EXAMINING ALGEBRA ACHIEVEMENT IN RURAL TEXAS SCHOOLS: THE ROLE OF STUDENT DEMOGRAPHICS AND PER STUDENT SPENDING

A Dissertation

by

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ABSTRACT

With close to a million Texas students attending rural schools, research on what influences student achievement is needed to guide policy, practice, and further research. Building on research relating student demographic variables and per student spending in rural schools to student achievement, through this dissertation research I used quantitative methods to investigate which of those variables contributed to student achievement in mathematics in Texas rural schools.

Employing a ex post facto design, STAAR Algebra I EOC assessment and demographic data from 1090 students in Texas rural schools were used to examine the relationships between the variables and what impacts student achievement in mathematics in Texas rural schools. This group was compared to a nonrural group of Texas schools from the same dataset.

Rural schools were shown to have significantly lower achievement scores than their nonrural counterparts (*d=.095, CI=(.034,.155)*). When controlling for race and per student spending in rural schools, student sex and SES were shown to be significant predictors of student achievement. When holding all other variables constant, for a change of one unit in SES, on average the decrease in score is nearly 500 points. Non-FRPL students scored significantly higher on the Algebra I EOC than their FRPL counterparts with the mean difference of 525.579 (*d*=.791 with a *CI*= (.657,.924)). There was no evidence to suggest a significant mean difference between male and female student achievement on average. White students scored significantly higher on average than the average of both their Black and Hispanic peers, with the true value of the mean difference being between 323 and 560. There was not a different effect of per student spending on achievement based on locality. There was not a different effect of per student spending on achievement based on SES.

The discussion of the context of the results in this study included the lack of consensus on a few the predictor variables, including race and per student spending. The study also included a discussion of student SES being perhaps the most important predictor variable when considering student achievement in rural schools. Policy, practice, and research recommendations were provided to conclude the study.

DEDICATION

There are many in my life deserving of having this dissertation dedicated either in their memory or in their honor.

First, I dedicate this work to my incredible wife, Candra. The superlatives that I could use to describe what you have meant to my life over the last 13 years do not suffice to share my love and admiration for you. This dissertation simply would not have happened without your constant patience and help through the struggles of the dissertation. This dissertation and the degree that accompanies it is just as much yours as it is mine. I love you!

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NOMENCLATURE

CCMR	College Career and Military Readiness
CDN	County/District Number
DOE	United States Department of Education
EOC	End of Course Assessment
ESSA	Every Student Succeeds Act
EST	Ecological Systems Theory
FRPL	Free or Reduced-Price Lunch
LEA	Local Education Agency
NAEP	National Assessment of Educational Progress
NCES	National Center for Education Statistics
NSLP	National School Lunch Program
OMB	Office of Management and Budget
TAKS	Texas Assessment of Knowledge and Skills
TEA	Texas Education Agency
TEC	Texas Education Code
TEKS	Texas Essential Knowledge and Skills
SES	Socioeconomic status
STAAR	State of Texas Assessment of Academic Readiness
UA	Urban Area
UC	Urban Cluster
U.S.	United States
USCB	United States Census Bureau

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CHAPTER I

INTRODUCTION

Background

There is shared concern among stakeholders for improving students' algebra achievement in the United States (U.S.). There is little consensus in the literature dealing with student achievement and locality (see Byrnes, 2003; Durwood et al., 2010; Stein et al., 2011), with most of the research focused on urban centers (e.g., Miller et al., 2013). Rural settings are inadequately represented in the research literature, and the southern U.S. is particularly underrepresented. This fact makes syntheses of what works in mathematics learning limited to mostly urban centers. The present dissertation was designed to address this gap in the research and to begin understanding what student factors impact algebra achievement in rural settings.

Rural schools in the southern U.S. are somewhat unique in the world of education. Rural schools are different from urban and suburban schools due to variables relating to their locations and current academic state (Lee & McIntire, 2000). To create positive change in rural schools, alterations to school practice need to fit in with the culture and climate of the schools rather than simply fit a cookie cutter approach used for all localities (Bell & Segura-Pirtle, 2012). The factors that make rural schools unique are deeper than physical location alone (Johnson & Howley, 2015; Uekawa & Lange, 1998). Therefore, the researcher in the present study considered other factors in describing rural schools and algebra achievement in those schools, namely issues of race and ethnicity, gender, socioeconomic status (SES), school funding, and educational expectations and curriculum standards.

Despite their differences, rural schools share a lot of common features with urban schools, which contrasts with schools in suburban areas. Many of the challenges in algebra achievement faced by rural schools and students are the same as those faced by their urban counterparts. In fact, school classification as urban, suburban, or rural has been shown to not be directly associated with students' mathematics achievement (Maldonado et al., 2018), though there is a mathematics achievement gap between rural/urban and suburban schools (Graham & Provost, 2012; Williams, 2005). In other words, some factor (or factors) other than locality must explain the achievement gap (Howley & Gunn, 2003; Williams, 2005; Young, 1998). As has been the case in urban schools, location and school SES have been shown to explain some variance regarding mathematics and science achievement, but student-level demographic factors accounted for most of the achievement variability in rural schools (Meece, 2009; Williams, 2005; Young, 1998). In one study, factors that were shown to impact students' mathematics achievement included the percentage of low-SES students, percentage of participants in college readiness curricula, and students’ scaled scores (Maldonado et al., 2018). Rural and urban schools are similar in mathematics achievement outcomes not because of their locality but due to characteristics of the students they serve and, to a lesser degree, school SES. Situating rural schools in the context of other types of schools can help unpack the similarities of rural schools to urban schools as well as nuances that make rural schools unique from both urban schools and suburban schools.

My View of Rural Algebra Achievement and What Inspired This Study

As a lifelong resident of a rural area in East Texas, I have personally experienced many of the issues associated with rural education and its intersection with mathematics education and achievement. I spent my entire primary, elementary, and secondary school years at a rural school. Upon completion of my master’s degree, I returned to the same school district to work as an administrator. My personal perspective from having been a rural student, educator, and researcher gives me a unique lens to approach the issues facing rural schools in Texas. This interest was the reason I chose to study statewide testing data for algebra achievement in rural Texas schools.

Purpose of the Study

There is a lack of research on the degree to which student factors impact rural students' algebra achievement. The previous literature on the topic of rural student achievement in general and algebra achievement is evidence of the impact that race, sex, and SES can have. A factor that is not widely studied is per student spending. The literature does not address the total amount of variance explained by these factors or the amount explained by any individual factor. The purpose of the present study is to establish a baseline on salient factors of algebra in rural schools instead of inducting them from urban settings.

Research Question

1) What are the factors that influence algebra achievement in rural schools as compared to non-rural schools?

Hypotheses

H_1: If students attend rural schools in Texas, then Algebra achievement will be different for those students than their non-rural counterparts.

H_{2a}: If per student spending on instruction in rural Texas schools is changed, then Algebra achievement will also change.

H_{2b}: If when adjusting for race, SES, and gender, per student spending on instruction in rural Texas schools is changed, then Algebra achievement will also change.

H_3: If student SES is low, then Algebra achievement will be different than students with high SES in rural Texas schools.

H_4: If a student attending a rural school is female, then their Algebra achievement will be different than their male counterparts.

H_5: If a student attending a rural school is White, then their Algebra achievement will be different than their Black and Hispanic counterparts.

H_6: Disaggregating by locality, if per student spending is changed, then there will be a different effect on Algebra achievement in rural schools than in nonrural schools.

H_7: Disaggregating by student SES level, if per student spending is changed, then there will be a different effect on Algebra achievement for economically disadvantaged students than those without economic disadvantage.

CHAPTER II

LITERATURE REVIEW

Procedures for Literature Search

The literature reviewed for this chapter of the dissertation was organized through the lens of the framework for improved dissertation literature reviews suggested by Boote and Beile (2005). The categories of the framework include coverage, synthesis, methodology, significance, and rhetoric. Boote and Beile (2005) argue that a well-articulated and substantive literature review is a necessary condition for meaningful research. Therefore, what follows in this literature review will include: a) what was included and excluded from the review and reasons for such inclusion or exclusion, b) contextualizing the problem within the field of education generally and mathematics education in particular, c) how previous research has been conducted from a methodological standpoint, and d) situating the practical and scholarly significance of the current study within the larger context of the problem. The coverage of the literature and where literature was retrieved is the first facet of the review framework considered.

Databases and Sources of Literature

I utilized various databases to acquire literature for review. These included: the databases of the Texas A&M University Library, EBSCOHost, Education Resources Information Center databases, Sage Journals, Google Scholar, JSTOR, as well as the Library of Congress website, the U.S. Department of Education (DOE) website, the Texas Education Agency (TEA) website, the U.S. Census Bureau (USCB) website, and ProQuest Theses and Dissertations Global. I also reviewed reference lists from retrieved articles to gain additional references. Various search strings were used to acquire articles from these sources.

Search Keywords and Procedure

I used several keywords to locate literature for this dissertation, which included the following: achievement, algebra achievement, demographics, free and reduced lunch eligibility, high-stakes testing, income, mathematics, algebra achievement, rural, rural districts, rural schools, SES, and standardized testing,

Inclusion Criteria

Studies that met the following criteria were eligible for inclusion in this review:

1. Peer-reviewed articles and edited books, dissertations, and gray literature (such as government reports or those conducted by non-governmental entities)
2. Published since the year 2002 (unless a work is seminal to the field or meaningful for the historical context)
3. Utilized and experimental, quasi-experimental, or other empirical study design

Historical Context of Rural Education

Rural schools constitute a significant proportion of schools in the U.S., though historically they have been overlooked both from a research and policy standpoint. The context of contemporary rural education research has been influenced by the events of prior generations and thus an unpacking of the historical context is important for understanding the current state of the field (Coladarci, 2007; DeYoung, 1987; Theobald, 1991). The educational reforms beginning near the turn of the twentieth century are explored first.

Rural Education at the Turn of the Twentieth Century

Community attributes associated with rural schools worked against them as educational reformers of the sought to make schooling fit a single paradigm that matched the changes being experienced in the U.S. at the time. As the urbanization of America took hold, education reformers of the time believed that the schools that typified rural areas would continue to decline, though continuing to keep a community identity espoused by rural schools was essential for the newer urban schools (DeYoung, 1987). Moreover, those educational reformers believed that the rural school model was directly in conflict with the improvement of efficiency and institutionalization of education due to the lack of sophistication of rural schools (DeYoung, 1987; Theobald, 1991). In contrast, most students of the period attended rural schools (Theobald, 1991). The lack of discussion of rural schools in educational history is as Theobald (1991) argues that documentation of urban schools was more available than for rural schools. This urban focus in the educational reform and policymaking structure led to a field both from research and practice that had an urban bias.

Urban Bias and the Drive for More Cost-Efficient Schools

Rural education practice and research in the early twentieth century was shaped by the educational reforms made by policymakers at the state level, which were largely urban-centric in nature. Both from a policy and research standpoint in the early twentieth century, the goal of many policymakers was for schools to look the same from an operational and curricular standpoint (Rosenfeld & Sher, 1977; Theobald & Wood, 2010). There was little empirical research done in rural schools in the early twentieth century and what research was conducted, such as school surveys were utilized as a tool to highlight deficiencies and bring schools under state bureaucratic control (DeYoung, 1987). Subsequent research involved: tools for estimating efficiency and growth of schools (Tyack & Hansot, 1982), improving school management practices (Callahan, 1962), and the furthering of the idea that rural schools had high populations of cognitively deficient students because of parents who had not been able to have success outside of the rural area (Silver & DeYoung, 1985; Theobald & Wood, 2010). The prevalence of urban-centric policy and research in the early twentieth century gave way to efforts to consolidate rural schools and further the urbanization of education practice and research.

Landmark legislative and judicial action of the civil rights movement of the 1960s and 1970s sparked changes to rural schools in several areas, the first of which I discuss is racial integration of rural schools. While the landmark U.S. Supreme Court Case Brown v. Board of Education of Topeka (1954) invalidated de jure racial segregation of schools, many rural schools did not integrate their schools until at least 1970 (McCoy, 2006), with others remaining under federal court orders to desegregate into the twenty-first century (McLaughlin, 2017). Another key issue of this period was the effort to consolidate schools.

School consolidation was one of the most influential policy efforts on rural schools from the 1930s through the 1980s. Consolidating schools was such a popular and idealized practice that Tamblyn (1971) argued that "school district reorganization and school consolidation are among the most significant accomplishments throughout most of rural America, and this trend can be expected to continue until we reach a total of not more than 5,000 local school districts supported by 250 to 500 intermediate school districts" (p. 10). Another proponent of school consolidation, Conant (1959) argued that small high schools were not capable of providing the education necessary for a modern society:

> The prevalence of such high schools - those with graduating classes of less than 100 students - constitutes one of the serious obstacles to good secondary education throughout most of the United States. I believe that such schools are not in a position to provide a satisfactory education for any group of their students... A small high school cannot by its very nature offer a comprehensive curriculum. (as quoted in Feldmann, 2003, p.58).

The consolidation of schools also merged assets and centralized rural schools and administrations, much like the prescriptions of earlier education reforms (DeYoung, 1987; Howley, 1991). Those attempting to justify school consolidation argued that rural schools were not efficient enough for the demands of an urban, industrial world, an issue termed the "rural school problem" (Kannapel & DeYoung, 1999; Schafft & Youngblood Jackson, 2010). In reality, though the efforts to consolidate schools decreased school districts in the U.S. from 130,000 in 1930 to 15,000 in 2000 (Lyson, 2002), there is evidence to suggest that the increased efficiency and cost effectiveness have not followed (Bard et al., 2006; Schafft, 2010; Sher & Tompkins, 1977). School consolidation, while prominent in prescription, was less effective in practice to make schools more effective and efficient.

Civil rights legislation regarding equality of educational opportunity was influential in rural education in the 1970s and beyond. Educational opportunity was to be equal across disadvantaged groups including race, SES, ability status, sex, and others (DeYoung, 1987; Phelps & Prock, 1991). These changes to national educational policy spurred research and a paradigm shift in the type of educational research conducted, though most was urban-centric, with little educational research coming out of rural contexts (DeYoung, 1987). As was the case with other factors of educational research, policy, and practice, themes of educational opportunity and disadvantaged groups were largely prescribed and analyzed using an urban focus.

Shifting to a Rigorous Approach to Educational Research

Though educational research moved to a more rigorous empirical approach in the 1970s and 1980s, much of that research was still focused in urban areas without a clearly defined construct for rural education. The shift to a more rigorous empirical research paradigm led to discussions of funding, administration, and school size as a means of addressing outcome measures for disadvantaged groups in rural schools (DeYoung, 1987; Nachtigal, 1991). Proponents of school consolidation argued that the economies of scale that existed in larger schools were simply not possible in rural schools, where providing special services was often more expensive (Nachtigal, 1991). Conversely, as Dunne (1977,1983) and Barker (1986) argued, schools being smaller and in rural settings allowed for many of the reforms sought at the national level such as: individualized instruction, strong community support, high teacher expectations, peer tutoring, and others. The lack of a defined and unified research agenda for rural education led to an uneven patchwork of research in the field.

