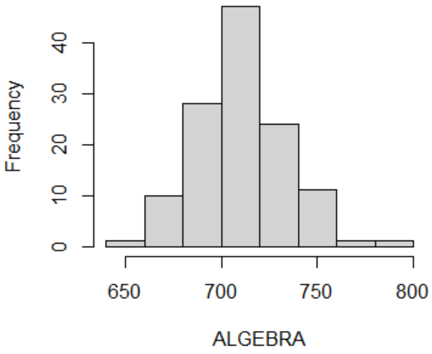


Figure 8: Histogram of STAR

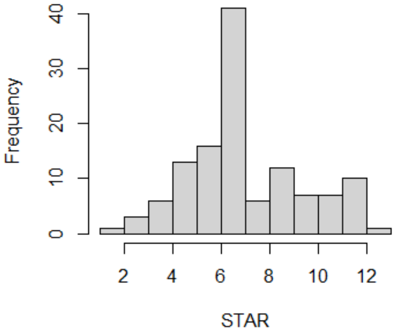


Figure 9: Boxplot ALGEBRA

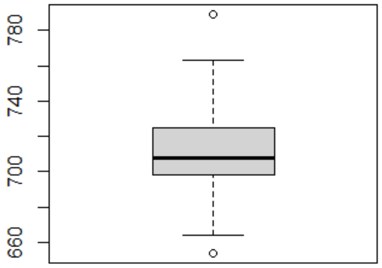


Figure 10: Boxplot Star

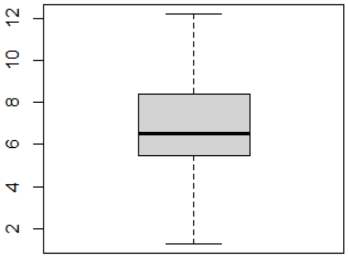


Figure 11: Normal QQ Plot

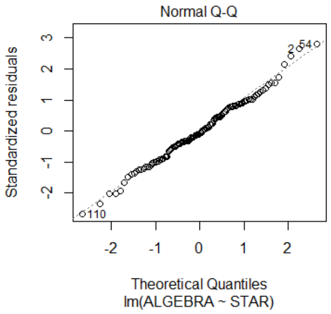


Figure 12: Scale-location plot

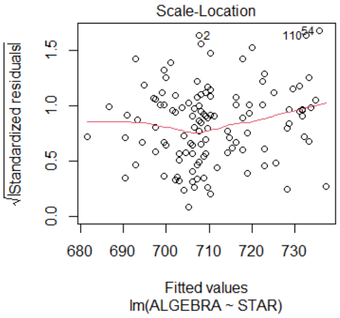
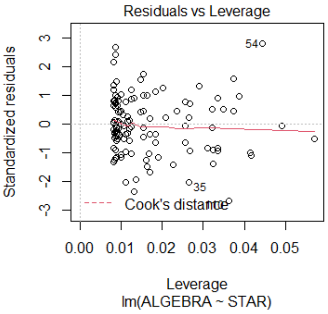


