MODELING SUCCESSFUL INCLUSIVE STEM HIGH SCHOOLS: AN ANALYSIS OF STUDENTS' COLLEGE ENTRY INDICATORS IN TEXAS

A Dissertation

by

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ABSTRACT

This dissertation highlights a conceptual framework for specialized Science, Technology, Engineering, and Mathematics (STEM) schools and the college readiness of Inclusive STEM High School graduates in comparison to traditional high school graduates. In reviewing the literature, I found the current perception for specialized STEM schools can be described as unique environments including advanced curriculum, expert teachers, and opportunities for internships and immersion. Finding from the studies exploring college and career readiness of students attending these schools revealed students from specialized STEM schools are performing slightly better on high-stake mathematics and science tests in comparison with students in traditional schools. Studies also showed students from specialized STEM schools are more interested in STEM, more willing to attend classes, more likely to pass state tests, and more likely to earn college degrees. After synthesizing the literature, I created a conceptual framework of effective learning environments for specialized STEM schools using an ecology metaphor.

In answering the research questions related to success of students attending either T-STEM or traditional schools, I concluded success on reading, mathematics, science high-stake tests for students does not differ by school type. However, student demographic variables (i.e., gender, ethnicity, socioeconomic status, and special education status) may influence success of students attending T-STEM schools. For example, results revealed statistical significance between male, Hispanic, White, and economically disadvantaged students from T-STEM and traditional schools on reading, mathematics, and science scores.

In answering the research question related to success of T-STEM in comparison with traditional schools, I found no statistical significance in measures of schools' success. However, regardless of school type, female students performed better on reading scores whereas male students performed better on mathematics and science scores. In addition, White and Asian students outperformed all other ethnic groups on performance measures. Also, economically disadvantaged students and students in special education program were outperformed by students not identified as disadvantaged or learning disabled. On school level indicators, regardless of school type, dropout rate negatively associated with students' reading, mathematics, and science scores. In addition, percentage of students taking AP/IB end of course exam had a positive association with reading, mathematics, and science scores. Finally, percentage of students taking SAT/ACT also demonstrated a positive association with reading and mathematics scores, but not science scores. In conclusion, specialized STEM schools can be the solution to the problem of shortages in the STEM workforce; however, there still work remains.

DEDICATION

I would like to dedicate this dissertation to those who believed in me through this long journey.

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NOMENCLATURE

HLM	Hierarchical Linear Modeling
ISHS	Inclusive STEM High Schools
NCSSSMST	National Consortium for Specialized Secondary Schools of Mathematics, Science, and Technology
PISA	Programme for International Student Assessment
S&E	Science and Engineering
SES	Socioeconomic Status
STAAR	State of Texas Assessments of Academic Readiness
STEM	Science, Technology, Engineering, and Mathematics
TAKS	Texas Assessment of Knowledge and Skills
TIMSS	Trends in International Mathematics and Science Study

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CHAPTER I

INTRODUCTION

In the current global economy, knowledge in science, technology, engineering, and mathematics (STEM) fields has become a central issue in the creation of many occupations. This issue is expected to continue well into the future. Historically, between the years 1950 and 2009, the average annual growth rate in the United States (U.S.) for science and engineering (S&E) occupations was 5.9%, whereas the total workforce grew by only 1.2%. Between the years 2000 and 2009, although the average annual growth rate of S&E occupations grew by only 1.4%, this rate was greater than the 0.2% rate experienced by the total workforce (National Science Foundation [NSF], 2012). In terms of individuals, approximately 7 million people in 2000 held occupations requiring STEM knowledge. By 2010, however, this number had grown to 7.6 million people. In looking to the future, the U.S. Department of Commerce (2011) estimates 8.6 million people by 2018 will hold occupations requiring STEM knowledge. This increase in individuals translates to a growth of 17% between 2008 and 2018 (U.S. Department of Commerce, 2011).

Where Education Systems in the U.S. Fall Short

Education systems in the U.S. fall short in preparing students for occupations requiring STEM knowledge. In 2008, 31.4% of the student population in the U.S. had earned a baccalaureate degree in an S&E field. This percentage value is lower in comparison to the percentage values for the student populations in Japan (60.6%), China

(50.7%), and South Korea (41.1%; NSF, 2012). In addition, national data from the U.S. indicates in 2010 7.6 million people (5.5% of the nation's workforce) held occupations requiring STEM knowledge with only 5.2 million (68%) of these people possessing at least a baccalaureate degree, while 1.7 million (23%) had some college or associate's degree and 0.7 million (9%) had some secondary education or high school diploma (U.S. Department of Commerce, 2011).

Until now, the U.S. workforce has filled the gap in S&E occupations with international students who choose to remain in the U.S. post graduation (Atkinson, Hugo, Lundgren, Shapiro, & Thomas, 2007). A recent report by the NRC (2011) indicated one third of graduate students in S&E occupations within the U.S. were international students and 70% of those students had decided to work in the U.S. post graduation. However, researchers now conclude increased opportunities for occupations requiring STEM knowledge in countries outside the U.S. may lead to fewer international students choosing to join the U.S. workforce (Atkinson et al., 2007; NRC, 2011). As a result, some U.S. business leaders have expressed concern with a potential shortage of graduates with STEM knowledge, regardless of nationality, for the U.S. workforce (NRC, 2011).