Rural education researchers were conducting meaningful research on those topics in the 1980s and beyond, even without a clear focus or agenda. Prior to the analysis by DeYoung (1987) and his subsequent book (DeYoung, 1991), several researchers discussed rural education topics such as vocational and occupational training (Harl, 1985; Rosenfeld, 1983), economic development (Forbes, 1985; Lick, 1985), student skills and rural schools as hubs for economic development (Hobbs, 1979; Rosenfeld, 1983; Sher, 1977), among others. Many of these topics explored were included in a proposed research agenda and policy recommendations presented by authors in DeYoung's 1991 book (Haas, 1991; Nachtigal, 1991; Stephens & Perry, 1991). The historical context of rural education and rural education research both as standalone ideas and within their broader fields of education and educational research were important in shaping contemporary rural education research.

Contemporary Rural Education Research

Though the subfield of rural educational research exists in the broader educational research context, the area needs further study and careful attention paid to the factors that influence such research. In the preceding two decades, research in rural education has been bolstered by three research journals on the topic, as well as more notice from governmental entities and others (Coladarci, 2007). With improvements to the quantity of rural education research has come quality and methodological concerns (Coladarci, 2007), particularly in doctoral dissertations (Howley et al., 2014). The concerns about the quality and methods in rural education research has sparked debate and recommendations for future research on the topic.

There are methodological concerns regarding rural education research that have been addressed by previous researchers. Often, research on rural education has been conducted purely for the convenience of rural samples (Coladarci, 2007; Howley et al., 2014). Another methodological pitfall that has been addressed by numerous quantitative or qualitative researchers is how rural was defined (Coburn et al., 2007; Coladarci, 2007; Cromartie & Bucholtz, 2008; Hart, et al., 2005; Hawley et al., 2016; Howley et al., 2005; Longhurst, 2022; Thier et al., 2021). Yet another significant methodological concern in rural education research identified by several researchers was the personal bias of either conducting a study based upon a comfortable methodology or using a certain dataset to advance personal convictions (Biddle et al., 2019; Coladarci, 2007). One final concern with rural education research methods has been the quantity of journals where quality empirical rural education research has been published and total number of studies (Azano et al., 2022; Biddle et al., 2019). While there are at least two journals specifically dedicated to rural education research, namely the *Rural Educator* and the *Journal for Research in Rural Education*, the low number of studies on a particular topic has made it difficult for: 1) researchers to develop sound conceptual frameworks within the field, 2) researchers to get published within the field, and 3) getting rural education research into a more mainstream position in the broader education and social sciences fields (Azano et al., 2022; Biddle et al., 2019). Methodological concerns in rural education research may exist because of what is being researched, how the terms and variables are defined, who is conducting the research, and where the research is being published (or not).

There have been few seminal or systematic reviews of rural education research, Perhaps the most seminal and comprehensive work on rural education research until recently was that of DeYoung (1987). More recently, a few books on the topic of rural education have been published, most notably edited works from Schafft and Youngblood Jackson (2010) and a new volume from Azano et al. (2022). A sample from many, if not most issues facing rural education and rural education research, was conducted by Azano et al. (2022). From these works and others, there have been explicit pushes to strengthen rural education research.

Swan Song and Strengthening Rural Education Research

The need to strengthen rural education research has been debated and unpacked in recent years. In his final essay as editor of the *Journal for Research in Rural Education*, Coladarci (2007) gave specific prescriptions for ways of strengthening rural education research, namely asking researchers to (a) not only fully describe the rural context in which their research occurs, but also establish "compelling justifications" (p.3) for the rural conclusions drawn, (b) frame and justify their research questions as rural questions, (c) draw explicitly from other related disciplines (anthropology, history, psychology), (d) synthesizing the extant research to aide novice researchers in the field, policymakers, practitioners, and others looking to inform themselves on rural topics, (e) explore empirical questions with as little personal agenda as possible, and (f) discuss the relevance of the phenomenon of interest in the context of how relevant the rural setting is. By 2019, Coladarci's (2007) call and recommendations for strengthening of rural education research had been cited no less than 175 times, with increasing frequency as time has gone on (Biddle et al., 2019). Moreover, the citations of Coladarci's Swan Song have been much more influential in dissertations than in published journal articles (Biddle et al., 2019). Others have refined, reframed, and expanded recommendations to include: examining the reasons for the dominance of urban-centric (Corbett & White, 2015) and utopian (Shucksmith, 2016) research methodologies, redefining the boundaries of rural education research to not be solely focused on the rural warrant of the research, but also on describing how topics are critical to rural communities and how power and marginality of rural communities impact those critical topics (Biddle et al., 2019), means for moving in the direction of a transdisciplinary research agenda through thoughtful hiring of researchers in scholarly settings, engaging rural stakeholders, policymakers, and practitioners, and pursuing funding for research across disciplines (Stapel & DeYoung, 2011). Another key reframing of the boundary work in rural education was the argument that boundary markers should serve as a means of pinpointing "intersections and bridges, rather than the building of walls" (Azano et al., 2022). While there has not been consensus on the specifics of how to strengthen rural education research, there has been agreement on the key tenet that rural education research can and should be improved.

The Challenge of Defining Rural

There has been much debate in rural education research regarding how to define the word rural and the implications of various definitions. Coladarci (2007) argued for the clear delineation of what makes a study rural and a need for a clear context of the definition of rural employed. Further, the use of any definition of rural can determine who benefits from related policy (Coburn et al., 2007), how results are interpreted and generalized (Thier et al., 2021), how future research is conducted, particularly for novice researchers in the field (Howley et al., 2014). Some authors have advocated for a single, unified definition of rural (Helge, 1992), many more have recognized that there is no reasonable way to have one definition of rural that can be employed in all contexts of policy, practice, and research (Coladarci, 2007; Cromartie & Bucholtz, 2008; Farmer, et al., 2022; Longhurst, 2022; Thier et al., 2021). Moreover, there are at least 15 such definitions of rural used for U.S. government programs alone (Coburn et al., 2007), not to mention the fragmentation of defining rural contexts either quantitatively, qualitatively, or not at all (Thier et al., 2021). The lack of a single definition of rural makes the need to clearly articulate a definition much more important in research.

Examples of Definitions of Rural

Rural has been defined and articulated in various ways by different entities. Bosak and Perlman (1982) presented one way of organizing these definitions of rural presented in sociology and mental health research: external quantitative, homemade quantitative, verbal, or not stated. External quantitative refers to definitions that are based on external sources, particularly governments and government agencies (Longhurst, 2022; Thier et al., 2021). Homemade quantitative definitions use quantitative measures that are not based on some external sources (Bosak & Perlman, 1982; Thier et al., 2021). Verbal and not stated are more straightforward categories with verbal being definitions based upon qualitative description of rural and not stated being that no specific definition was presented (Bosak & Perlman, 1982). This framework provides a meaningful way to organize definitions of rural and examples of external quantitative definitions was applicable for this dissertation.

Most definitions of rural used in rural education research are external quantitative and were developed for use by U.S. government agencies at the federal level, with some additional definitions developed by state agencies like the TEA. At the federal level, the U.S. government has two sets of definitions for rural classification, the USCB and the Office of Management and Budget (OMB). Most of the resulting definitions used by other agencies within the federal government use one of these two sets of definitions (Coburn et al., 2007; Cromartie & Bucholtz, 2008).

The USCB classified and defined rural as "all territory, population, and housing units located outside Urban Areas" for the 2020 Census (USCB, 2022a). In other words, rural is everything that is not considered urban. Then for narrowing down what rural is, the census definition of urban is needed. The USCB uses two classifications of what is urban, which have been utilized since the 2010 Census and the American Community Survey since 2010: Urban Areas (UAs), which are urbanized areas that have at least 50,000 people and Urban Clusters (UCs), which have populations of at least 2,500 and less than 50,000 (USCB, 2022b). Thus, rural is any locality with less than 2,500 people. The use of urban categories is new, but according to the USCB, the lower limit for urban at 2,500 has existed since 1910 (USCB, 1994). The "what's left" approach to defining what is rural is common across government agencies and is similar to the organization of the OMB.

The OMB has three classifications for counties in the U.S.: metropolitan, micropolitan or neither (OMB, 2010). The definition of metropolitan in the OMB framework is an urban area having more than 50,000 people and the definition of micropolitan is an urban area having no less than 10,000 people. Longhurst (2022) and Thier et al. (2021) mentioned that the "micropolitan" and "neither" counties are considered rural in the OMB framework and that this is an often-used way of defining rural in rural education research. Conversely, according to the OMB (2010), the "Metropolitan and Micropolitan Statistical Area Standards do not produce an urban-rural classification, and confusion of these concepts can lead to difficulties in program implementation. Counties included in Metropolitan and Micropolitan Statistical Areas and many other counties may contain both urban and rural territory and population" (p. 37246).

Of the rural education research in which rural is defined, the most commonly used (Thier et al., 2021) definitions were developed by the National Center for Education Statistics (NCES). The NCES locale classifications, like other government definitions of rural are dependent on the USCB definition (NCES, n.d.). The NCES classifications place every public school in the U.S. as either city, suburb, town, or rural and for rural as either fringe, distant, or remote (NCES, n.d.). The categories of rural according to the NCES locale classifications can be found in Table II-1. The TEA uses a classification system for school districts in Texas to what is used by NCES.

Table II-1 *NCES Rural Locale Classifications*

Classification	Definition
Rural, Fringe	Census-defined rural territory that is less than or equal to 5 miles from an Urbanized Area, as well as rural territory that is less than or equal to 2.5 miles from an Urban Cluster.
Rural, Distant	Census-defined rural territory that is more than 5 miles but less than or equal to 25 miles from an Urbanized Area, as well as rural territory that is more than 2.5 miles but less than or equal to 10 miles from an Urban Cluster.
Rural Remote	Census-defined rural territory that is more than 25 miles from an Urbanized Area and also more than 10 miles from an Urban Cluster.

Source: NCES (n.d.).

The TEA uses a tiered classification system for defining school district type. The categories used by TEA for district type include Major Urban, Major Suburban, Other Central City, Other Central City Suburban, Independent Town, Non-Metropolitan: Fast Growing, Non-Metropolitan Stable, Rural, and Charter School Districts. The definitions of each of these categories are presented in Table **II-2**.

The TEA definition for a rural district is a combination of student enrollment and enrollment growth statewide (TEA, 2017a). School districts between 300 students and the median district enrollment for the state that have not seen an enrollment growth of greater than or equal to 20 percent and districts with less than 300 students are considered rural (TEA, 2017a). In 2016, there were a total of 459 school districts that the TEA considered rural based on its definition (TEA, 2017a).

Table II-2 T*EA District Type Classifications*

Classification	Definition	Districts
Major Urban	(a) it is located in a county with a population of at least 950,000; (b) its enrollment is the largest in the county or at least 70 percent of the largest district enrollment in the county; and (c) at least 35 percent of enrolled students are economically disadvantaged. A student is reported as economically disadvantaged if he or she is eligible for free or reduced-price meals under the National School Lunch and Child Nutrition Program.	11
Major Suburban	(a) it does not meet the criteria for classification as major urban; (b) it is contiguous to a major urban district; and (c) its enrollment is at least 3 percent that of the largest contiguous major urban district or at least 4,500 students. A district also is classified as major suburban if: (a) it does not meet the criteria for classification as major urban; (b) it is not contiguous to a major urban district; (c) it is located in the same county as a major urban district; and (d) its enrollment is at least 15 percent that of the largest major urban district in the county or at least 4,500 students.	79
Other Central City	(a) it does not meet the criteria for classification in either of the previous subcategories; (b) it is not contiguous to a major urban district; (c) it is located in a county with a population of between 100,000 and 949,999; and (d) its enrollment is the largest in the county or at least 75 percent of the largest district enrollment in the county.	41

Table II-2 Continued

Classification	Definition	Districts
Other Central City Suburban	(a) it does not meet the criteria for classification in any of the previous subcategories; (b) it is located in a county with a population of between 100,000 and 949,999; and (c) its enrollment is at least 15 percent of the largest district enrollment in the county. A district also is other central city suburban if: (a) it does not meet the criteria for classification in any of the previous subcategories; (b) it is contiguous to another central city district; (c) its enrollment is at least 3 percent that of the contiguous other central city district; and (d) its enrollment is equal to or greater than the median district enrollment for the state of 879 students.	161
Independent Town	(a) it does not meet the criteria for classification in any of the previous subcategories; (b) it is located in a county with a population of 25,000 to 99,999; and (c) its enrollment is the largest in the county or is at least 75 percent of the largest district enrollment in the county.	68
Non-Metropolitan: Fast Growing	(a) it does not meet the criteria for classification in any of the previous subcategories; (b) it has an enrollment of at least 300 students; and (c) its enrollment has increased by at least 20 percent over the past five years.	31
Non-Metropolitan Stable	(a) it does not meet the criteria for classification in any of the previous subcategories; and (b) its enrollment is equal to or greater than the median district enrollment for the state	174
Rural	(a) an enrollment of between 300 and the median district enrollment for the state and an enrollment growth rate over the past five years of less than 20 percent; or (b) an enrollment of less than 300 students.	459

Table II-2 Continued

Classification	Definition	Districts
Charter School Districts	Charter school districts are open-enrollment school districts chartered by the commissioner of education with final approval for operation provided by the State Board of Education.	183

Source: TEA (2017)

The TEA definition of rural is the one used in this dissertation because the data are from Texas schools and students and is the most applicable means for comparison based on the variables in the dataset, which are described in detail in Chapter III.

The Challenge of Funding in Rural Schools

Rural schools have been impacted by low institutional funding. Rural schools face significant economic challenges in terms of institutional funding (Johnson & Howley, 2015; Showalter et al., 2017). More than one quarter of public schools are rural, but only 17 percent of funding from state governments goes to rural schools (Showalter et al., 2017). Furthermore, rural schools are tasked with providing quality education to their students while dealing with challenges related to unfunded mandates and ever higher achievement standards (Howley & Howley, 2005; Lee & McIntire, 2000). Rural schools have experienced the same decline that their respective communities have in the past several decades (Harmon, 2001), with a key concern that cost per student for rural schools has been greater than that of larger nonrural schools (Sipple & Brent, 2008). In the context of Texas, which has the highest number of rural students in the U.S., average spending per student in rural schools was $5,204 in 2016, the thirteenth lowest in the nation (Showalter et al., 2017). Thus, rural southern schools, including those in Texas, have had to find ways to improve student achievement with few funds to do so. One way that rural school districts have been able to improve offerings and achievement is through technology. Changes in technology have enabled rural schools to provide students with seemingly endless educational opportunities (Harmon, 2001). Many rural schools have sought to improve cost effectiveness and their curricula by offering distance education courses through interactive television (Brent et al., 2004), as well as professional development for educators (Bell & Segura-Pirtle, 2012). This has been further improved by courses being offered through online conferencing portals such as Zoom. As broadband internet has expanded further into rural communities, both schools and their students have been able to connect reliably and at faster speeds across vast expanses of geography and culture (Harmon, 2001). Technology can empower rural school districts to improve the education of their students and, by extension, their students' achievement.

Unpacking Student Demographic Factors

Student Sex/Gender

Student sex/gender has been a topic of study and research in rural education research, though there has been no real consensus of the impact of sex/gender. In fact, on topics of identity and equity, Azano et al. (2022) acknowledge their regret of not including a specific chapter in their handbook on gender and sexuality. At minimum, there should be an unpacking of sex/gender issues and how it has been defined in previous work.