Figure 13: Resid vs Lev



Research Question 2

Figure 14: Residuals vs Leverage

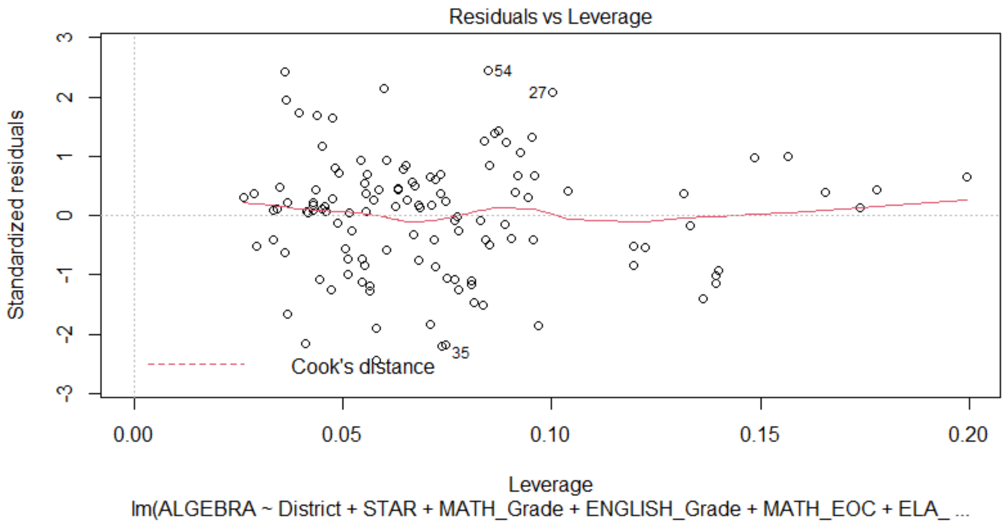


Figure 15: Q2 Residuals vs Fitted

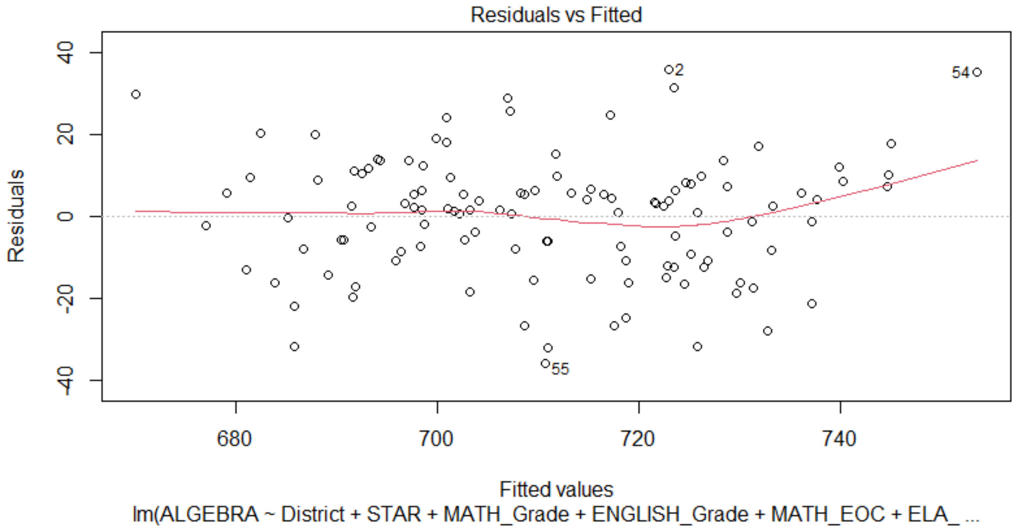


Figure16: Q2 Normal QQ Plot

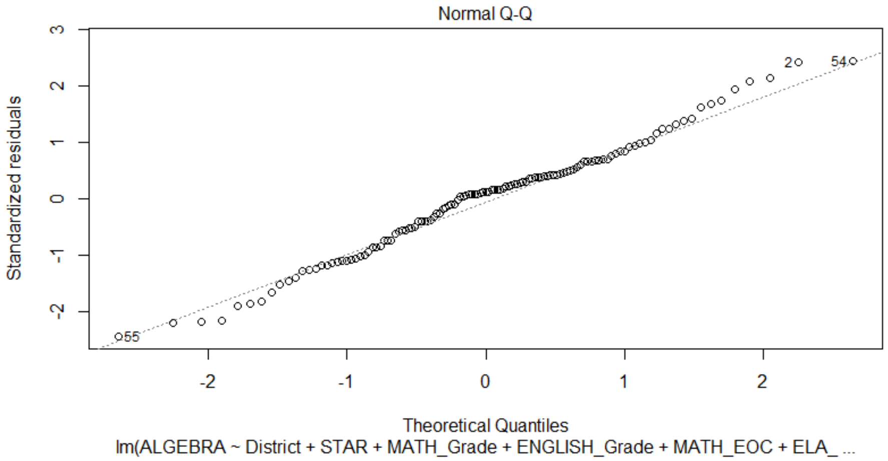


Figure 17: Q2 Scale – Location

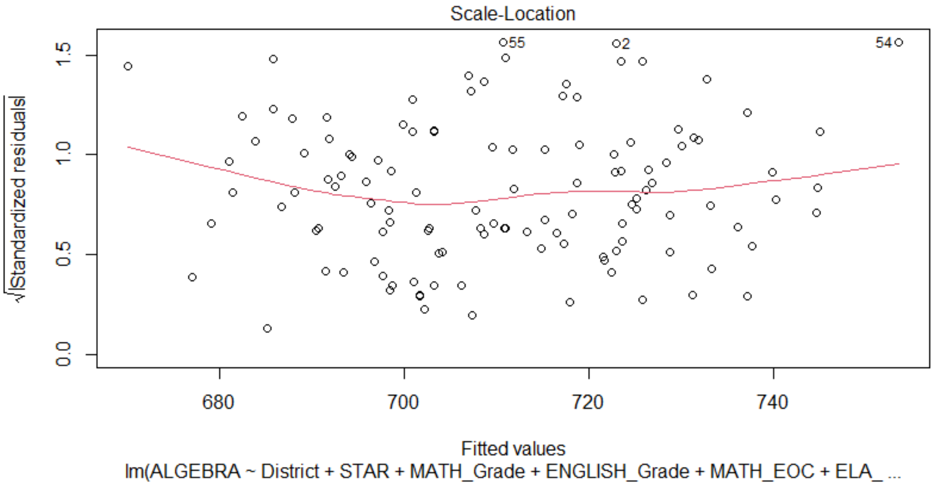
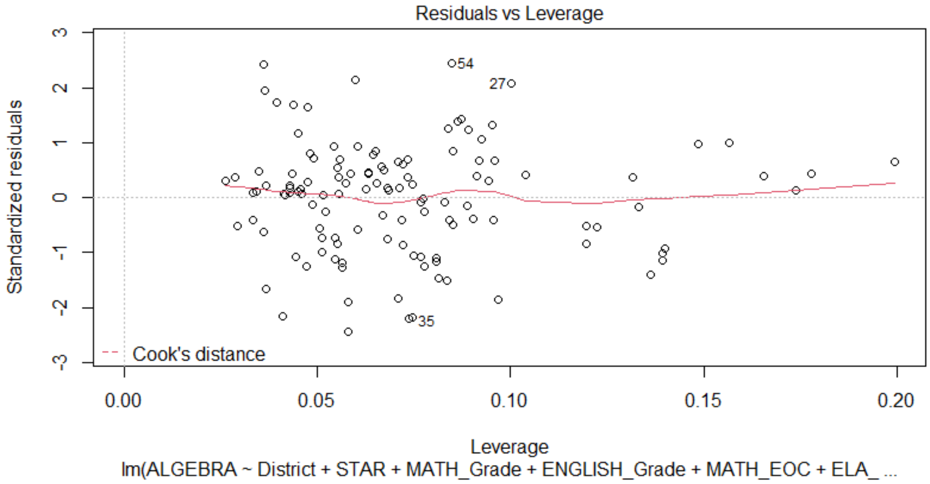


Figure 18: Q2 Residuals vs Leverage



Linearity:

Figure 19: Plot(Math_Grade, ALGEBRA)

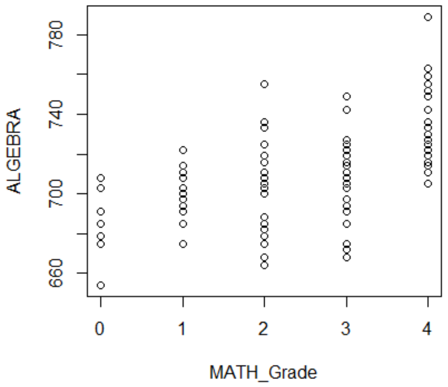