Responses by U.S. Policymakers

Responses by policymakers in the U.S. to national and international indicators, such as the NRC report mentioned above, point to the development of new strategies for increasing the number of students interested in S&E occupations, especially those students from historically underrepresented populations (i.e., female, diverse, and disabled). Current research suggests these occupations are disproportionately dispersed among U.S. citizens (see Table 1.1; NSF, 2013). For example, male citizens are three times more likely than female citizens to work in S&E occupations. Additionally, regardless of gender, White citizens are three times more likely than all other citizens to work in these occupations.

The results from Table 1.1 are even more disturbing for gender studies (see Table 1.2; NSF, 2013). For example, the percentage of female citizens in the U.S. population is equal to the percentage of male citizens. This suggests female citizens are greatly underrepresented in S&E occupations. Additionally, regardless of gender, White citizens constitute almost two thirds of the U.S. population. This further supports the conclusion non-White citizens are underrepresented in S&E occupations.

Table 1.1

Cross Distribution of Ethnicity and Gender for U.S. Citizens in S&E Occupations During 2010

	Gender	
Ethnicity	Female (%)	Male (%)
White	18.0	51.0
African American	2.0	3.0
Hispanic	2.0	4.0
Asian	5.0	13.0
Other	1.0	1.0
Total	28.0	72.0

Note. The Other ethnicity includes American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander, and multiple races.

Table 1.2

Cross Distribution of Ethnicity and Gender for U.S. Citizens During 2010

	Gender	
Ethnicity	Female (%)	Male (%)
White	32.3	31.3
African American	6.4	5.8
Hispanic	8.3	8.1
Asian	2.5	2.2
Other	1.6	1.5
Total	51.1	48.9

Note. The Other ethnicity includes American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander, and multiple races.

The Current State of STEM Education in the U.S.

The authors of the report *Successful K-12 STEM Education* suggest students in the U.S. do not possess high levels of STEM knowledge before accepting S&E occupations (NRC, 2011). According to results from the National Assessment of Educational Progress (NAEP) in 2009, 33% of U.S. 4th graders and only 26% of U.S. 8th graders were proficient in mathematics. These percentages do exhibit an increase from 1996 results, when the percentages were only 19 and 20, respectively (Schmidt, 2011). Although percentages from 2009 show growth, almost three out of four students still complete 8th grade without exhibiting proficiency in mathematics (NRC, 2011).

Consequently, the current state of STEM education in the U.S.'s secondary and postsecondary education institutions may negatively impact the future U.S. economy.

International assessments also indicate U.S. students are falling behind students from other nations. Results from the Trends in International Mathematics and Science Study (TIMSS) in 2011 suggest only 7% of U.S. 8th grade students met the TIMSS advanced international benchmark in mathematics, while these values were 49% and 48% for Chinese Taipei and Singapore students. These results were also similar for 4th grade students in science (see Table 1.3; Provasnik et al., 2012). The results from another international assessment, the Programme for International Student Assessment (PISA) 2009, suggest U.S. 15-year-olds scored on average 487 in mathematics, slightly below the average score of 496 for all students across 65 other countries. Of these 65 countries, students from 23 outperformed U.S. students, students from 29 underperformed, and students from 12 performed equally well. In the same report, U.S. 15-year-olds on average scored 502 in science, equal to the average score of 501 for all students. Across the 65 countries, students from 18 outperformed U.S. students, students from 33 underperformed, and students from 13 performed equally well (Fleischman, Hopstock, Pelczar, & Shelley, 2010). These results suggest the current U.S. education system adequately prepares students when compared to most countries. However, more reform may be necessary in STEM education for the U.S. system to take a leading global position.

Table 1.3

Percentage of U.S. Students Meeting the TIMSS International Benchmarks in Mathematics and Science: 2011

	Percentage of students meeting each international benchmark			
	Advanced (%)	High (%)	Intermediate (%)	Low (%)
4th grade math	13.0	47.0	81.0	96.0
8th grade math	7.0	30.0	68.0	92.0
4th grade science	15.0	49.0	81.0	96.0
8th grade science	10.0	40.0	73.0	93.0

Note. International TIMSS scale average is set at 500.

Significance

To address the issue of reform in STEM education within the U.S. secondary education system, policymakers and reformers have recently set both long and intermediate term goals for improving the STEM knowledge of individuals in the U.S. workforce. Long-term goals include: (a) improving the degree of training for STEM related careers, (b) increasing the number of people for the workforce, and (c) generating a more scientifically literate population (NRC, 2011). To address these goals, education leaders, policymakers and researchers often use intermediate goals. The NRC (2011) has set three intermediate goals for STEM education in the United States: (a) teaching

STEM-focused content and practices, (b) helping to create positive attitude toward STEM, and (c) raising lifelong learners.