The demographic descriptors of gender and sex are often used interchangeably even though they are not synonyms. Sex has been previously defined as "the biological sex of the individual- whether a person is born physically female or male" (Caplan & Caplan, 2016, p. 6). This has historically been treated as dichotomous in nature, based on biology (though there are some contradictions to this strict definition; Caplan & Caplan, 2016). In contrast, gender has been defined as "the social role of being a woman or being a man" (Caplan & Caplan, 2016, p. 6). This definition is complicated by the fact that oftentimes the gender role of being female is treated as being a woman and the role of being male is treated as being a man (Caplan & Caplan, 2016). Such strict definitions and binary categorization have not only essentialized the lived experiences of real people, but it has also prevented the study of individuals not encompassed in the dominant binary paradigm (Johnson & Repta, 2012). These definitions and collection of data with the narrow binary scope leave researchers with very little choice on large-scale data but to follow the binary paradigm until the winds of the field shift, all of which is beyond the scope of this paper. For the purposes of this paper, we will use sex to classify students as either male or female, as is reported in data from TEA.

There is a prevalence of sex/gender stereotyping in mathematics education. Female students are typically less interested in pursuing mathematics-related fields for various reasons (Anaya et al., 2022; Assouline et al., 2021). Female students in rural schools have seen the importance of mathematics, yet they have not been interested in pursuing mathematics-related careers because of psychosocial factors, such as attribution and self-efficacy (Assouline, 2022; Cheema & Galluzzo, 2013). In a survey of opinions related to gender roles, college students rated caring about others above self as a female-dominant trait while rating competitiveness and leadership as male-dominant traits (Piatek-Jimenez et al., 2018). However, although traits associated with workplace success were seen as male dominant, traits associated with success in academics were gender neutral or somewhat female dominant (Piatek-Jimenez et al., 2018). In both the workplace and in academic settings, female students may be subjected to negative stereotypes related to mathematics.

This stereotyping may contribute to mathematics anxiety for female students, which leads to less participation in mathematics as a whole. Female students have been shown to have significantly higher levels of mathematics anxiety (Hill et al., 2016) and significantly lower confidence and interest (Ganley & Lubienski, 2016) than their male peers. As early as Grade 1, female students have been shown to possess significant implicit negative attitudes toward mathematics, while males did not (Cvencek et al., 2021). Furthermore, patterns of mathematics anxiety differences between the sexes have been shown to exist at the primary, elementary, and secondary levels of schooling (Hill et al., 2016). Other researchers have found the implications of early mathematics anxiety to be possibly more detrimental to mathematics-anxious female students than mathematics-anxious male students (Casanova et al., 2021). Another factor that has been studied with relation to gender/sex gaps in mathematics anxiety is mathematics achievement/performance.

Despite the consensus on gender/sex stereotypes and attitudes towards mathematics, there have been mixed results on whether a gender/sex gap exists in mathematics achievement. For instance, male students in Grades 3–8 have been shown to have higher levels of achievement than female students, with the gap between the sexes narrowing as students progress through grade levels (Ganley & Lubienski, 2016). Additionally, while students entered kindergarten with similar levels of mathematics ability, a gap in mathematics achievement appeared as early as first grade (Robinson & Lubienski, 2011). Conversely, there have been studies in which no significant difference existed between female and male students regarding mathematics achievement scores (Hill et al., 2016). There is a lack of consensus in the research literature as to whether a gender/sex gap in mathematics achievement exists, so consideration of other variables that might explain variation in mathematics achievement by gender/sex has utility.

The relationship between gender/sex and mathematics achievement may be linked through other variables. Though mathematics attitudes, affect, and performance have been shown to have only slight gender/sex effects, they should not be dismissed because of stereotypes of females performing more poorly than males in mathematics (Frost et al., 1994). Female students have been shown to have less confidence and interest in mathematics than their male colleagues, but by eighth grade, these gaps, along with that of achievement, narrow (Ganley & Lubienski, 2016). Thus, there was little basis for female students' lack of confidence in their mathematics skills. However, mathematics anxiety has been shown to contribute to Black and Latinx female students' mathematics achievement in long-term measures (Casanova et al., 2021). Previous researchers have found conflicting links between gender/sex and mathematics achievement, and thus additional research is needed regarding the relationship between mathematics anxiety and achievement among diverse groups of students across other demographic variables at different grade levels (Chang & Beilock, 2016). The same holds true for students in rural settings. Through this dissertation research I have sought to understand the degree to which gender/sex impact mathematics achievement in rural schools to hopefully spur additional research centered around those issues.

Race/Ethnicity

Race and ethnicity are two demographic characteristics that are often used interchangeably even though they represent two distinct concepts that need defining and careful review. Researchers need to be cautious in their use of language and intentional with their design, implementation, and evaluation of interventions related to racial and ethnic inequity in education (Gaias et al., 2020). Unfortunately, racial and ethnic data have been inconsistently reported for decades, despite calls for consistency and quality of reporting beginning as early as 1984 (Gaias et al., 2020). Furthermore, race and ethnicity as constructs for research have been used in ill-defined ways and are often treated as synonymous terms (Dein, 2006). As such, it is important to consider definitions for and the collecting of data regarding race and ethnicity.

The collection of data regarding race and ethnicity is contradictory at different levels of academia and government, as are definitions of these terms. Consider Slavin (2003), who defined race as "visible characteristics of individuals that cause them to be seen as members of the same broad group" (p. 109) and ethnicity as "a group within a larger society that sees itself as having a common history, social and cultural heritage, and traditions, often based on race, religion, language, or national identity" (p. 108). These definitions provide a somewhat conflicting position compared to how the U.S. government has operationalized the use of the terms and the collection of related data. For example, The USCB collects race and ethnicity data based on the 1997 OMB standards for race and ethnicity (USCB, 2020). Specifically, the USCB classifies responses to the census into five race categories, White, Black or African American, American Indian or Alaska Native, Asian, and Native Hawaiian or Other Pacific Islander, but allows self-identification reporting of more than one race (USCB, 2020). Finally, the USCB considers ethnicity to be dichotomous as being either Hispanic/Latino or not Hispanic/Latino (USCB, 2020). The USCB collection method is consistent with the requirements of the DOE and the NCES (NCES, 2009).

In Texas, the TEA follows requirements set by the DOE based on the OMB standards for collecting race and ethnicity data from schools. There are two questions that are presented in a specific order. The first asks the respondent about ethnicity and gives two choices: "Hispanic/Latino" and "not Hispanic/Latino." The second question is about race. The choices are the same as those asked by the USCB, and the question allows for selecting multiple races but is not open ended (i.e., it does not allow respondents to write in a response). Self-identification is also the practice of TEA questionnaires, but these allow observers to identify an individual's race/ethnicity if the individual declines or fails to choose for themselves (TEA, 2018a). This is in direct contradiction to the USCB (2020) requirement that respondents must provide a self-identified response and the policy that observers are not allowed to make identifications. These contradictions of definition and collection of data create problems for researchers.

There is a need in education research to collect race and ethnicity data in a more meaningful, consistent manner. Educational research can benefit from including more variables in studies to unpack racial and ethnic disparities from other demographic variables, such as SES, language, and gender (Gaias et al., 2020). Furthermore, the use of more self-selective measures of race and ethnicity, along with the interaction of those measures with other demographic descriptors, can help researchers unpack and attain a better understanding of racial and ethnic groups (Dein, 2006). A key to understanding the context of race and ethnicity in educational research is in knowing that there are some ways to address the inconsistency in collection and reporting strategies in the field and thereby improve them.

Though data regarding race and ethnicity are not perfect, there are still meaningful results and discussions to be had regarding the relationship between race and ethnicity and mathematics achievement. Achievement scores for students in ninth grade have been shown to vary slightly by race/ethnicity, but the gap widens for those students by eleventh grade (Kotok, 2017). When compared to White students, Asian students scored significantly higher and African American and Latino students scored significantly lower (Kotok, 2017). Similarly, in a study of a nationally representative sample of algebra students and their achievement, White students were found to have higher mean scores than Black and Hispanic students (Ayieko et al., 2016). Given previous results that indicated an impact of race or ethnicity on student achievement in mathematics, there is utility in understanding the degree to which race/ethnicity impact student algebra achievement in rural Texas schools.

Family Socioeconomic Status

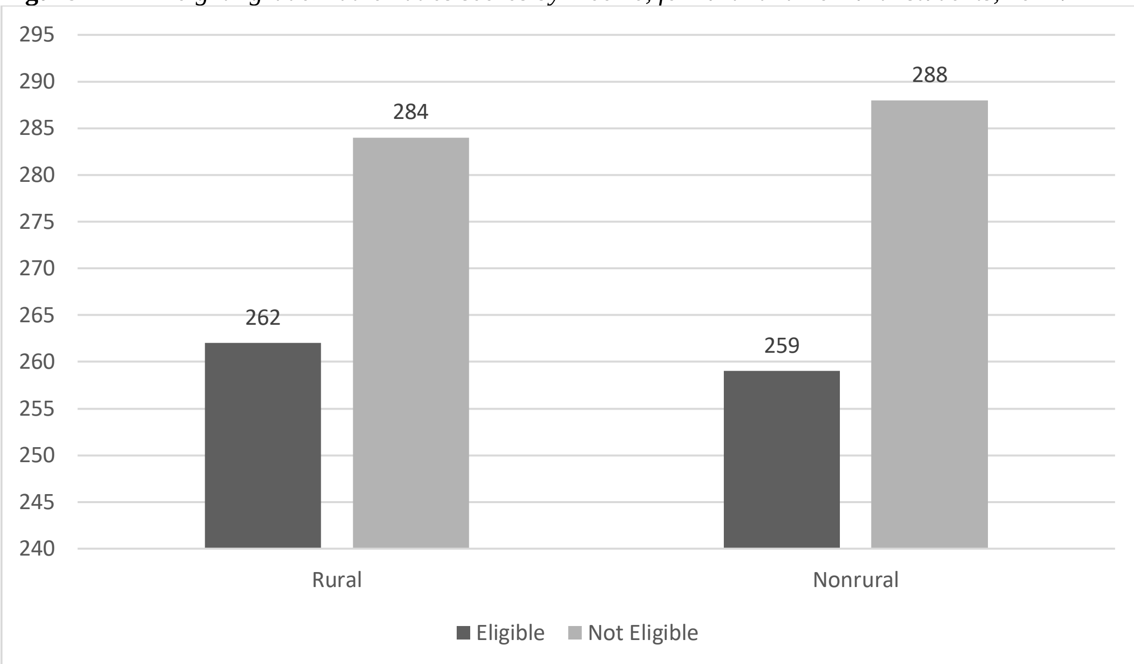
The impact of SES on rural students' mathematics achievement and schools in general depends upon the degree of disparity in SES. On one hand, students in rural schools with low family SES have been shown to outperform their nonrural counterparts with low family SES (Hopkins, 2005; Stewart, 2009). One possible reason for this was the degree of social capital in smaller communities that does not exist in larger communities (Hopkins, 2005). Moreover, the existence of a family atmosphere in rural schools contributed to their higher achievement (Stewart, 2009). Thus, rural schools have been able to promote academic success in ways that urban and suburban schools have not, particularly for low-SES students (Stewart, 2009). On the other hand, moderate-SES students performed poorer in rural areas than in urban and suburban areas (Hopkins, 2005). This could have been the case due to the cultural capital available to urban and suburban students. Student SES is a factor under consideration in this dissertation.

Predictors of Student Mathematics Achievement

Socioeconomic Status and Student Mathematics Achievement

There has been debate, research and national statistical evidence of achievement gaps in mathematics based on different levels of SES. These achievement gaps have been documented in several prior studies (Hanushek et al., 2020; Reardon, 2016). Several studies have documented that family SES was predictive of achievement scores in Michigan (Maylone, 2002), New Jersey (Tienken et al., 2017; Turnamian, 2012), and Massachusetts (Ardon, 2012; Caldwell, 2017). The National Assessment of Educational Progress (NAEP), given regularly by the NCES with the data published online give a viewpoint into how demographics can shape achievement (Gagnon, 2022). Student eligibility in the National School Lunch Program (NSLP) is a way to measure student SES (Gagnon, 2022). The categories used are eligible for free or reduced-price lunch (FRPL) (low SES) or not eligible (high SES). From a numerical standpoint, rural students who were eligible for FRPL fared slightly better in the 2022 administration of the NAEP than their nonrural counterparts (NCES, 2022a). This is consistent with the results found in previous studies on rural achievement and SES (Ardon, 2012; Hopkins, 2005; Stewart, 2009). Also, rural students who were eligible for FRPL fared slightly better than their nonrural peers (NCES, 2022a). In both rural and nonrural groups, there was a gap in mathematics achievement between eligible and noneligible students (NCES, 2022a). There were no data from Texas to make the same comparisons due to a lack of meeting reporting standards (NCES, 2022b). Visual representations of these data are presented in Figure 1. Student SES has been shown to be a significant predictor of student achievement in mathematics and the gaps that exist between rural and nonrural and low and high income have not been fully explained and unpacked by previous research.

Figure 1 *NAEP eighth grade mathematics scores by income, for rural and nonrural students, 2022.*

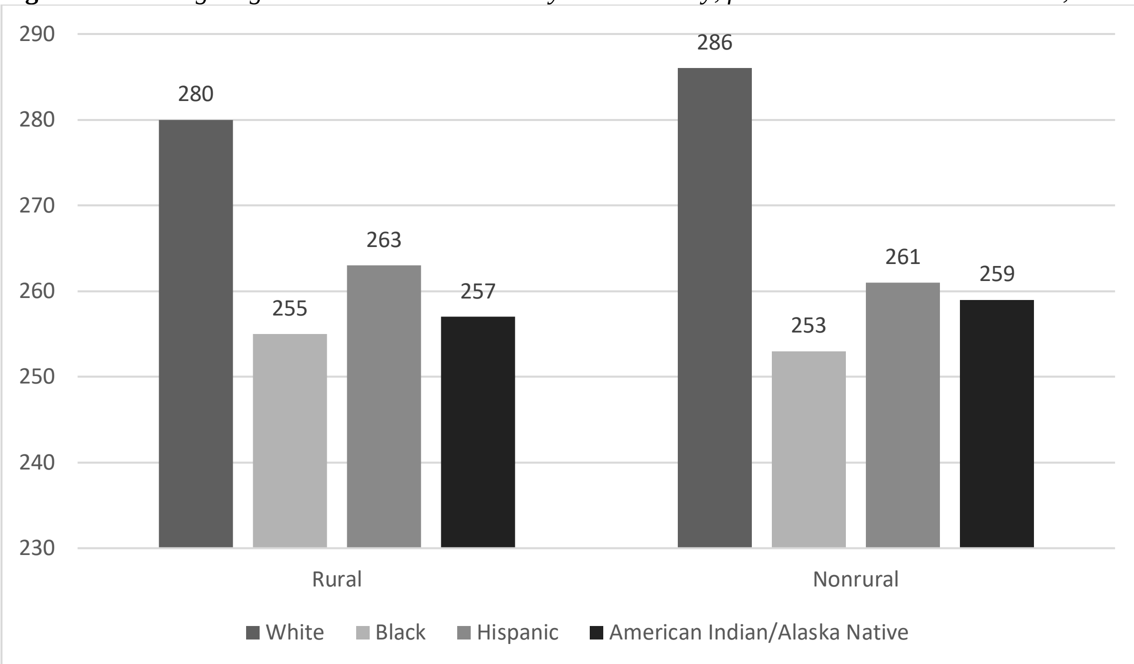


Source: NAEP Data Explorer (NCES, 2022b)

Race/Ethnicity and Student Mathematics Achievement

The existence of achievement gaps across race/ethnicity in rural areas has been explored in past research and in national assessments of student achievement. Based on the data collected with the 2022 NAEP, White students in both rural and nonrural settings had higher mathematics achievement than their Black, Hispanic, and American Indian/Alaska Native peers (NCES, 2022a). In all cases, the achievement gap between White and each of Black, Hispanic, and American Indian/Alaska Native, the mathematics achievement gaps were smaller in rural settings than in nonrural settings (NCES, 2022a). These data are consistent with results found in prior work by Gagnon and Mattingly (2018). Interestingly, Black and Hispanic students in rural areas achieved at slightly greater levels than their nonrural counterparts (NCES, 2022a). Visual representations of these data are presented in Figure 2. Student race/ethnicity has been shown to be a predictor of student mathematics achievement in prior research and national statistics from NAEP provided evidence that there are achievement gaps based on race/ethnicity in rural settings.