Figure 20: Plot(English_Grade, ALGEBRA)

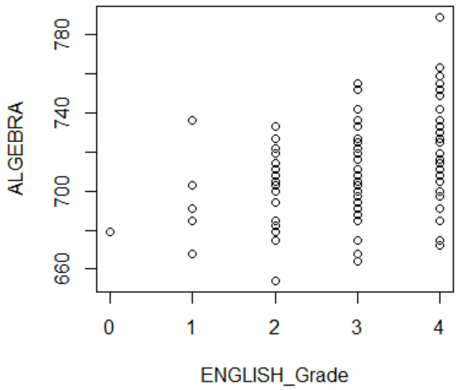


Figure 21: Plot(Math_EOC, ALGEBRA)

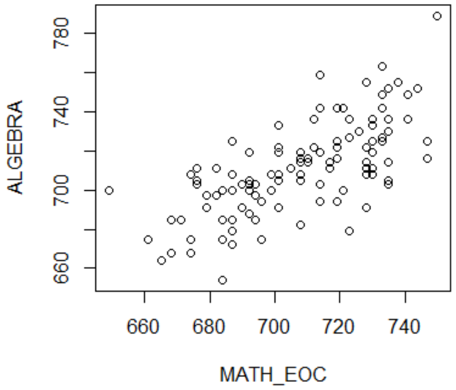
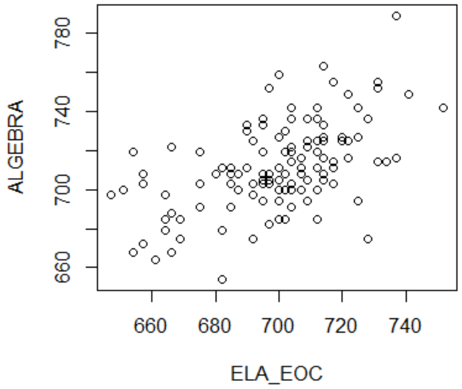


Figure 22: Plot(ELA_EOC, ALGEBRA)



Independence: Independence is violated because this study does not use a random sample. At best results can be generalized to students for the school districts contained within this study. Results cannot be generalized to other districts.