In asking for specific recommendations to accomplish the long and intermediate term goals, the President's Council of Advisors on Science and Technology (PCAST) provided a set of specific recommendations. The set of recommendations provided by PCAST included:

(a) supporting states in creating mathematics and science standards,

(b) recruiting and training 100,000 teachers over the next decade,

(c) recognizing and rewarding STEM teachers,

(d) expanding the use of educational technology,

(e) creating opportunities for students outside of school,

(f) creating 1,000 new STEM-focused schools over the next decade, and

(g) ensuring strong and strategic leadership (PCAST, 2010).

The report from PCAST further emphasized the potential for specialized STEM schools to serve as unique national resources. Specifically, these schools would have a direct impact on students while also closing the gap in STEM learning opportunities for historically underrepresented student populations (Lynch, Behrend, Burton, & Means, 2013; PCAST, 2010). In addition, the PCAST report identified specialized STEM schools as the best way to feed the STEM talent pool. The NRC (2011), being aware of the importance of STEM education in schools, gathered a committee to categorize specialized STEM schools under three headings: (a) selective STEM schools,

(b) inclusive STEM schools, and (c) schools with STEM-focused career and technical education (CTE).

Types of Specialized STEM Schools

Selective STEM schools serve talented students exhibiting personal motivation and interest in STEM knowledge. These schools select students by using past academic achievement and additional admission criteria. These schools focus on one or more STEM discipline and attempt to prepare those students likely to pursue a STEM related career (NRC, 2011; Subotnik, Tai, & Almarode, 2011).

Inclusive STEM schools serve students similar to those found in selective STEM schools. However, inclusive schools have no admission criteria and focus on students from historically underrepresented populations. Inclusive STEM schools also focus on one or more STEM discipline and create unique opportunities for students to enter STEM related careers (NRC, 2011; Young et al., 2011).

Schools with STEM-focused CTE serve students also at the high school level. These schools have no admission criteria and focus on students who are at-risk for dropping out of school. STEM-focused CTEs are found in different educational institutions, such as regional centers, career academies, and STEM-focused programs within traditional high schools (NRC, 2011; Stone III, 2011).

T-STEM Schools

A T-STEM school is a type of inclusive STEM school initiated in Texas during the 2006-07 academic year. As of the 2012-13 academic year, there were 65 of these schools in Texas serving a population of approximately 35,000 students. Funding for these schools has reached $133 million to date, which is more than same size traditional schools received, and turned these schools into the largest investment for inclusive STEM high schools (ISHS) in the U.S. Also, T-STEM schools are supported by partnerships with seven T-STEM centers, helping to create instructional materials and provide professional development workshops for over 2,800 teachers (Texas Education Agency [TEA], 2013). T-STEM schools were designed and implemented using a detailed blueprint. This blueprint required students to (a) participate in a college preparatory curriculum, (b) develop real world relevant practices, (c) learn in a strong academic support system, and (d) master a wide range of STEM coursework (NRC, 2011; Young et al., 2011).

Statement of Purpose

The purpose of this dissertation is to design a conceptual framework for specialized STEM schools and measure the college readiness of ISHS graduates in comparison to traditional high school graduates. Schools classified as ISHS were chosen to represent a new school typology having the potential to direct women, minorities, and students with disabilities into STEM related careers. While evaluations and research are limited, state administrations continue to promote and expand ISHS across the U.S. As research is needed to monitor the benefits of these schools to students (Lynch et al., 2013; Young et al., 2011), my dissertation research is timely and fills a void in what we currently know about the outcomes of students attending these schools.

Research Questions

In particular, my dissertation responds to three research questions:

1. How do students from ISHS and traditional high schools in Texas compare on achievement outcomes in reading, mathematics, and science?
2. For students attending ISHS in Texas, how do gender, ethnicity, socioeconomic status, and disability status associate with their achievement outcome measures? Are these associations comparable to students attending traditional schools?
3. How do students from ISHS and traditional high schools in Texas compare on student and school level indicators of college readiness?

Limitations

Every study has multiple limitations. I wish to focus on a single limitation of my study. In my study, I use a cross-sectional set of student data to describe the success of ISHS. Measuring success in preparing students for college is likely best answered using a longitudinal set of student data. Currently, however, neither government institutions nor non-profit organizations collect such data (NRC; 2013; Young et al., 2011). Although the proposed study can still be useful in providing baseline data for comparing schools' performance on indicators of college readiness, my study is limited to a cross-sectional data set for indicators collected by the state of Texas.

Key Terms

In this dissertation, STEM represents science, technology, engineering, and mathematics and is defined as

> An interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology,

> engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy (Tsupros, Kohler, & Hallinen, 2009).

In this dissertation, ISHS represents Inclusive STEM High Schools. According to Young et al. (2011) ISHS can be defined as follows:

> Inclusive STEM [High] [S]chools are predicated on the dual premises that math and science competencies can be developed; and that students from traditionally underrepresented subpopulations need access to opportunities to develop these competencies to become full participants in areas of economic growth and prosperity" (p. 2).