Figure 2 *NAEP eighth grade mathematics scores by race/ethnicity, for rural and nonrural students, 2022.*



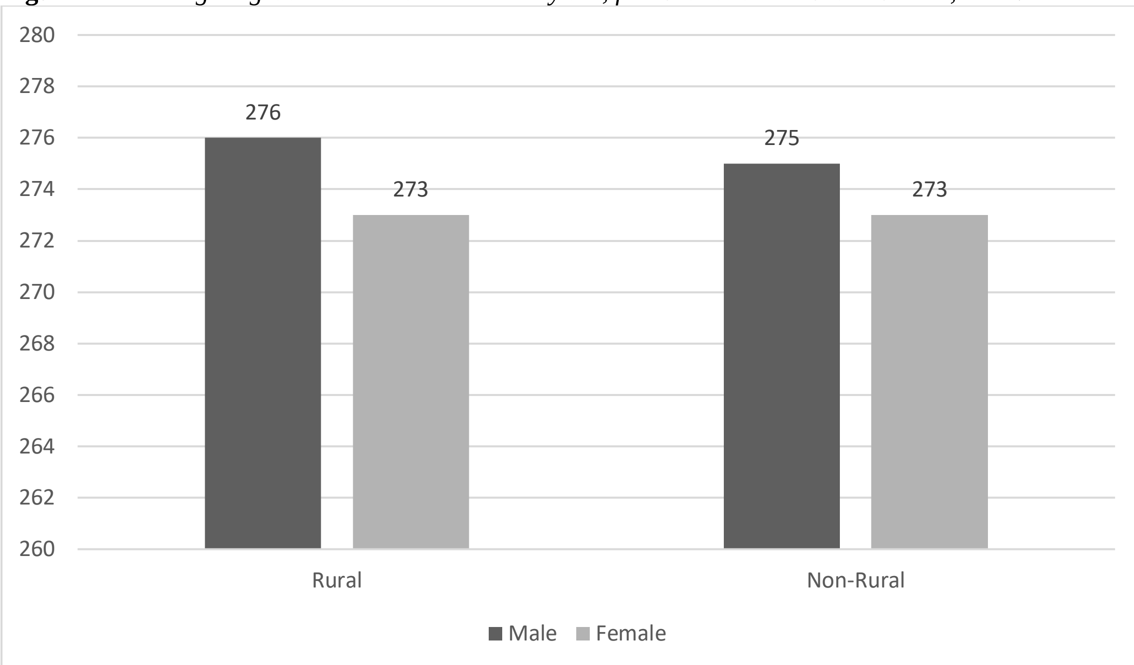
Source: NAEP Data Explorer (NCES, 2022b)

Student Gender/Sex and Student Mathematics Achievement

The area of gender/sex and rural student mathematics achievement has not been widely explored in the literature and further research is needed on this topic. In a chapter on rural student achievement, Gagnon (2022) explored several factors, including race/ethnicity, SES, and region, but did not include sex/gender. Interestingly, the editors of the volume in which Gagnon (2022) was a contributor alluded to the fact that sex/gender should have been included in the work (Azano et al., 2022). In one study of mathematics achievement in two distinct rural areas in the U.S., researchers found an association between mathematics achievement and gender (Ribner et al., 2017). Based on data from the 2022 administration of the NAEP, there was a slight advantage in mathematics achievement for males in rural schools compared to their female counterparts (NCES, 2022a). Males in rural schools also scored one point higher than their non-rural counterparts (NCES, 2022a). Female students scored numerically the same on average in both rural and non-rural settings (NCES, 2022a). Visual representations of these data are presented in Figure 3.

The relationship between gender/sex and rural student mathematics achievement needs to be explored considering the lack of consensus on a mathematics achievement gap due to gender/sex generally, the existence of little research on the topic, and the inconclusive nature of the 2022 NAEP results as related to gender/sex.

Figure 3 *NAEP eighth grade mathematics scores by sex, for rural and nonrural students, 2022.*



Source: NAEP Data Explorer (NCES, 2022b)

District Expenditure Per Student and Student Achievement

There has been some research on per student spending and student achievement, though less has been done specifically addressing mathematics achievement and little in the last decade. One reason for the lack of research on the topic of per student spending is due to a lack of adequate data to separate per student spending on personnel versus other instructional materials (Condron & Roscigno, 2003). There has also been disagreement about whether a relationship even exists between school spending and achievement gaps (Biddle & Berliner, 2002). These researchers (Biddle & Berliner, 2002) have suggested that other studies of academic achievement in which funding/spending differences were not influential have bias to using some other explanation for differences in achievement between wealthy and poor school districts. Hanushek (1997) indicated in a prior study that school funding and spending was not related to student achievement. Moreover, Hanushek (1997) asserted that studies with contrary results were likely due to methodological reasons. Hanushek and Woessmann (2017) stated that "the international evidence provides little confidence that quantitative measures of expenditure… are a major driver of student achievement, across and within countries." (p. 149). In the same study, Hanushek and Woessmann (2017) found that per student spending and locality were significantly related to student mathematics achievement. While some prior studies have found no link between per student spending and academic achievement (Stringfellow, 2007), other researchers have also found that per student spending significantly impacted academic achievement (Biddle & Berliner, 2002; Izbicki, 2003). There is a lack of consensus on the relationship between per student spending and student achievement as well as a lack of recent research on the topic, particularly for mathematics achievement and in rural schools.

State and Federal Education Policy Matters

Federal Public Policy: The Every Student Succeeds Act

Public schools across the U.S. are subject to regulation in the *Every Student Succeeds Act* (ESSA) by the federal government and the DOE. The ESSA was signed into law by President Barack Obama in December 2015 and included new requirements for schools and state education agencies across the U.S. (DOE, n.d.). Among those requirements was that states must differentiate between high- and low-quality schools based upon student achievement on standardized tests, graduation rates, student progress, and one or more additional variables chosen by the individual state (Weiss & McGuinn, 2017). The ESSA allowed states to develop their own framework for accountability systems, so long as the system had clear delineation of school quality (Martin, 2016) and was transparent and clearly articulated both from a comprehensibility and computational perspective (Martin et al., 2016; Weiss & McGuinn, 2017). While the intention of the ESSA was to allow innovation in school accountability systems across states, the reality of its implementation led to many states including Texas choosing an A-F accountability system based upon a single grade for schools.

Texas Public Policy

In Texas, public policy in public education is based on a shared governance model between the state education agency, the TEA and local education agencies (LEAs). The Texas Education Code (TEC) delineates what powers are granted by statute and who those powers are granted to. Two areas of public policy in Texas are the high-stakes assessments used to measure student performance and growth, the State of Texas Assessments of Academic Readiness (STAAR) and the accountability system in which schools and school districts are measured based on their students' performance, the A-F accountability system. Both STAAR and the A-F accountability system are explored in depth in this dissertation.

High Stakes Testing in Texas: STAAR

The State of Texas' public schools have administered high-stakes testing known as the State of Texas Assessments of Academic Readiness since 2012, with a history of standardized assessment going back to 1979. The 66th Texas Legislature was the first to require a basic skills test for mathematics in 1979, with the Texas Assessment of Basic Skills being administered for the first time in 1980 (TEA, n.d.). Subsequently, there have been numerous names and formulations of state assessments in Texas, the most recent and current being the STAAR tests implemented since 2012 (TEA, n.d.). In each grade level from 3–8, students take a mathematics STAAR test (TEA, n.d.). When STAAR was first implemented, there were STAAR end of course (EOC) assessments in Algebra I, Geometry, and Algebra II (TEA, n.d.). The 83rd Texas Legislature changed graduation requirements for Texas students with House Bill 5, reducing the total number of STAAR EOC assessments from 15 to five and the number of STAAR EOCs in mathematics from three to one: Algebra I (TEA, n.d.). Generally, students in Texas are required to take STAAR tests and EOCs to gauge their individual's learning and provide a means for holding Texas public schools accountable for that learning.

Texas School Accountability Ratings

Schools in Texas receive accountability ratings each academic year based on criteria in several categories. The current accountability rating system, called the A-F accountability system was passed as House Bill 22 in the 85th regular session of the Texas Legislature (TEA, 2022a). The A-F accountability system measures schools in three domains: student achievement, school progress, and closing the gaps (TEA, 2022b). Within all three domains, student achievement is a key focus area, with schools being measured by how much students improve and by how well schools can close achievement gaps over time (TEA, 2022b). Schools are judged in the aggregate with an A-F letter grade, a scale score, and domain specific scores.

Each school and district in Texas is given a rating based on its performance in the three domains, which are computed using domain specific weights. Schools are scored in all domains based on all their students, but in the closing the gaps domain, they are also scored based on disaggregated data in demographic areas where gaps exist (TEA, 2022b). The final accountability score for a school is based on the following weights: the higher of student achievement and school progress (70 percent) and closing the gaps (30 percent) (TEA, 2022c). The three domain scores have subdomains that determine how the domain score is reached.

Each of the three domain scores is computed based upon the type of school: elementary, middle, high, K-12, and district. For elementary and middle schools, 100 percent of both the student achievement and closing the gaps domains are determined by the school's STAAR results (TEA, 2022b). For high schools and campuses that contain K–12 on a single campus, the student achievement domain is weighted based on STAAR performance (40 percent), college career and military readiness (CCMR, 40 percent), and graduation rate (20 percent) (TEA, 2022d). The school progress domain for all schools is determined by the higher of academic growth and relative performance (TEA, 2022b). The closing the gaps domain for high schools, K–12s, and school districts is weighted based on academic achievement in mathematics and reading (50 percent), federal graduation rate (10 percent), English language proficiency (10 percent), and school quality (30 percent) (TEA, 2022b, 2022e). Schools and districts are judged based on their performance on student measures and outcomes, with particular emphasis on students' scores on the STAAR test.

The Texas A-F accountability system is the law in Texas education, carrying with it a seemingly easy-to-understand single grade for schools, but it is not without critics. By the time House Bill 22 passed and was signed into law by Texas Governor Greg Abbott in 2017, 16 other states had A-F systems (Tanner, 2016). While proponents of A-F argue that such ratings help the public understand school performance, Tanner (2016) noted that the derivation of the grade requires a great deal of explanation. Other critics have noted that the letter grade is an amalgamation of disparate components (Murray & Howe, 2017). While a single grade for school quality is meant to improve schools by having them compete and improve the quality of education in theory (Tanner, 2016). By pressuring school districts with the threat of sanctions (Adams et al., 2016) to reach for the "A" grade, the practical ramifications are that A-F systems have been shown to be highly correlated with poverty (Ableidinger, 2015) and biased towards poor and minority students (Adams et al., 2016; Tanner, 2016). A-F accountability systems like the one in Texas can significantly impact schools and policy decisions both at the campus, district, and state levels are made using these data, most of which are based upon student achievement on the STAAR test.

Theoretical Framework

Ecological Systems Theory

Ecological systems theory (EST) is built on the idea that individuals are embedded in an environment with overlapping social systems, which include not only the physical environment or place, but also various cultural, historical, and other social aspects. A similar theory (general systems theory) was first used to describe interdependent systems in biology by von Bertalanffy and was later adapted by Bronfenbrenner to describe both an individual's interdependence with others as well as the broader system interdependency (Bronfenbrenner, 1977, 1995; Farmer et al., 2022; Robbins, et al., 1998). The five systems described by Bronfenbrenner (1977, 1995) are:

(1) Microsystem, which includes the factors/influences that will be most direct, including family, peers, teachers, school, neighbors, and community.

(2) Mesosystem, which includes the interaction of factors in the microsystem, including relationships between any combination of family, peers, teachers, school, neighbors, and community.

(3) Exosystem, which involves factors within the individual's life that they do not have control of, such as government agencies or extended family.

(4) Macrosystem, which includes factors related to culture, such as SES, poverty, and race.

and

(5) Chronosystem, which includes factors related to environmental changes over the course of time, such as change in family status, puberty, or moving schools.

Systems consist of individuals, groups, and other entities and structures that influence or are influenced by an individual in the setting (Farmer et al., 2022). Ecological systems theory in the context of rural education could include factors including students, their families, teachers, peers, school administrators, as well as other societal factors such as SES, race, gender, school economics, high-stakes testing set forth by federal and state governments, among others.

CHAPTER III

METHODOLOGY

An ex post facto design (Silva, 2010) was used in the present study involving students' Algebra I achievement scores in Texas schools. An ex post facto design involves analyzing extant data in situations where performing experimental studies would be impractical or impossible (Silva, 2010). Furthermore, the ex post facto design is useful for examining relationships among variables in instances where researchers do not interfere with the data collection environment, such as for large samples or populations. The data were obtained by the authors from the TEA. The data were the a) scores from the April 2016 administration of the STAAR, which included student demographic variables, and b) 2015–2016 financial data regarding per student spending for school districts from TEA.

Participants

The participants in the study were all students who took the Algebra I STAAR test in April 2016 (N = 435,547). There was a total of 1,207 school districts in Texas during the 2015–2016 academic year (TEA, 2017a). Of those 1,207 districts, 459 districts were identified as rural, which were defined as having either "an enrollment of between 300 and the median district enrollment for the state and an enrollment growth rate over the past five years of less than 20 percent" or "an enrollment of less than 300 students" (TEA, 2017a, para. 8). The remaining 748 districts were identified as nonrural. There was a total of 14,609 students who took the April 2016 Algebra I STAAR test from 421 rural school districts (the remaining 38 districts did not have students in the dataset). Of those 14,609 students, there were a total of 1,090 students who took the April 2016 Algebra I STAAR test from 153 rural school districts whose data were not masked. In other words, only 7.46 percent of students in rural schools who took the test had results that were included in this study. Masking is applied to districts where student enrollment in a variable of interest, if provided, could be linked back to specific students.