Homogeneity of Variance:

Figure 23: Plot (STAR, Residuals)

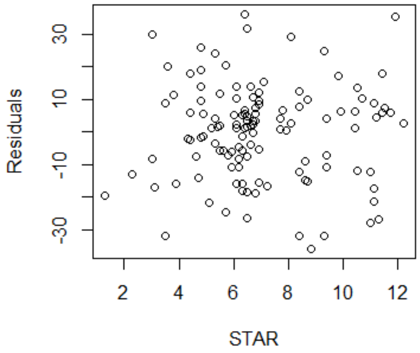
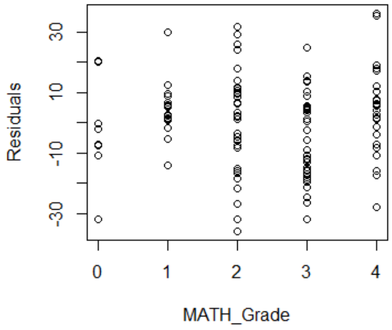


Figure 24: Plot (MATH_Grade, Residuals)



Homogeneity of Variance Cont.

Figure 25: Plot (ENGLISH_Grade, Residuals)

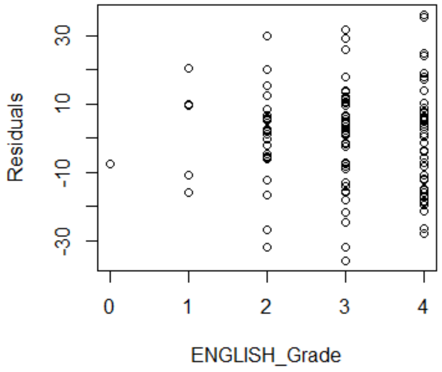


Figure 26: Plot (MATH_EOC, Residuals)

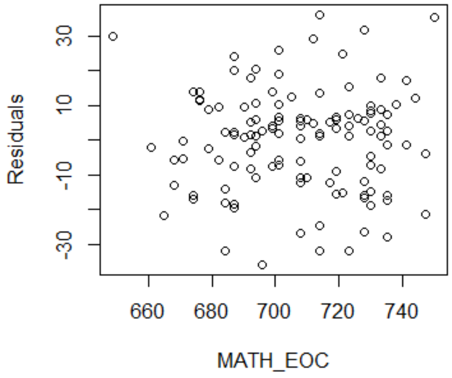


Figure 27: Plot (ELA_EOC, Residuals)

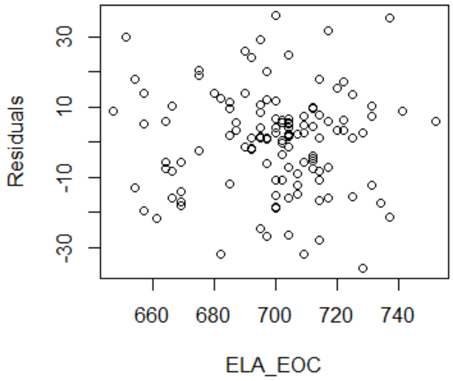
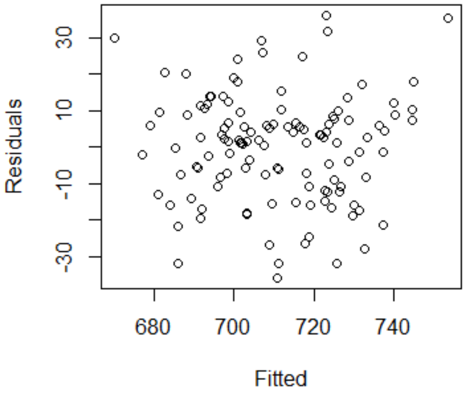


Figure 28: Plot (Fitted, Residuals)



Normality:

Figure 29: Histogram of Math Grade

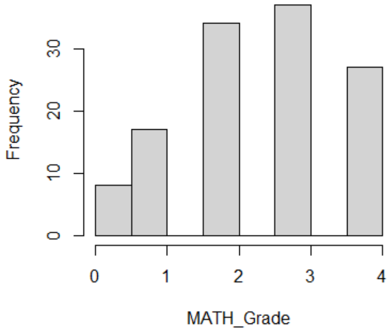
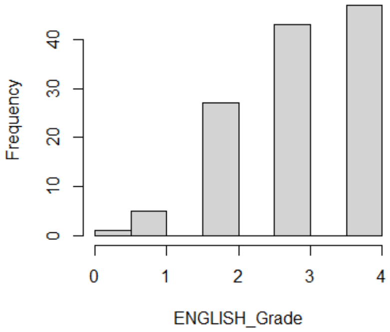


Figure 30: Histogram of English Grade



Normality Cont.