Structure of the Dissertation

I chose the multiple-dissertation format to design a conceptual framework for specialized STEM schools and report the results of two studies associated with the college readiness indicators of inclusive STEM schools. In Chapter I, I present a brief introduction, purpose statement, my research questions, limitations, and key terms. In Chapter II, I synthesize and conceptualize the current literature related to specialized STEM schools as well as inclusive STEM schools. In Chapters III and IV, I present the methodology and results of two research studies. Chapter III attempts to answer questions which emerged from the literature review presented in this chapter. Chapter IV details the results of a study from Chapter III using school level variables (e.g., AP passing rates, SAT passing rates, dropout rates) considered significant indicators in students’ college readiness. In Chapter V, I discuss the results from each of the studies presented in Chapter III and Chapter IV, respectively. In this chapter (i.e., Chapter V), I compare and contrast these studies with conclusions from my review of literature, state my interpretations and opinions, and make recommendations for future research.

CHAPTER II

REVIEW OF THE LITERATURE

This literature review presents a discussion on the research regarding students from specialized STEM schools. I focus on the historical background of these schools, learning environments found within their walls, demographic characteristics of students attending these schools, and the college readiness of those students. These foci translate into the following questions, which also emerged in Lynch et al. (2013) study: (a) How are specialized STEM schools defined in the literature? (b) How do specialized STEM schools operate? (c) What are the common models for specialized STEM schools? (d) Who benefits from attending specialized STEM schools? (e) What are the critical design components of specialized STEM schools? (f) How consistent and in what ways are their goals actualized?

Significance of This Review

The significance of this review of literature refers to common goals expressing the need for attention to the preparation of students in STEM. A goal of many reports from the NRC and other governmental organizations is to generate better understanding of the background for specialized STEM schools. For this goal, the NRC (2013) identified indicators that form a national system for monitoring STEM education in the U.S. relevant to improve STEM education at both the state and national levels. In addition to understanding the background for specialized STEM schools, another goal in STEM education relates to the identification of components for effective learning environments. Lynch et al. (2013) hypothesized specialized STEM schools do more than merely focus on STEM disciplines or integrate new technologies. Therefore, identifying the critical components of specialized STEM schools should help to create effective learning environments for producing graduates prepared for STEM related careers. To assist in identifying these components, I present a conceptual framework at the end of the review modeling an effective learning environment for specialized STEM schools.

A third goal in STEM education requiring attention relates to describing the demographics of students who benefit from attendance at specialized STEM schools (Cole & Espinoza, 2008; Rogers-Chapman, 2013; Tyson, Lee, Borman, & Hanson, 2007). Recently, the U.S. Department of Commerce (2011) projected an increase in S&E occupations for the next 5 years. The National Science Foundation (2012), however, has indicated the U.S. is not producing enough graduates of any demographic background to fill these occupations. The NSF (2013) also highlighted the disproportionate dispersion of S&E occupations across ethnicity and gender demographics (see Table 1.1, Chapter I). These statistics emphasize the importance of considering students' demographics in specialized STEM schools to better understand how to improve STEM education.

A fourth goal in STEM education requiring attention relates to characteristics of specialized STEM schools (Means, House, Young, Wang, & Lynch, 2013; Tyson et al., 2007; Young et al., 2011). These characteristics are vital to preparing students for college experiences. Tyson et al. (2007) discussed the importance of understanding course-taking patterns among students in specialized STEM schools and the influence of these patterns on students' participation in STEM learning. In addition, Means et al.

(2013) indicated a significant influence of students' academic backgrounds on their decisions to remain in STEM courses. Young et al. (2011) investigated how ISHS performed in comparison to other high schools. These studies indicate a need to identify the characteristics of successful specialized STEM schools to better understand STEM education.

Background of Specialized STEM Schools

While specialized STEM schools are at the peak of current research interest, these schools have existed for over 100 years. The body of literature addressing STEM schools has historically used the name "specialized Science, Mathematics, and Technology (SMT) schools" (Olszewski-Kubilius, 2010; Subotnik, Tai, Rickoff, & Almarode, 2010; Thomas & Williams, 2010). The very first examples of these schools were founded in New York City during the early part of the 20th century.

The Beginning of Specialized STEM Schools

In 1904, Stuyvesant High School became the first specialized SMT school (Thomas & Williams, 2010). This "manual training school for boys" was established for the development of talent in science, mathematics, and technology. In 1969, Stuyvesant High School began to accept girls for the first time. Currently, 43% of the students at this school are girls (Stuyvesant High School, 2013). Brooklyn Technical High School opened in 1922 to serve students in the Brooklyn borough of New York City (Thomas & Williams, 2010). The purpose of this specialized SMT school was to provide courses in science, mathematics, drafting, and shops, for students choosing to attend college or begin technical careers. In 1970, female students began to first enroll in Brooklyn

Technical High School (Brooklyn Technical High School, 2013). The Bronx High School of Science, another specialized SMT school in New York City, was founded in 1938 (Thomas & Williams, 2010). Again, the emphasis of this school was on science and mathematics education for preparing technically trained students. In 1946, The Bronx High School of Science became co-ed to provide equal opportunities for female students (The Bronx High School of Science, 2013).