The Texas Education Agency has specific procedures for masking student data. The TEA defines masking as the concealment of data using special symbols to protect student confidentiality (TEA, 2016). The TEA performs masking of data to comply with the Family Education Rights and Privacy Act (FERPA) (TEA, 2016). The masking is done to prevent either direct identification of an individual student or indirect identification of a student through imputation (TEA, 2016). There are specific cases in which an individual might be identified. One case is that with small numbers of students in a particular group, it may be possible to identify a student or students (TEA, 2016). The other main case is that in which all students in a particular group achieve the same result (TEA, 2016). In the second case, even if the student's result is a positive result, sharing the information would be a violation of their FERPA rights (TEA, 2016). When considering specific outcome measures, if the total number of students in a particular demographic group in a district or school is less than five (including zero), then an asterisk is used to mask the actual value of the measurement, the number of students in the group with that value, and the total number of students in the group (TEA, 2016). If the measurement is the same for all individuals in a group, then an asterisk is used to mask the actual value of the measurement, the number of students in the group with that value, and the total number of students in the group (TEA, 2016). If the outcome measure for a subset of students in a group is the same and the is different from the total number of students in the overall group by less than three, then only aggregate percentages may be reported, masking with an asterisk the number in the subset and the total number in the group (TEA, 2016). If the outcome measure for a subset of students in a group is the same and totals less than five, then only aggregate percentages may be reported, masking with an asterisk the number in the subset and the total number in the group (TEA, 2016). These rules apply to all indicators from TEA, including race/ethnicity, sex, economically-disadvantaged status, special education status, etc. (TEA, 2016). There are additional masking rules that apply to special populations, but those would not be applied in the dataset used in this dissertation because the STAAR Alternate versions of the EOC are in different datasets. Masking of student data both in the individual and the aggregate cases impacts the data that can be analyzed when small groups are present in schools, which is particularly likely in rural schools in which low student enrollment is a criterion for meeting the definition of rural.

Demographics for the 1,090 selected rural students, including SES, race, and sex, are displayed in Table **III-1**.

There were four predictor variables under consideration in this dissertation study and their level of measurement is as follows: student socioeconomic status (SES); dichotomous categorical, race; categorical, sex; dichotomous categorical, and per student spending; continuous. These predictor variables were used to predict student achievement on the Algebra I STAAR EOC, with scale scores from that assessment being continuous.

Table III-1 *Rural Student Demographic Crosstabulation*

Sex		Economic Disadvantage: Not Economically Disadvantaged	Economic Disadvantage: Eligible for Free Meals	Economic Disadvantage: Eligible for Reduced Price Meals	Economic Disadvantage: Other Disadvantage	Total
Female	Black	1	24	0	1	26
	Hispanic	25	128	0	8	161
	Two or More Races	0	1	0	0	1
	White	324	56	1	2	383
	Total	350	209	1	11	571
Male	Black	0	22	0	0	22
	Hispanic	25	78	0	14	117
	Two or More Races	0	1	0	0	1
	White	298	61	1	19	379
	Total	323	162	1	33	519
Total	Black	1	46	0	1	48
	Hispanic	50	206	0	22	278
	Two or More Races	0	2	0	0	2
	White	622	117	2	21	762
	Total	673	371	2	44	1090

Instrumentation

The STAAR Algebra I test is a high-stakes assessment that is a requirement for completion of Algebra I in the state of Texas. The test assesses students' proficiency in topics related to Texas Essential Knowledge and Skills standards for Algebra I. The main administration of the assessment used in the current study occurred in the spring semester of 2016. The April 2016 administration of the test consisted of a total of 51 multiple-choice questions and three numerical answer questions.

The first time a student takes the test is typically in Grade 8 or Grade 9. Students' scores were categorized into one of four performance levels as defined by TEA (2017b). Of the four performance levels, three are considered passing and one is considered failing. The failing performance level is "did not meet grade level," which states that students so categorized "do not demonstrate a sufficient understanding of the assessed knowledge and skills" (TEA, 2017b, para. 4). Students who do not meet grade level expectations would be unlikely to be successful in subsequent coursework without significant intervention (TEA, 2017b). The lowest passing category is the "approaches grade level" performance level, which applies to those students who "generally demonstrate the ability to apply the assessed knowledge and skills in familiar contexts" and would be able to succeed in subsequent coursework with some targeted intervention (TEA, 2017b, para. 3). The next passing category is the "meets grade level" performance level, which states that students who meet grade level expectations "generally demonstrate the ability to think critically and apply the assessed knowledge and skills in familiar contexts" and will succeed in subsequent coursework with limited intervention. (TEA, 2017b, para. 2). The highest passing category is the "masters grade level," which is defined as students that "demonstrate the ability to think critically and apply the assessed knowledge and skills in varied contexts, both familiar and unfamiliar" and will be successful in subsequent coursework with "little or no intervention" (TEA, 2017b, para. 1). Students who fall into the "did not meet grade level" performance level must retake the STAAR Algebra I test, leading to students who have taken the test multiple times in the various administrations (TEA, 2018b, para. 2).

Effect Size Estimates

Effect size is a standardized way of comparing across groups. The effect size of various levels of factors on rural algebra achievement in Algebra I is the reason for its use in the present study. The researcher chose Cohen's *d* as the effect size measure for the current study. Cohen's *d* is versatile for comparing between groups and studies and has a straightforward interpretation (Capraro, 2004; Lakens, 2013). Cohen's *d* is computed by taking the difference of the group means (from each of the comparisons considered) and then dividing by the pooled standard deviation. This standardized value is then able to be interpreted in terms of standard deviations away from the population mean (Patten & Newhart, 2018). Effect size has utility both as a separate construct and in combination with inferential statistics and is reported in this dissertation for each hypothesis.

Statistical Analysis

For this dissertation, I tested 8 hypotheses regarding algebra achievement in Texas schools. Each hypothesis was tested with an appropriate statistical method, which are summarized in Table **III-2**.

Assumptions for each model were also checked and are included in the results section. A description of the analyses to be performed for each of the hypotheses is detailed in the remainder of this chapter.

Table III-2 *Hypotheses and Analysis Used*

Hypothesis	Type of Statistical Analysis
H_1: If students attend rural schools in Texas, then Algebra achievement will be different for those students than their non-rural counterparts.	Student's t test
H_{2a}: If per student spending on instruction in rural Texas schools is changed, then Algebra achievement will also change.	Simple Linear Regression
H_{2b}: If when adjusting for race, SES, and gender, per student spending on instruction in rural Texas schools is changed, then Algebra achievement will also change.	Multiple Linear Regression
H_3: If student SES is low, then Algebra achievement will be different than students with high SES in rural Texas schools.	Student's t test
H_4: If a student attending a rural school is female, then their Algebra achievement will be different than their male counterparts.	Student's t test
H_5: If a student attending a rural school is White, then their Algebra achievement will be different than their Black and Hispanic counterparts.	Linear Contrast in Analysis of Variance (ANOVA)
H_6: Disaggregating by locality, if per student spending is changed, then there will be a different effect on Algebra achievement in rural schools than in nonrural schools.	Multiple Linear Regression with Interaction Term
H_7: Disaggregating by student SES level, if per student spending is changed, then there will be a different effect on Algebra achievement for economically disadvantaged students than those without economic disadvantage.	Multiple Linear Regression with Interaction Term

Compiling the Dataset

The base dataset from TEA contained student demographic data, raw scores, scale scores, and individual item scores from the 2016 STAAR Algebra I EOC. I created a Microsoft Excel macro to retrieve district expenditure data from all the school districts in Texas defined as rural. Each school district in Texas can be identified by a six-digit number known as a county/district number (CDN), which is based on the state's county numbering system for the 254 counties in Texas and the number of districts within a given county. The macro then extracted per student spending on instruction for the districts and compiled it into a separate spreadsheet using the XLOOKUP function in Microsoft Excel to match a district's CDN to its respective per student spending. To combine the two datasets, I used the CDN of each student and the XLOOKUP function in Microsoft Excel to match the per student spending amount from the spreadsheet created by the macro. I also created a dichotomous rural/nonrural variable using a filter based on district CDNs and TEA's definition of rural. These data were analyzed to test the hypotheses using statistical methods as follows.

Hypothesis 1

Hypothesis 1 was designed for testing whether there was a difference between the mean dependent variable for Algebra achievement based on locality. In other words, do rural students achieve at different levels than their nonrural counterparts? All of the other hypotheses are trivial if there is no such mean difference, as it would make just as much sense to consider the variables in the context of the entire sample, not just the rural data frame. A common way to analyze this sort of mean difference is using the student's *t*-test, accounting for the assumptions of the test. The analysis for Hypothesis 1 was conducted using IBM SPSS version 25 (SPSS).

Hypotheses 2a and 2b

Hypotheses 2a and 2b are both related to the effect of per student spending on rural Algebra achievement, both by itself and when accounting for other demographic factors. In the case of Hypothesis 2a, simple linear regression was used to assess if a linear relationship exists between achievement and per student spending and if so, to what was the rate of change between the two. In this case, algebra achievement was aggregated using the mean score at the district level. The analysis for Hypothesis 2a was conducted using SPSS. In the case of Hypothesis 2b, multiple linear regression was used to assess whether per student spending significantly impacts student achievement when adjusting for race, SES, and gender. Multiple regression is typically used to help develop a prediction model. However, multiple regression is in the general linear model and can be used to subsume all tests preceding it in the general linear model. I used multiple regression analysis not only to test for significance, but also to find the degree to which the selected factors impact the variance of students' algebra achievement in rural schools without inflating Type I error. The model was computed using SPSS. Structure coefficients were computed using SPSS as well. Structure coefficients have been used to help understand the variance contributed to the model (Thompson, 2006). Although the variance contribution is not mutually exclusive for all the variables, it can help to make decisions about the relative importance of any one variable to the model, though it should not be used to argue that any one variable is more important than another. The researchers chose multiple regression analysis for its robustness to departure from some of its assumptions. I also checked the assumptions for the respective regression models in the hypotheses and checked for evidence of multicollinearity in the multiple regression model in Hypothesis 2b.

Hypothesis 3

Hypothesis 3 was related to the relationship between student achievement and student SES. For the purposes of this dissertation, student SES is "low" if the student received FRPL and "high" if the student did not receive FRPL. Similar in structure to the analysis in Hypothesis 1, a student's *t*-test was conducted to test for differences in mean achievement, accounting for model assumptions. The analysis for Hypothesis 3 was conducted using SPSS.

Hypothesis 4

Hypothesis 4 was related to the relationship between student achievement and student sex/gender. Similar in structure to the analyses in Hypotheses 1 and 3, a student's *t*-test was conducted to test for differences in mean achievement, accounting for model assumptions. The analysis for Hypothesis 4 was conducted using SPSS.

Hypothesis 5

Hypothesis 5 was related to the relationship between student achievement and race/ethnicity. In this case, I used linear contrast in analysis of variance (ANOVA) because there are multiple groups being compared to determine if group achievement means for Black and Hispanic students are different than White students. The null hypothesis in this case is:

$$H_0: \mu_1 = \frac{\mu_2 + \mu_3}{2},$$

where μ_1 , μ_2 , and μ_3 are the population achievement means for White, Black, and Hispanic students, respectively. The analysis for hypothesis 5 was conducted in SAS JMP 15.

Hypothesis 6

Hypothesis 6 was related to the impact of per student spending when accounting for locality. This was tested using a multiple regression model including an interaction term between per student spending and locality of the form:

$$Y = a_0 + a_1X_1 + a_2X_2 + a_3(X_1X_2),$$

Where Y is achievement, X_1 is locality, X_2 is per student spending, and X_1X_2 is the interaction term between locality and per student spending. The analysis for Hypothesis 6 was conducted in SPSS.

Hypothesis 7

Hypothesis 7 was related to comparing achievement means based on per student achievement when accounting for student SES. This was tested using a multiple regression model including an interaction term between per student spending and SES of the form:

$$Y = a_0 + a_1X_1 + a_2X_2 + a_3(X_1X_2),$$

Where Y is achievement, X_1 is SES, X_2 is per student spending, and X_1X_2 is the interaction term between SES and per student spending. The analysis for Hypothesis 7 was conducted in SPSS.

CHAPTER IV

RESULTS

Hypotheses

Hypothesis 1

Prior to conducting the student's *t*-test, I checked the histograms of the distributions of achievement scores in the rural and nonrural groups for normality. The histograms of the distributions are presented in Figure 4 and Figure 5, respectively. Both distributions appear to be sufficiently normal for conducting a *t*-test. One thing that was uncovered in reviewing the histograms is the presence of many zero scores in both groups. I subsequently created a dichotomous variable with "0" being an actual zero score and "1" being any other score. I conducted a regression analysis with this variable as the dependent variable and the predictors in the remaining hypotheses and in each case (rural and nonrural), gender, race, SES, and per student spending were all significant predictors of whether a student scored a zero or scored above zero.

Figure 4 *Histogram of the Distribution of Student Achievement Scores in the Nonrural Group*

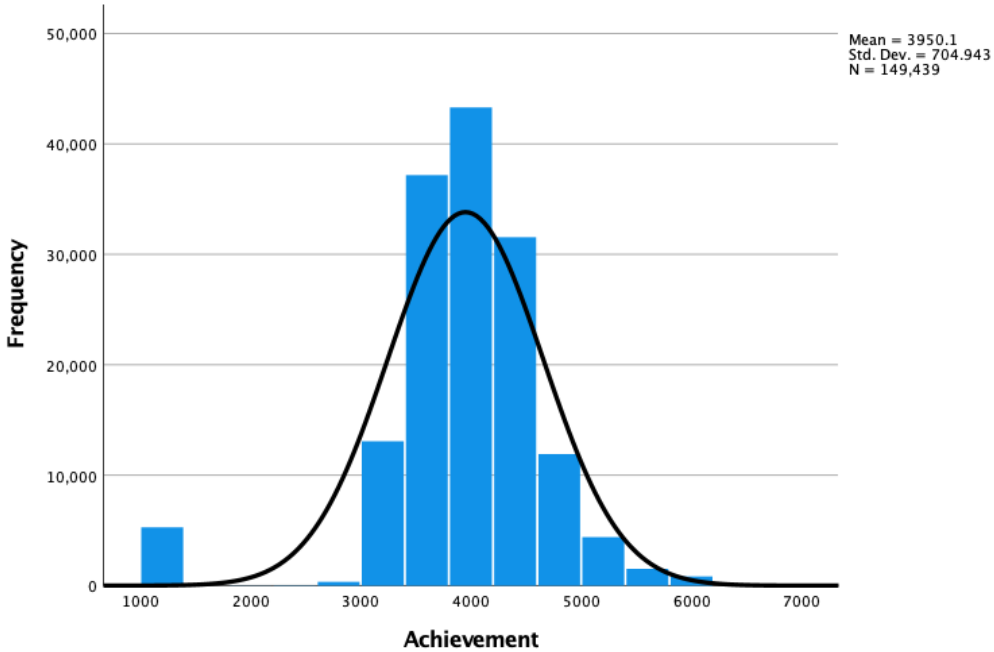
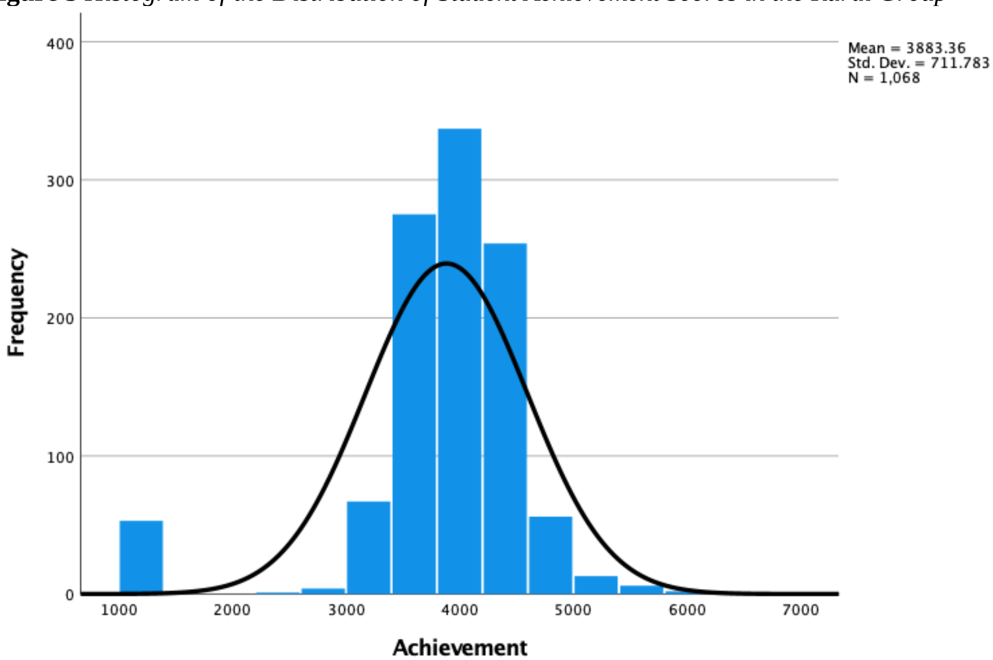