Figure 31: Histogram Math EOC

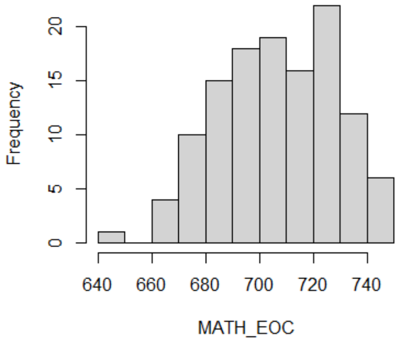
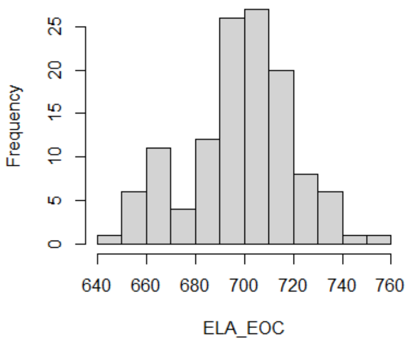


Figure 32: Histogram ELA EOC



Appendix D

Question 2 Models

Table 15: Summary of Full Model

Full Model	Estimate Std.	Error	t	P(significance)
(intercept)	293.76	81.10	3.62	0.000438***
DistrictB	-12.59	3.29	-3.83	0.000210***
STAR	1.91	0.95	2.01	0.046867 *
MATH_Grade	2.67	1.95	1.37	0.173931
ENGLISH_Grade	2.25	2.17	1.04	0.301496
MATH_EOC	.54	.11	5.06	1.6e-06 ***
ELA_EOC	.02	.11	0.16	0.876391
SWDY	-3.58	5.64	-0.64	0.5267
GenderM	2.03	3.04	-0.67	.504363
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1				

Table 16: Summary of Model 2

Model	Estimate Std.	Error	t	P(significance)
(intercept)	279.27	77.63	3.598	.000475 ***
DistrictB	-12.60	3.28	-3.845	0.000198 ***
STAR	1.96	0.95	2.075	0.040194 *
MATH_Grade	2.55	1.94	1.318	.189984
ENGLISH_Grade	2.17	2.16	1.003	.317800
MATH_EOC	0.54	0.11	5.125	1.21e-06 ***
ELA_EOC	0.03	0.11	0.312	0.755838
GENDERM	1.98	3.03	0.655	0.513815

Table 17: Summary of Model 3

Model	Estimate Std.	Error	t	P(significance)
(intercept)	292.67	64.39	4.545	1.36e-05 ***
DistrictB	-12.86	3.16	-4.0475	8.46e-05 ***
STAR	2.14	0.76	2.812	0.00578 **
MATH_Grade	2.51	1.92	1.304	0.19489
ENGLISH_Grade	2.15	2.15	1.001	0.31869
MATH_EOC	0.56	0.10	5.763	6.92e-08 ***
GENDERM	1.77	2.94	0.602	0.54825

Table 18: Summary of Model 4

Model	Estimate Std.	Error	t	P(significance)
(intercept)	293.69	64.20	4.575	1.19e-05 ***
DistrictB	-12.64	3.13	-4.043	9.50e-05 ***
STAR	2.16	0.76	2.854	0.00511 **
MATH_Grade	2.53	1.92	1.317	0.19033
ENGLISH_Grade	1.77	2.05	0.864	0.38961
MATH_EOC	0.56	0.10	5.790	6.02e-08 ***

Table 19: Summary of Model 5 (Best Model)

Model	Estimate Std.	Error	t	P(significance)
(intercept)	306.41	62.42	4.909	2.97e-06 ***
DistrictB	-12.42	3.11	-3.990	0.000115 ***
STAR	2.22	0.75	2.950	0.003835 **
MATH_Grade	3.58	1.48	2.428	0.016673 *
MATH_EOC	0.54	0.09	5.734	7.68e-08 ***

Table 20: Summary of Model 6

Model	Estimate Std.	Error	t	P(significance)
(intercept)	227.34	54.33	4.184	5.51e-05 ***
DistrictB	-13.15	3.16	-4.162	5.99e-05 ***
STAR	2.18	0.77	2.842	0.00528 **
MATH_EOC	0.67	0.08	8.238	2.61e-13 ***

BIBLIOGRAPHY[1]

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