Evolution of Specialized STEM Schools

National policymakers in the U.S. during the latter half of the 20th century placed more emphasis on STEM education. Concurrently, state policymakers created more SMT schools through statewide initiatives (Stephens, 1999). One of the first state initiatives to emerge at this time was a residential summer program for gifted students in North Carolina. In 1980, this program was transformed into a residential specialized SMT school taking the name The North Carolina School of Science and Mathematics (Pfeiffer, Overstreet, & Park, 2010). Over time, each U.S. state has made similar progress in founding a residential specialized SMT school for highly capable students (Pfeiffer et al., 2010; Stanley, 1987). In 1988, a number of SMT schools came together to establish the National Consortium for Specialized Secondary Schools of Mathematics, Science, and Technology (NCSSSMST; Olszewski-Kubilius, 2010; Thomas & Williams, 2010). The eleven founding schools – with year of opening in parenthetical – included:

- Illinois Mathematics and Science Academy (1986),
- Louisiana School for Math, Science, and the Arts (1983),
- Montgomery Blair High School (1985),

- Eleanor Roosevelt Science and Technology Center (1976),
- Mississippi School for Mathematics and Science (1987),
- North Carolina School of Science and Mathematics (1980),
- Liberal Arts and Science Academy High School of Austin (1985),
- Central Virginia Governor’s School for Science and Technology (1985),
- New Horizons Governor’s School for Science and Technology (1985),
- Roanoke Valley Governor’s School for Science and Technology (1985), and
- Thomas Jefferson High School for Science and Technology (1985; NCSSSMST, 2013).

The NCSSSMST was founded to function as a catalyst for advancing STEM education. By providing students, teachers, and communities with the means to achieve in a technology driven society, the NCSSSMST meets the overall mission of the consortium: (a) preparing students for success and leadership in STEM, (b) scaffolding communication and collaboration between member schools, (c) transmitting information about current developments in STEM education, and (d) expanding efforts for advanced STEM education (NCSSSMST, 2013). Currently, the NCSSSMST serves over 39,000 students and 1,600 educators in almost 100 institutions. Together, these individuals and institutions work with people in over 55 additional affiliate institutions (e.g., universities, companies, and educational centers; NCSSSMST, 2013; Thomas & Williams, 2010).

The evolution of STEM education in the last century also included a transition from “manual training schools” to “specialized SMT schools”. In the late 20th and early

21st centuries, additional schools took the name “specialized STEM schools.” These schools were often created through state and national initiatives designed to address concerns over U.S. economic competitiveness and the perceived shortage in the STEM workforce. The current perception of most education leaders, policymakers, and researchers for specialized STEM schools can be described as follows:

> …[Specialized STEM schools] offer a unique and comprehensive environment—one that includes an advanced curriculum and opportunities for significant immersion in the work of the field through mentorships, internships, and research apprenticeships that are often beyond what is available in even the best high schools; a faculty with exceptionally high levels of content area expertise, often consisting of doctorates in content areas; and a select population of students who are homogeneous with respect to ability levels, interests, and aspirations. (Olszewski-Kubilius, 2010, pp. 61-62)

General Characteristics of Specialized STEM Schools

Characteristics of specialized STEM schools vary depending on the context and location of schools. However, most of these schools accept students after a sophomore year of high school experience. Admission into these schools is often selective and based on a set of criteria including: (a) standardized test scores, (b) essays, (c) portfolios, (d) references, and (e) interviews (Kolloff, 2003; Olszewski-Kubilius, 2010; Sayler, 2006). The student populations in these schools may be diverse, reflecting the demographic background of the student population found within the school’s home state. In addition, student populations within these schools are often homogenous in terms of interest in STEM courses (Kolloff, 2003); including Advance Placement (AP) and International Baccalaureate (IB; see Kolloff, 2003; Olszewski-Kubilius, 2010; Sayler, 2006). Many of these schools also encourage students to participate in national and international science fairs and Olympiads. Another opportunity or requirement in some schools is the integration of internships occurring in the business community outside of the school. Internships in this context can be described as any type of service that has certain learning goals related to STEM. Each of these general characteristics for specialized STEM schools has evolved over time until becoming common for most schools (Kolloff, 2003; Olszewski-Kubilius, 2010; Sayler, 2006).

Curriculum in Specialized STEM Schools

Pfeiffer et al. (2010) examined how specialized STEM schools incorporate content into curriculum. Results of their study with 16 participating schools indicated specialized STEM schools were likely to offer research opportunities for students. Students in 15 of the 16 schools conducted research with a faculty member or a mentor and students in 13 schools continued their research throughout summers with the assistance of a mentor. Also, students in 12 schools conducted their own research using either a laboratory or off-campus facility. Not surprisingly, students in 11 schools participated in contests to disseminate results of research. Of the 16 schools, administrators in six indicated the incorporation of STEM content with the humanities curriculum. While administrators in 13 schools identified a minimum number of mathematics courses for students, only seven of 16 schools required a minimum number of science courses. However, the average number of science courses offered by these schools was 34 and the average number of mathematics courses was 21.