Figure 5 *Histogram of the Distribution of Student Achievement Scores in the Rural Group*



I conducted a *t*-test to test *Hypothesis 1*. The mean difference between rural and nonrural achievement was 66.738. The 95 percent confidence interval (*CI*) for the mean difference was (24.306,109.170). The test statistic for the *t*-test was t=3.083 with $df=150505$. The *p*-value for the two-sided *t*-test was p=.002. The calculated Cohen's *d* effect size was d=.095 with a *CI* for *d* of (.034,.155). This is a significant effect because the *CI* does not capture zero. These statistics and others are presented in Table IV-1.

Based upon the statistical analysis for *Hypothesis 1*, there was a significant difference between rural and nonrural students' achievement. **Nonrural students scored significantly higher on the Algebra I EOC than their rural counterparts with the mean difference of 66.738. Moreover, the true difference in the mean scores of the groups is likely to be between 24.306 and 109.170 with a confidence of 95 percent. Finally, the Cohen's *d* effect size of *d*=.095 with a *CI*=(.034,.155) means that nonrural students scored on average roughly 0.1 standard deviations higher than their rural counterparts.**

Table IV-1 *Differences in Student Achievement Based on Locality*

	Rural		Nonrural					
	M	*SD*	*M*	*SD*	*df*	*t*	*p*	Cohen's *d*
Student Achievement	3883.36	711.783	3950.10	704.943	150505	3.083	.002	.095

Hypothesis 2a

The purpose of Hypothesis 2a was to determine if there was a linear relationship between per student spending and student achievement in rural schools in Texas. Prior to conducting simple linear regression between the two variables, I examined a scatterplot, which is presented as Figure 6. I proceeded to conduct a simple linear regression and found that per student spending was not a significant predictor of student achievement and the coefficient from the regression model was $\beta = .052$. Further, I computed the correlation between the two variables and the correlation was not significant and the point estimate for the correlation coefficient was $r = .052$. The regression analysis output is presented in Table **IV-2**. In summary, the relationship between mean student achievement by district and per student spending in rural Texas schools is not linear and not significant when considered without any other predictors. In other words, spending more per student in a rural school does not necessarily result in improved achievement and there must be other variables that help explain variation in student achievement.

While I had initially hypothesized that the relationship between achievement and per student spending would be linear, at first glance of the scatterplot, a linear relationship seems unlikely at best. I proceeded to conduct a simple linear regression and found that per student spending was not a significant predictor of student achievement and the coefficient from the regression model was β =.052. Further, I computed the correlation between the two variables and the correlation was not significant and the point estimate for the correlation coefficient was *r*=.052. The regression analysis output is presented in Table **IV-2**. In summary, the relationship between mean student achievement by district and per student spending in rural Texas schools is not linear and not significant when considered without any other predictors. In other words,

spending more per student in a rural school does not necessarily result in improved achievement and there must be other variables that help explain variation in student achievement.

Figure 6 Scatterplot of Per Student Spending and Mean Achievement by District in the Rural Group

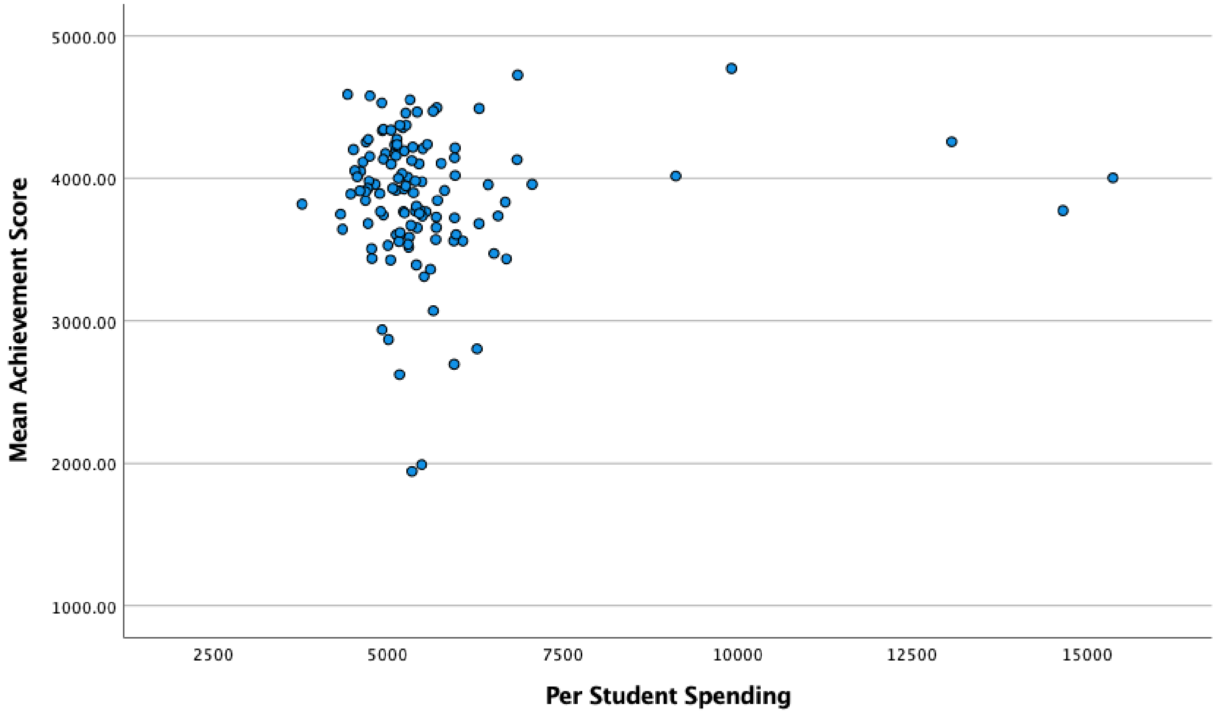


Table IV-2 *Simple Linear Regression Coefficients of Per Student Spending on Student Achievement*

Variable	B	β	SE	p
Constant	3786.443		156.487	<.001
Per Student Spending	.015	.052	.027	.571

Hypothesis 2b

There were four predictor variables considered in the regression model for *Hypothesis 2b*: sex, per student spending, race/ethnicity, and SES. The multiple regression weights, structure coefficients, and *p* values from the regression model are presented in Table IV-3. **For the model, only sex and SES were significant predictors of Algebra I achievement at the $p = .05$ level. The adjusted R^2 value for the model was .125, meaning that the model accounted for 12.5 percent of the overall variance in Algebra I achievement scores. When considered individually, race/ethnicity accounted for 41.7 percent of that portion of the overall variance, and SES accounted for 96.6 percent.** Clearly, there is overlap in the variance explained by race/ethnicity and economic disadvantage, as the two summed to greater than 100 percent. The other significant predictor in the model, sex, accounted for only 1 percent of the variation in achievement as explained by the model. Although the overall amount of variance in achievement scores explained by this model is low, that does not make it without meaning. **Another key result is that when holding all other variables constant, for a change of one unit in SES (from no FRPL to FRPL), on average the decrease in score is nearly 500 points. The 95 percent *CI* for this point estimate of the slope is (391.010, 606.901).**

Table IV-3 *Multiple Regression Weights, Structure Coefficients, and p Values from Regression Model*

Predictor	**B**	**β**	r_s	r^2_s	***p* value**
Sex	88.043	.062	.106	.011	.036
Per Student Spending	.012	0.040	.038	.002	.571
Race/Ethnicity	-30.529	0.210	.646	.417	.329
SES	-498.955	-0.070	.983	.966	<.001
R^2	.129		R^2_{adj}	.125	

In addition to the presented model with all the predictor variables, I also explored using the various combinations of predictor variables in regression models for both the rural and nonrural subsets of the data. Due to the large sample sizes, all the variables were statistically significant in all of the models in which they appeared in the nonrural subset. **Of the 15 iterations of regression conducted with the rural subset, per student spending was not a statistically significant predictor of achievement in any of the eight models in which it appeared. On the other hand, SES was a statistically significant predictor of student achievement at the *p*=.001 level in each of the eight models in which it appeared.** Race and Sex were both statistically significant in four of the eight models in which they appeared. **Interestingly, Sex was only statistically significant in models in which it appeared with SES.**

Hypothesis 3

Prior to conducting the student's *t*-test, I checked the histograms of the distributions of achievement scores in the FRPL and non-FRPL groups in the rural subset for normality. The histograms of the distributions are presented in, Figure 7 and Figure 8, respectively. Both distributions appear to be sufficiently normal for conducting a *t*-test given their relatively large sample sizes. As in *Hypothesis 1*, the zero score values were considered along with the rest of the scores in the analysis.

Figure 7 *Histogram of the Distribution of Student Achievement Scores in the Rural FRPL Subgroup*

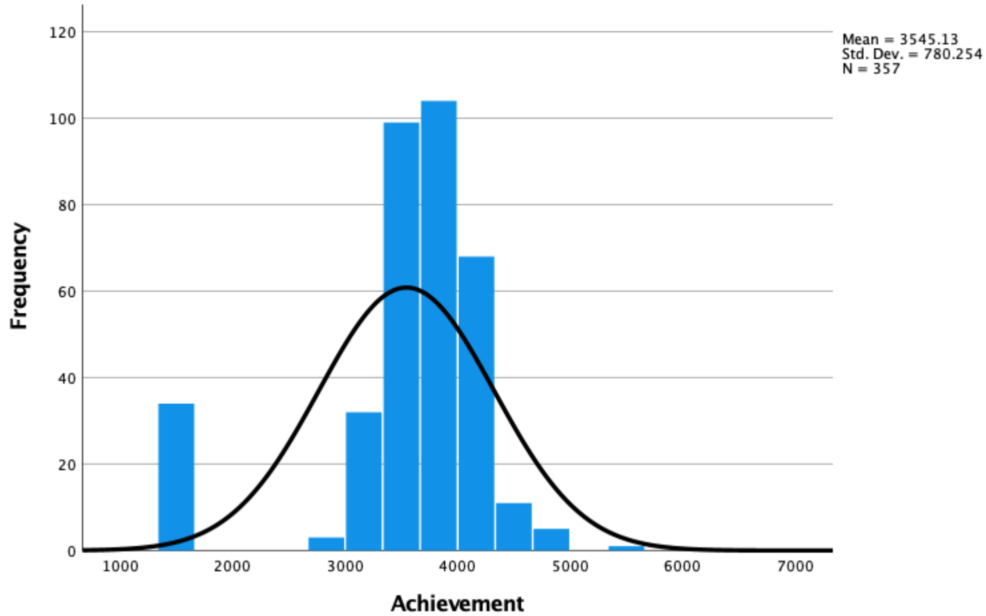
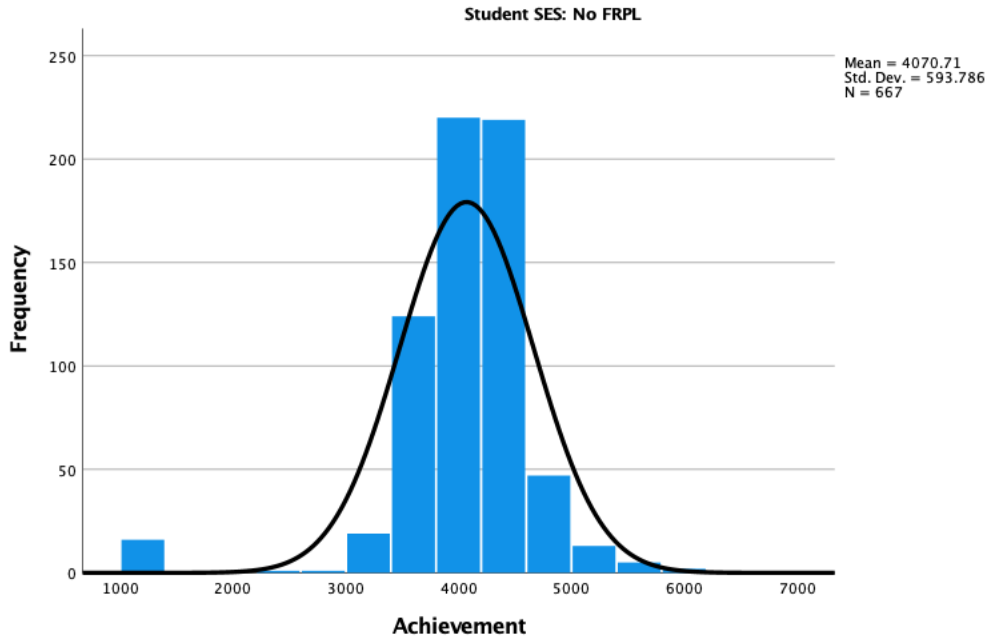


Figure 8 *Histogram of the Distribution of Student Achievement Scores in the Rural non-FRPL Subgroup*



I conducted a *t*-test to test *Hypothesis 3*. The mean difference between rural FRPL and non-FRPL achievement was 525.579. The 95 percent confidence interval (*CI*) for the mean difference was (432.749,618.409). The test statistic for the *t*-test was $t=11.120$ with $df=581.066$. Due to a high *F* statistic value, equal variances were *not* assumed. The *p*-value for the two-sided *t*-test was $p<.001$. The calculated Cohen's *d* effect size was $d=.791$ with a *CI* for *d* of (.657,.924). This is a significant effect because the *CI* does not capture zero. These statistics and others are presented in Table IV-4. Based upon the statistical analysis for *Hypothesis 3*, there was a significant difference between rural FRPL and non-FRPL students' achievement. **Non-FRPL students scored significantly higher on the Algebra I EOC than their FRPL counterparts with the mean difference of 525.579. Moreover, the true difference in the mean scores of the groups is likely to be between 432.749 and 618.409 with a confidence of 95 percent. Finally, the Cohen's *d* effect size of *d*=.791 with a *CI*= (.657,.924) means that non-FRPL students scored on average roughly 0.8 standard deviations higher than their FRPL counterparts.**

Table IV-4 *Differences in Student Achievement Based on SES (FRPL Status)*

	Non-FRPL		FRPL					
	M	*SD*	*M*	*SD*	*df*	*t*	*p*	Cohen's *d*
Student Achievement	4070.71	593.786	3545.13	780.254	581.066	11.120	<.001	.791

Hypothesis 4

Prior to conducting the student's *t*-test, I checked the histograms of the distributions of achievement scores in the male and female groups in the rural subset for normality. The histograms of the distributions are presented in Figure 9 and Figure 10, respectively. Both distributions appear to be sufficiently normal for conducting a *t*-test given their relatively large sample sizes. As in *Hypothesis 1* and *Hypothesis 3*, the zero score values were considered along with the rest of the scores in the analysis. I conducted a *t*-test to test *Hypothesis 4*. The mean difference between rural male and female achievement was 42.942. The 95 percent confidence interval (*CI*) for the mean difference was (-128.561,42.678). The test statistic for the *t*-test was $t=-.984$ with $df=1066$. The *p*-value for the two-sided *t*-test was $p=.325$. The calculated Cohen's *d* effect size was d=-.060 with a *CI* for *d* of (-.180,.060). **Both the *t*-test and the Cohen's *d* effect size are nonsignificant and based on this analysis there is no evidence to suggest a significant mean difference between male and female student achievement on average.** The test statistics and *CI* are presented in Table IV-5.

Figure 9 *Histogram of the Distribution of Student Achievement Scores in the Rural Male Subgroup*

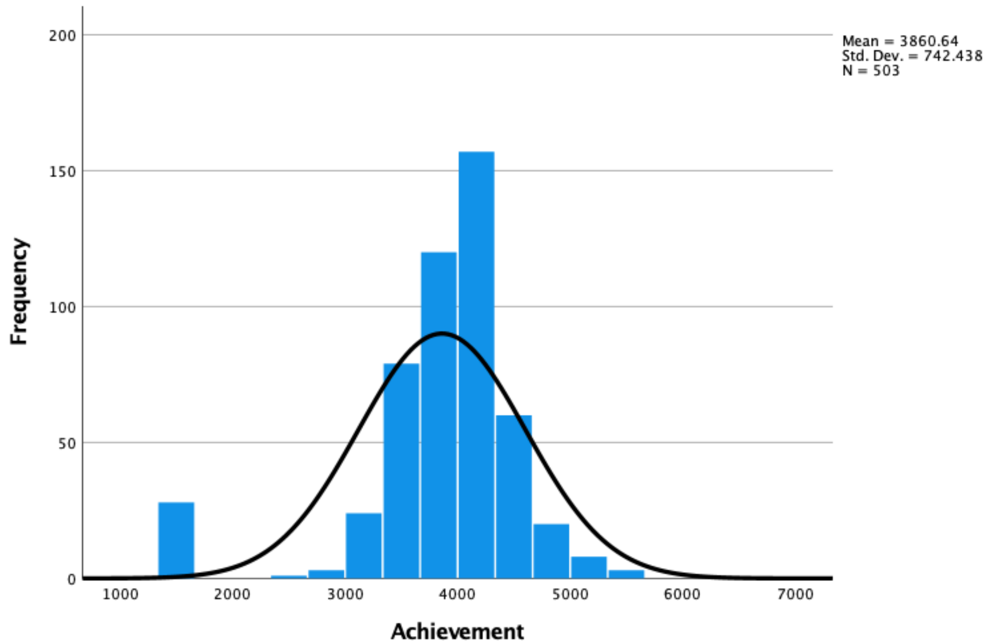


Figure 10 *Histogram of the Distribution of Student Achievement Scores in the Rural Female Subgroup*

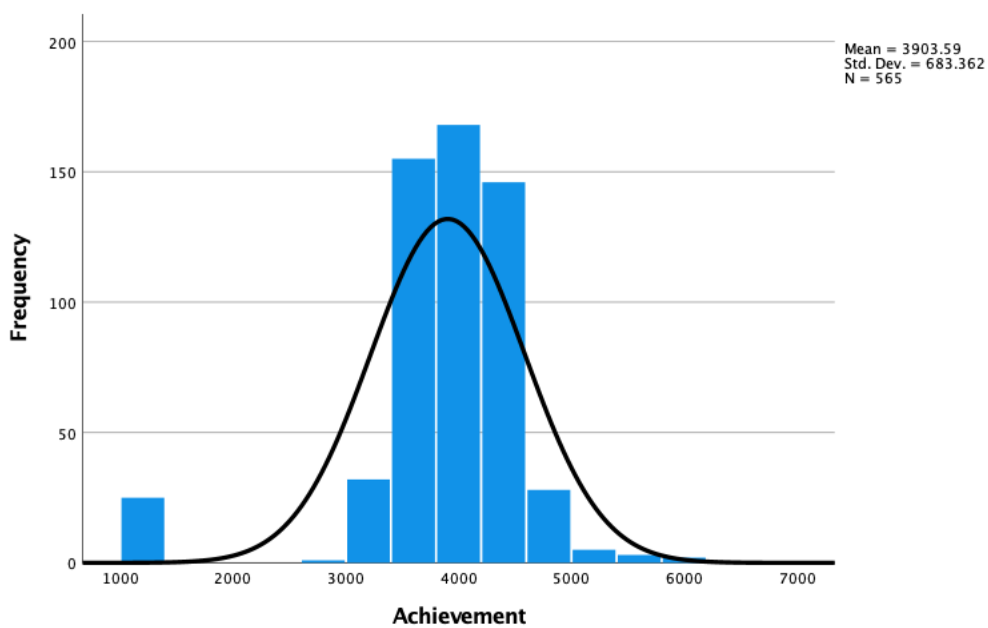


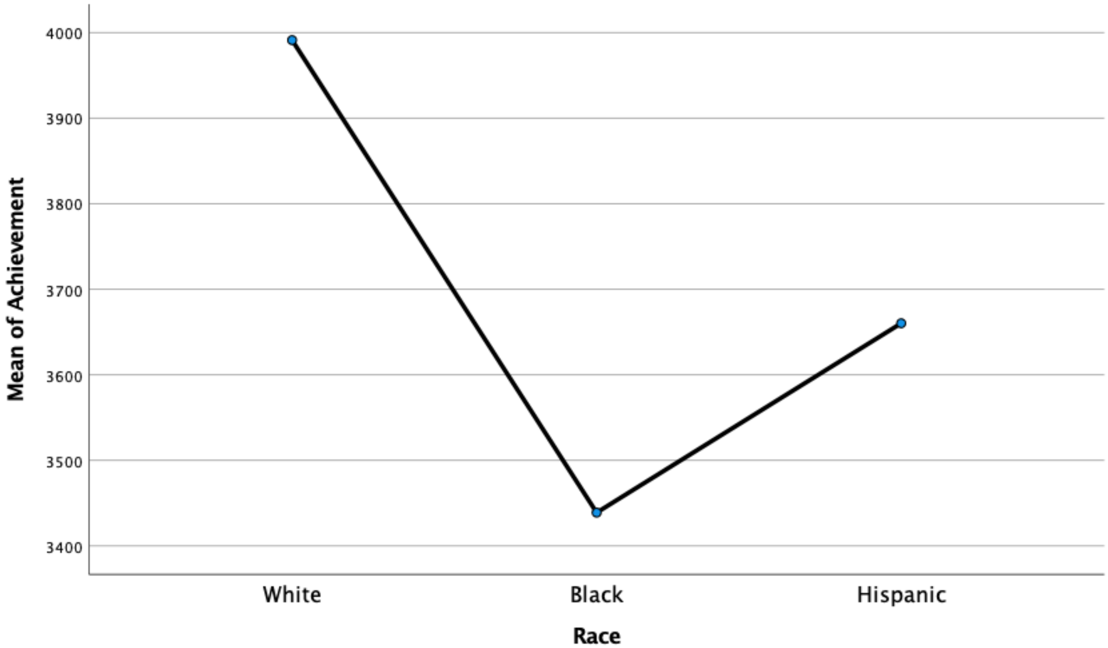
Table IV-5 *Differences in Student Achievement Based on Sex*

	Male		Female					
	M	*SD*	*M*	*SD*	*df*	*t*	*p*	Cohen's *d*
Student Achievement	3860.64	742.438	3909.59	683.362	1066	-.984	.325	-.060

Hypothesis 5

For *Hypothesis 5*, I used a linear contrast in analysis of variance (ANOVA) technique to determine if White students in rural schools scored significantly higher than their Black and Hispanic peers. The actual hypothesis tested was that White students scored on average statistically higher than both Black and Hispanic students. Linear contrast coefficients were defined as 1, -.5,-.5 for the three groups, respectively. The point estimate for the difference in the mean for White students and the average of the means for Black and Hispanic students was 441.76, with a 95 percent CI= (323.67, 559.85). The t-test statistic for the contrast test was t=7.340 with df=1065 and two-tailed p-value of p<.001. **Thus, the null hypothesis for this case is rejected and White students scored significantly higher on average than the average of both their Black and Hispanic peers, with the true value of the mean difference being between 323 and 560.** The Cohen's d effect size comparisons between White-Black, White-Hispanic, and Black-Hispanic are: d=.774, CI=(.477,1.071), d=.482, CI=(.342,.623), and d=.-246, CI=(-.262,-.230), respectively. **Each of the effect sizes were statistically significant, with the effect of being White compared with being Black having the largest effect, with an almost .80 standard deviation increase in achievement for White students compared to Black students. It should also be noted that being White had an effect of nearly 0.5 standard deviations higher achievement when compared to their Hispanic peers. Hispanic students scored approximately one-fourth of a standard deviation higher than their Black peers.** The mean comparisons are presented visually in Figure 11.

Figure 11 *Means Plot of Achievement Scores Based on Race*



Hypothesis 6

To test *Hypothesis 6*, I first computed an interaction variable between locality and per student spending in SPSS. I then ran a regression model with achievement as the dependent variable and locality, per student spending, and the interaction term as predictor variables. The regression output is presented in Table IV-6. The *p*-value for the interaction term was *p*=.377, which is not statistically significant. **As a result of this analysis, I failed to reject the null hypothesis that there was not a different effect of per student spending on achievement based on locality.**

Due to the size of the *p*-value in the model, I conducted a post-hoc power analysis to determine if there was sufficient power to detect a small effect size in the sample. I used G*Power 3.1 and the recommendations from Faul et al. (2007) to set up my analysis. With the especially large sample size in the model, it is surprising to have found a *p*-value of *p*=.377. Based on the post hoc analysis, the observed power given the sample size, alpha level, and the rule of thumb for a small effect (*f*=.15) was close to one. There was sufficient power to detect even a small effect, which justifies the resulting *p*-value from the model.

Table IV-6 *Regression Coefficients of Locality, Per Student Spending and Interaction Term on Student Achievement*

Predictor	**B**	**β**	***p* value**
Locality	-132.480	-.016	.119
Per Student Spending	-.012	-.007	.012
Locality * Per Student Spending	.014	.009	.377
R^2	<.001	R^2_{adj}	<.001

Hypothesis 7

To test *Hypothesis 7*, I first computed an interaction variable between SES and per student spending in SPSS. I then ran a regression model with achievement as the dependent variable and SES, per student spending, and the interaction term as predictor variables. The regression output is presented in Table IV-7. The *p*-value for the interaction term was p=.055, which is approaching statistical significance. As was the case in earlier hypotheses, there is not a linear relationship between achievement and per student spending, so finding one in this model was unlikely. Interestingly, the interaction between SES and per student spending is close to being significant at the $p=.05$ level. **As a result of this analysis, I failed to reject the null hypothesis that there was not a different effect of per student spending on achievement based on SES.**

Table IV-7 *Regression Coefficients of SES, Per Student Spending, and Interaction Term on Student Achievement*

Predictor	**B**	**β**	***p* value**
SES	-14.930	-.010	.956
Per Student Spending	.028	.039	.250
SES * Per Student Spending	-.095	-.351	.055
R^2	.128	R^2_{adj}	.125

Effect Sizes

Several Cohen's *d* effect sizes were computed in the analysis of the hypotheses for various groups to determine the practical effect of being in one group as opposed to another. The comparisons considered are as follows: rural versus nonrural, FRPL versus non-FRPL, male versus female, Black versus Hispanic, Hispanic versus White, and Black versus White. The effect sizes are presented in Table IV-8.

Table IV-8 *Effect Sizes of Various Achievement Comparisons*

Related Hypothesis	**Group**	**Compared to**	**Cohen's *d***	***95 % CI***
Hypothesis 1	Nonrural	Rural	.130	(.070,.190)
Hypothesis 3	No FRPL	FRPL	.781	(.650,.911)
Hypothesis 4	Female	Male	.060	(-.60,.180)
Hypothesis 5	Hispanic	Black	.246	(.230, .262)
Hypothesis 5	White	Hispanic	.482	(.342, .623)
Hypothesis 5	White	Black	.774	(.477,1.071)

CHAPTER V

DISCUSSION

Limitations

Prior to a discussion of the results of this dissertation and contextualizing them in the body of current research on the topic of student achievement, I believe it is meaningful to discuss ways in which the analysis in this dissertation could be improved upon in further studies. One of the most glaring areas of concern for me is related to the dataset itself. As mentioned in the methods section, there were over 150,000 students in the nonrural subset and just slightly over 1,000 students in the rural subset with achievement scores. This is problematic because there are far more rural students in Texas that took the Spring 2016 administration of the STAAR Algebra I EOC. This means that there were over 13,500 students whose data were masked to prevent personally identifying an individual student. It is conceivable that there are groups of students that were masked in rural districts that were systematically distinct from those included in the data. Such students' data not being present could inflate the analyzed *p*-values and effect sizes. Though the likelihood of the results being the same or different given the entire dataset without masking would not be easy to quantify, I approach the discussion of the results in the context that this research needs to be conducted on additional datasets and more complete ones as well. The masking at minimum truncated individuals, but also in very small districts removed entire districts from the analysis. The predictor I was most interested in was per student spending and numerous districts' spending and their students' resulting achievement are missing from this analysis.

Another limitation of this dissertation is the quantity used for per student spending. Based on known expenditures of districts from the school year in which the achievement data were collected, I chose to use per student spending on instruction, which is largely related to teacher pay and does not account for many other areas of per student spending in Texas. It should also be noted that funding from outside sources, such as the Federal government are included in the utilized measure for per student spending, but are aggregated at the district level. For example, funding grants, such as Title I of the Elementary and Secondary Education Act (ESEA) and special education funding from the Individuals with Disabilities Education Act (IDEA). Special funding sources such as these could vary greatly across districts, and the effects of particular funding sources are smoothed out by aggregating to the district level. A more detailed analysis of the possible differences in per student spending could be considered for future research.