Instructional Practices in Specialized STEM Schools

The transformation of specialized STEM schools over the last century has changed many learning goals for students. One exception, however, includes the goal of creating students who are experts in science (Bransford, Brown, & Cocking, 2000). To produce these experts, educators should develop instructional practices organized around meaningful and appropriate learning goals. These instructional practices should result in two abilities for students; applicability of prior knowledge and mastery of domain knowledge (Goldman, Petrosino, & Cognition and Technology Group at Vanderbilt, 1999). The *How People Learn* framework approaches instructional practices using four –centered perspectives: (a) learner, (b) knowledge, (c) assessment, and (d) community. In learner-centered environments, students establish both conceptual and cultural knowledge; whereas, in knowledge-centered environments, students make sense of learned content. In assessment-centered environments, students receive feedback from experts. Finally, in community-centered environments, students learn from other members of a group (Bransford et al., 2000). Minstrell, Anderson, and Li (2011) created a framework by embedding assessment within the teaching and learning cycle and instantiated the *How People Learn* framework. Building on Learner Thinking (BOLT) is the conceptualization of assessment and instruction as an ongoing process (see Figure 2.1). In this figure, boxes represent ideas while circles represent learning experiences.

Also, lines between the boxes and circles represent ongoing interactions. Numbers on the lines are only for reference and do not represent a certain order of interactions.

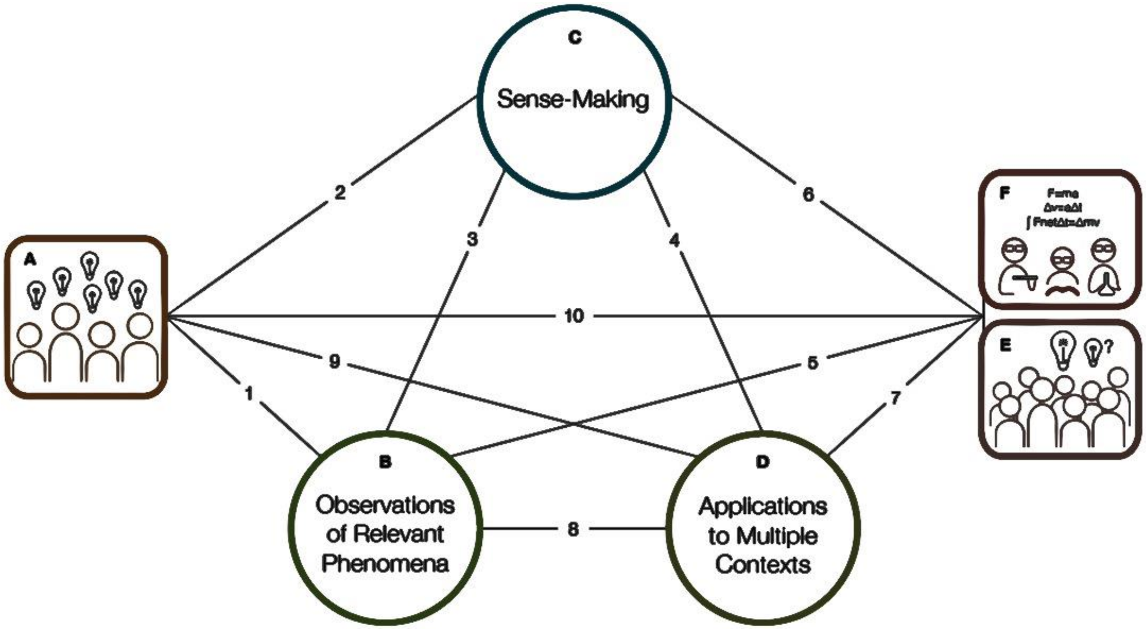

Figure 2.1. Diagram of the BOLT framework (Minstrell et al., 2011, p. 4).

In box A, students start instruction by brainstorming to identify initial ideas and hypotheses. In this process, teachers should address the failing ideas immediately; otherwise, these failing ideas may continue to exist. In box F, scientists' ideas appear to set learning goals for students. In box E, students determine shared ideas and identify those shared ideas which are similar to the scientists' ideas. In circle B, students collect and interpret data to test shared ideas. In circle C, students connect prior knowledge with inferred knowledge from data. In circle D, students find opportunities in different contexts to implement or generalize what they learned (Minstrell et al., 2011). Ongoing interactions represented by the lines are questions driven by the activities and the discourse in the classroom. As an example, lines 2 and 3 represent interactions between students' initial ideas (A), collected data (B), and inferences or explanations (C). Line number 4 represents the similarities and differences between students' inferences or explanation (C) and implementation or generalization of phenomena (D). In order to fully implement the BOLT framework, students and teacher should create a culture of learning. In addition, a strong example of implementation requires establishing more relationships between learning experiences (i.e., boxes and circles; Minstrell et al., 2011).

Types of Specialized STEM Schools

Researchers have categorized specialized STEM schools using characteristics of different school models (Subotnik et al., 2011). The NRC (2011) categorized these schools using students' outcomes and admission criteria into three types of schools: (a) selective STEM schools, (b) inclusive STEM schools, and (c) schools with STEM-focused career and technical education (CTE). The following discussion elaborates these categories.

Selective STEM Schools

Selective STEM schools focus on one or more STEM disciplines. Students enrolled in these schools are selected based on a set of criteria including academic achievement. Therefore, students in selective STEM schools are highly talented, motivated, and interested in STEM. Selective STEM schools incorporate expert teachers, rigorous curricula, advanced laboratory and other resources, mentorships, and improvement opportunities for their teachers (i.e., professional development workshops). NCSSSMST's member schools are examples of selective STEM schools (NRC, 2011; Subotnik et al., 2011).