Yet another limitation of the data used in this dissertation is the student SES predictor. The predictor is from a categorical variable called economic disadvantage, which has three levels, as mentioned in the methods section. At best this variable is a proxy for a continuous measure of family SES and at worst serves to poorly categorize students based on an optional program. This variable, along with the gender/sex variable and the race/ethnicity variable are subject to various errors in self-selection and clerical categorization errors, particularly when small districts collect the information on paper and a single person is responsible for transferring the information to a database.

Another limitation that needs to be considered is that of the dependent variable for algebra achievement. The achievement scores in the data analyzed for this dissertation study were scored by students likely at the beginning of their high school careers. Further, it is the final state assessment in Texas public schools in mathematics. The content covered by the assessment is too granular to be considered as a surrogate for mathematics achievement in general, though an argument can be made that because it is the final state assessment for mathematics in Texas, it is the best available measure for mathematics achievement in Texas secondary schools. Results from this study should be tempered with the understanding that the algebra achievement variable is not without flaws and could be improved with additional study and research.

Locality and Student Achievement

Locality matters. That is a simple way to summarize the algebra achievement differences between rural and nonrural students. First, the question of locality was foundational to the discussion of the remainder of the hypotheses I considered. Much literature has focused on what it means to be rural in education, the impact rurality has on research, and how definitions of rural provide little clarity to a seemingly abstract idea. In this case, rural was defined as TEA dubbed it as a district having: (a) an enrollment of between 300 and the median district enrollment for the state and an enrollment growth rate over the past five years of less than 20 percent or (b) an enrollment of less than 300 students. By using TEA's definition, the conclusions of this study are inextricably linked to Texas and any recommendations postulated may only have meaning in Texas. Based on NAEP data, some demographic groups favor rural versus nonrural, while others favor the nonrural setting. The analysis in this dissertation provides evidence that there is indeed a small distribution shift between rural and nonrural student achievement. Although improving the average score by one-tenth of a standard deviation may not seem like a big deal at first glance, finding out what variables stand in the gap between rural and nonrural schools can make a real difference for rural schools given the A-F Accountability System currently in place in Texas. Locality matters, but what matters in the rural locality?

Race and Student Achievement

Even though race was not a significant predictor in the regression model considered in *Hypothesis 2a*, there was a significant difference in the mean achievement between White and

Black students and White and Hispanic students. These gaps are consistent with the national level achievement data from the 2022 NAEP assessment, though the rural Texas gaps were wider than those found either in the NAEP data or in work by Gagnon and Mattingly (2018). The relatively low variance in achievement explained by race seems to suggest that at least in the rural setting, some other factors may dominate the reason for why these gaps exist. As in the case with previous research, achievement gaps between White students and Black and Hispanic students, respectively, have been narrower than their nonrural peers. From a theoretical perspective, both the social capital that exists in a rural area and the relationships in the micro- and meso-systems of EST may account for why a macrosystem factor like race may not be as much of an indicator of achievement as it might be in a nonrural urban or suburban setting. In other words, other relational or social factors may outweigh race as a factor in student achievement in rural settings. Based on my hypotheses and prior reading on the topic, I would have expected a greater deal of variation to be explained by race in the main regression model.

Gender/Sex and Student Achievement

There was not enough evidence in the analysis of the data considered in this dissertation to make a conclusion that there exists a gap between rural males and females in student achievement in mathematics. Numerically, a similar story can be told of a slim mean difference in the data in this dissertation when compared to the NAEP 2022 8^{th} grade mathematics assessment. The lack of a statistical association conflicts with Ribner et al. (2017), in which those researchers found an association between mathematics achievement and gender. Curiously, Azano et al. (2022) alluded to the need for a chapter on gender issues in rural areas, though one was not included. Without a clear consensus on whether there existed (or still exists) a gender gap in algebra achievement (in rural settings or in general), I am left with more questions than answers on this topic. I must emphasize my concern that given the prevalence of sex/gender-based stereotyping (Anaya et al., 2022; Assouline et al., 2021) regarding mathematics, a deeper analysis on the topic is warranted, with emphasis on the rural setting.

Gender/sex was nonsignificant in the statistical test and had an effect size of d =0.060. Though the results do not indicate a statistically significant difference, it is important to compare the effect size to previous research on the topic of algebra achievement. In the context of a cross-national study on gender differences in algebra achievement, female students were shown to score d = 0.11 standard deviations higher than their male counterparts across nations and d = 0.01 standard deviations higher than their male counterparts in the U.S. (Else-Quest et al., 2010). Those results are consistent with those found in this dissertation. Though not statistically significant, the presence of data for another effect moves the field closer to getting to the true population parameter for the effect (Thompson, 2002). The comparison of these results also highlights the need for additional investigation to seek more data on the effect, particularly in the rural context.

Per Student Spending: The Debate Continues

The analysis conducted in this dissertation regarding per student spending adds to the literature on the topic and reopens the debate about how spending impacts education. The results of the analysis regarding per student spending are quite clear: there is no linear relationship between per student spending on instruction and student achievement, whether accounting for other demographic variables or not. My initial thought was that if there were a linear relationship, then it would be simple to recommend that the Texas Legislature appropriate more funds per student through formula funding for the next biennium. This is in concert with the results found by Stringfellow (2007) and in *direct* contrast to Hanushek and Woessmann (2017).

The results from this dissertation study also contrast with other studies in which a link was found between per student spending and academic achievement (Biddle & Berliner, 2002; Izbicki, 2003). Though there is a lack of conclusive evidence in the literature, I am confident in saying that there are other factors which influence student achievement in mathematics to a greater extent than per student spending. Moreover, my recommendation to policymakers in Texas would be to seek out those factors that do directly influence student achievement and fund and require implementation of those programs.

Conversely, the figures for per student spending from this dataset should be a wake-up call for educational stakeholders in the state. The per student spending from my dataset was $5,638, which is higher than the numbers presented by Showalter et al. (2017) just two years later. Further, Texas' rural per student spending is around $400 less than the per student spending national rural average of $6,067 (Showalter et al., 2017) and most recent state overall average $5,929 (TEA, 2021). These comparisons are particularly troubling because most of a school's expenditures on instruction are for teachers and other instructional staff. This means that Texas' rural teachers make less money than teachers in other urban and suburban districts. While I believe teacher pay in rural schools is low, I must object to the notion that programs like the Teacher Incentive Allotment (TIA) will drive growth in achievement, even though that program is tied to student outcomes and growth. The idea of linking teacher bonus pay to student outcomes is a tenuous one.

Currently in Texas, there is a teacher shortage statewide, with many job openings being posted with no applicants seeking the positions (Lopez, 2022). The shortage will disproportionately impact rural schools, who already have trouble recruiting and hiring qualified teachers and whose departments may only have one teacher of every content area (Showalter et al., 2017). More research is needed on what does work in rural schools, but per student spending is not the driving factor I hypothesized it would be.

Student SES: The Best Indicator of Student Achievement?

In each of the hypotheses in which student SES was considered or analyzed because of a hypothesis, student SES was a significant predictor of student achievement. All the regression models that were conducted had SES as significant at the p=.001 level for rural settings. Student SES accounted for the single largest effect size of any of the predictor variables, accounting for an effect of nearly 0.8 standard deviations of difference between low-SES (FRPL) and high-SES (non-FRPL).

These results are consistent with the data from the NAEP 2022 eighth grade mathematics assessment as well as several other studies on the topic (Hanushek et al., 2020; Reardon, 2016). This adds to the growing literature of states in which SES has been found to be predictive of student achievement, including Michigan (Maylone, 2002), New Jersey (Tienken et al., 2017; Turnamian, 2012), and Massachusetts (Ardon, 2012; Caldwell, 2017). What is unique about the addition of Texas is its relationship to the other states mentioned: all of the states except Texas are in the northern US. This is important because it highlights the similarity between states even across regions and might spur additional study in other states. The results from the analysis in this dissertation highlight the importance of student SES on student achievement in mathematics.

From a theoretical perspective, SES would fall under the macrosystem in EST, a realm where a student has little control over outcomes. This is partially illustrated by the fact that when compared in 2015 to nonrural areas, 28 percent of rural children lived in poverty compared to 22 percent in nonrural metropolitan areas (United States Department of Agriculture [USDA], 2015). Further, the lack of economic resources in a rural area has been shown to also extend to fewer community resources, such as after-school programs, mentoring, school social work, and tutoring (Belanger & Stone, 2008). The lack of widely available resources in rural areas illustrate the utility of social capital and the importance of social connections in those areas to be successful at improving outcomes (Belanger, 2015). In other words, community is vitally important in a rural area and can be even more important for impoverished students. What happens to those students who meet poverty criteria, but do not receive the help afforded to other such students?

The NSLP criteria for FRPL is based upon federal poverty thresholds, from which schools determine a student's eligibility. There were three categories in the dataset analyzed for this dissertation. One group was the non-FRPL group. Another was the reduced-price lunch group. The last group was the free lunch group. Aside from the lack of data on actual family SES, there is a glaring problem with the eligibility process for NSLP: students' parents or guardians are responsible for applying for the assistance. Anecdotally, when I was attending public schools, I would have been eligible for free lunches based on my family's income level. Each month, my father would send a check with me to school to pay for my lunches. It was not because we did not know of our poverty or our meeting the criteria for the program, but rather the stigma that may have been associated with never paying for my own lunch. Thus, this brings up several important points. How many students are not being adequately fed when they meet the criteria for FRPL? How many students are self-selecting themselves out of FRPL because of a stigma related to poverty? Interestingly, the US Government provided free lunches for all schools that participated during the 2021-2022 school year, though that program has been stopped for the 2022-2023 school year. This was one way of preventing the stigma for impoverished students by not singling them out as having free lunches. Beyond these issues is another that could influence future policy and research.

The NSLP and the FRPL designations as defined are subject to change and manipulation by policymakers. The USDA is the federal agency in charge of the NSLP and helps set policy for the program as statutorily authorized by the Congress and mandated through executive branch and judicial action. Given the vast changes in policy because of the transition between the Obama-Trump and Trump-Biden administrations, it should be no surprise that manipulation of criteria and the poverty levels might be used as a political tool to either improve achievement artificially or poison data from states with opposing viewpoints to the executive regime in office at any given time. The case for SES being a significant predictor of student achievement could be made much more strongly if the surrogate for SES was not subject to categories determined by a federal agency only tied to education because of meals served to students.

Implications for Practice, Policy, and Further Research

There are several practical implications that can be gathered from the results in this dissertation study. One such implication is that per student spending alone does not increase student achievement in mathematics, even when accounting for other demographic variables. Schools can focus their attention to other areas for improving student achievement that are known to have greater impacts. One way to do that could be to effectively implement response to intervention (RTI) programs in rural schools. Early identification of students who are below grade level or are struggling with learning content could benefit greatly from these programs. Moreover, using the NSLP FRPL categories as well as other at-risk indicators in addition to student grades and teacher identification of student struggles could be beneficial. Another implication that involves both policy and practice is the implementation of a universal free lunch program. The Community Eligibility Provision of the National School Lunch Program allows schools with high levels of poverty to offer free lunch to all students in the school (Hecht et al., 2020). Schools that have participated in the Community Eligibility Provision program have been shown to have improved student nutrition, behavior and academic performance (Hecht et al., 2020). As the Texas Legislature heads into its 88th session in January 2023, legislators should consider this dissertation and the other bodies of research that suggests that food insecurity and family SES may account for a large proportion of the variability in student achievement in mathematics in general and in rural schools in particular. The legislature will go into the session with a $27 billion dollar budget surplus from the current biennium and a statutory cap of around $12.5 billion in budget increases in the 2023-2025 biennium (Harper, 2022). If student success is to be considered in the legislature in the session, free lunch programs should be an item discussed as a potential policy solution, as well as other means to help impoverished students and their families. Beyond these policy and practice implications, there are research implications for the field of rural education research.

Through my dissertation research, I have attempted to add to the growing body of educational research in rural settings. The research implications from this dissertation can be described in the framework described by Coladarci (2007) in his *Swan Song* and by others (Azano et al., 2022; Biddle et al., 2019; Corbett & White, 2015; Shucksmith, 2016; Stapel & DeYoung, 2011) subsequently. First, I believe that the rural context of this dissertation has been described in a way that researchers, educators, policymakers, and other stakeholders can better understand the nuances of how demographics impact student achievement in rural schools. Further, the analysis of the impact of SES compared with all the other predictors is indicative of a compelling reason to consider that variable further in additional study both in Texas, across states, and across levels of achievement. I also believe that the research questions and hypotheses in this dissertation were cast to highlight the rural nature of the study. My hope is that I have made connections between past research and my dissertation to spark additional questions for study based on my analysis. Additional research on these topics should engage other disciplines such as social work and sociology to gain a better understanding of the poverty and social capital issues present in rural settings. A collaborative approach of cross-disciplinary research on these topics can help fully unpack the issues that each of the fields may overlook individually. Additionally, the urban-centric nature of educational research should not prevent study of rural settings, but spark an interest to see if, as in this dissertation, that differences exist or if outcomes are similar. Researchers should reframe the boundary work in rural education to gain a better understanding of what works in different settings to improve outcomes for people in all areas without creating unnecessary stigmas around a certain locality. I also think there is an opportunity for researchers to analyze the use of different definitions of rural within a study to determine if the results of analyses are different when using different definitions of rural. Finally, I believe that to better understand rural algebra achievement in Texas, it would be beneficial to acquire and analyze deidentified data across the state with the full sample of students in rural schools to determine if the same results hold when the masked data are not missing. Further, the limitation of the dependent variable in this dissertation is a compelling reason to consider additional analyses of different mathematics content areas to gain further understanding of mathematics achievement in rural schools generally. That Texas only assesses mathematics through Algebra I is problematic in that most students still have most of their high school careers after taking Algebra I. It would be interesting to know if algebra achievement is a meaningful surrogate of mathematics achievement in general. Additional study is needed in these areas. By conducting this dissertation study research, I have developed a greater understanding of the issues faced by rural school in the United States and in Texas and has helped me uncover additional areas in which research can be conducted to help schools and students improve their outcomes.

Study Summary

Recognizing the need for a more thorough understanding of what impacts student achievement in rural Texas schools, this dissertation study was written to examine those factors based on a statewide set of state assessment and demographic data. Initially, I hypothesized that when accounting for student demographic variables, per student spending would be significant predictor of achievement outcomes. The reality was that demographic variables far outshined per student spending, particularly student SES. Based on the theoretical framework considered, including ecological systems theory and social capital theory, I was able to unpack why those demographic variables are important in a rural setting and substantiate that demographics such as sex, race, and SES, relationships, and social interactions with things that are proximal to a student are more likely to impact their achievement than something on the fringe of their system like how much money is spent for their instruction.

Through dissertation research, I also highlighted the degree to which student SES impacts student achievement. Of the variance in achievement explained by the regression model analyzed, SES accounted for well over 90 percent of the variance explained by the model. SES had predictive value for student achievement and should serve as a starting point for research, policy, and practice decisions made for rural Texas schools over the next few years.

Finally, based on the results of this dissertation, I highly recommend a rethinking of the current approach of relying so heavily on education researchers and practitioners to develop programs to improve achievement. As has been recommended by others in rural education journals for over a decade (Coladarci, 2007), it is imperative to engage experts from other fields such as anthropology, sociology, psychology, social work, and others.

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