Subotnik and colleagues (2011) approached selective STEM schools from a deeper perspective, focusing on characteristics unique to each school model rather than focusing on common characteristics. According to this study, selective STEM schools can be categorized under four headings: (a) state residential schools, (b) comprehensive schools, (c) schools-within-schools, and (d) half-day schools. State residential schools are selective schools run with state money; therefore, states stipulate that the student population in state residential schools represent every county. Comprehensive schools are also selective schools and are generally established in metropolitan areas to serve gifted students in a particular area. Schools-within-schools are established in urban areas and mostly serve gifted and historically underrepresented student groups with limited resources. Half-day schools are typically located in economically disadvantaged neighborhoods or rural areas and provide challenging coursework for gifted students of the region. Students are transported by busses to half-day STEM schools after they attended classes in their home schools (Subotnik et al., 2011).

Inclusive STEM Schools

Inclusive STEM schools provide STEM education for a broad population of students. These students, regardless of past achievements, are eligible for admission at inclusive STEM schools. However, inclusive STEM schools are also designed especially for students from historically underrepresented groups. Students may choose to attend inclusive STEM schools for a number of reasons, including: safe environment, new technology, or college preparatory program (Lynch et al., 2013; NRC, 2011; Rogers-Chapman, 2013; Young et al., 2011). Inclusive STEM schools are known for having college preparatory curricula, small school sizes, expert teachers, and technology rich environment (NRC, 2011). Schools in Texas' STEM school initiative are examples of inclusive STEM schools.

Schools with STEM-Focused Career and Technical Education (CTE)

Schools with STEM-focused CTE were established as support programs for students interested in STEM. These schools are usually located in educational centers, comprehensive high schools, or career academies. STEM-focused CTEs predominately focus on science, mathematics, and technology. Students usually attend these schools or programs for a half-day after attending a district designated school. Schools with STEM-focused CTE serve two primary purposes: prepare students for college and assist students at risk for dropping out of high school. To achieve these two purposes, schools with STEM-focused CTE offer students real-world applications of STEM education in the classroom (NRC, 2011; Stone III, 2011). Dozier-Libbey Medical High School is an example of a STEM-focused CTE. The school functions as a bridge between the high school and college learning environments while focusing on a practical science education. All students attending this school are required to take at least four science courses, four mathematics courses, and two years of foreign language. As a result, graduates of Dozier-Libbey Medical High School meet most of the course requirements for the University of California. In addition, school curricula are organized around the health sciences and project-based learning is chosen as the primary teaching strategy. Therefore, teachers and partnering organizations develop hands-on activities for instructional purposes. These activities include following an employee, guided site visiting, in-service experience, research projects, and internships (Dozier-Libbey Medical High School, 2013; NRC, 2011).

Design Components for Successful Specialized STEM Schools

After transformation of SMT schools into specialized STEM schools, the perception among education leaders, policymakers, and researchers for these schools was developed as described by Olszewski-Kubilius (2010) above. However, the current status of specialized STEM schools is not seen as promising by some researchers (Lynch et al., 2013; Marshall, 2010). One common idea expressed by these researchers is that of a flawed design in U.S. schools show a disconnection between the needs and the expectations of the nation for an advanced STEM education. Significant changes in educational, technological, and economical contexts may cause the flawed design (Marshall, 2010). In response, researchers have suggested new design principles and conceptual frameworks necessary to create environments to inspire and attract a new generation of students (Lynch et al., 2013; Marshall, 2010).

Marshall (2010) argued learning environments designed to advance STEM education must help students in developing positive intellectual habits. These habits lead to new skills, such as creative thinking, problem solving, leadership, and innovation.

These learning environments, hubs for transformation in STEM education, should work as systems in which students' innovations, talents, and leadership skills are nurtured. Marshall (2010) suggested a number of fundamental design principles should occur in successful specialized STEM schools. The nine principles Marshall suggested include: (a) creating a living ecosystem in which innovation, talent, and leadership dominate; (b) learning through a series of experiences; (c) personalizing the experience for every individual; (d) including community; (e) providing access to global commons such as digital technologies; (f) ensuring students master each STEM domain; (g) triggering integrative and trans-disciplinary thinking in students' minds; (h) including authentic curriculum, instruction, and assessment in the learning environment; and (i) making learning occur at the right time and place. Taken together, these principles should, according to Marshall, create successful specialized STEM schools.

Based on these nine design principles, Marshall (2010) created a conceptual framework for learning in specialized STEM schools. Her framework reimagined these schools to include three learning environments with an integrating hub. The first of the three learning environments centers on inquiry, research, and interdisciplinary learning. The second centers on innovation and design while the third centers on global leadership and social entrepreneurship. Each of these three learning environments intersects at an integrating hub Marshall refers to as the Leadership, Innovation, Knowledge (LINNK) Commons and Transformation Exchange. For Marshall, the LINNK provides a network for the larger academic community including students, mentors, leaders, and other

STEM professionals. Her framework is one of many useful for describing specialized STEM schools.

Another framework proposed by Lynch et al. (2013) provides a broader perspective. Lynch and colleagues suggested a framework covering design dimensions as well as implementation practices and student outcomes. These researchers created a conceptual framework after determining not a single design existed for all specialized STEM schools. However, they did determine a shared set of components existing in all these schools. Lynch et al. (2013) identified ten shared components. These ten components include: (a) STEM-focused curriculum (Atkinson et al., 2007; Brody, 2006; Lynch et al., 2013; Subotnik et al., 2010), (b) reform instructional strategies (Atkinson et al., 2007; Lynch et al., 2013; Subotnik et al., 2010), (c) integrated and innovative technology use (Atkinson et al., 2007; Lynch et al., 2013), (d) blended formal and informal learning (Lynch et al., 2013; PCAST, 2010), (e) real-world STEM partnerships (Atkinson et al., 2007; Brody, 2006; Lynch et al., 2013; Stone III, 2011; Subotnik et al., 2010), (f) early college-level coursework (Atkinson et al., 2007; Lynch et al., 2013), (g) well-prepared STEM teaching staff (Lynch et al., 2013; Subotnik et al., 2010), (h) inclusive STEM mission (Lynch et al., 2013; PCAST, 2010), (i) administrative structure (Lynch et al., 2013), and (j) support for underrepresented students (Lynch et al., 2013).

According to Lynch and her colleagues (2013), these components are critical in creating specialized STEM schools, which are successful in assisting students’ mastery of STEM knowledge. In developing these components, the authors began with a conceptual framework for specialized STEM schools patterned on ISHS. These schools were chosen due to their mission of serving historically underrepresented student populations.

The U.S. Department of Commerce’s (2011) projections regarding opening job occupations related to STEM in this decade directed education leaders and policymakers to include minority groups, such as female or underrepresented ethnic groups, into the STEM pipeline. Their recommendation for education leaders and policymakers was to first understand the demographics of students attending specialized STEM schools (Rogers-Chapman, 2013). However, studies reporting genders, ethnicities, or socioeconomic levels of students attending specialized STEM schools are limited.

Demographics of Students Attending Specialized STEM Schools

According to the NSF (2013), females constitute a small portion of the STEM workforce in the U.S. (see Table 1.1, Chapter I). However, females in the U.S. constitute half the population (see Table 1.2, Chapter I). A recent study in STEM education suggested gender plays no role in students’ learning; however, females are less likely to earn baccalaureate degrees related to STEM or continue in the STEM pipeline (Tyson et al., 2007). Additionally, a recent report indicated as much as half of 9th grade students enrolled in ISHS were female (Young et al., 2010).

NSF (2013) also reported the distribution of ethnicity for U.S. job occupations related to STEM, which were 69% for Whites, 5% for African Americans, 6% for Hispanics, 18% for Asians, and 2% for others (see Table 1.1, Chapter I). As indicated in the table, non-Whites are not represented adequately in job occupations related to

STEM. In a study on ethnicity of students attending specialized STEM schools, the average percentage of White/Caucasian students enrolled in 15 residential STEM schools was 70% in 2008, while the percentages were 11% for African Americans, 3% for Hispanics, 14% for Asians, and 2% for Native Americans (Jones, 2010). Percentages from this study are very similar to those reported by the NSF in 2013. Another study exploring the STEM related achievement gap among different ethnic groups in high school reported African American and Hispanic students underperforming White and Asian students (Tyson et al., 2007).

Rogers-Chapman (2013) conducted a study on ethnicity and socioeconomic levels of students attending specialized STEM schools. Using Common Core Data from 2007, difference means test analyses indicated student populations in inclusive STEM schools was three times larger than populations in selective STEM schools. Researchers reporting on the 221 inclusive STEM schools found 33% of students were from the low socioeconomic status, while 40% of students were from the low socioeconomic status that attended one of the 52 selective STEM schools. However, the distribution of ethnicity for students in both school types was similar. For example, averages within inclusive STEM schools’ population were 24% white, 45% African American, 20% Hispanic, 10% Asian, and 1% other students. Similarly, averages within selective STEM schools’ population were 25% white, 41% African American, 29% Hispanic, 4% Asian, and 1% other students.

Overall, research results suggest students from historically underrepresented groups (i.e., female, African American, Hispanic, or low SES) earn STEM degrees at lower rates than students from highly represented groups (i.e., male, White, Asian, or high SES; Tyson et al., 2007). Disparities in earning STEM degrees go beyond student demographic characteristics. Other factors also include course taking opportunities and parental involvement (Cole, 2008; Griffith, 2010; Rogers-Chapman, 2013). Specialized STEM schools are designed to reduce the influence of students' demographic characteristics and other factors by providing equitable learning opportunities for all students (Lee, 2011). One question remains unanswered; do specialized STEM schools prepare students for college? In research, this preparation for students is described as college and career readiness.

College and Career Readiness of Students Attending Specialized STEM Schools

In 2010, a blueprint for U.S. educational reform focused on college and career readiness of students. This blueprint resulted from 40% of college freshman students taking remedial courses (U.S. Department of Education, 2010). To address this issue and prepare all students for college and career, the U.S. federal government reauthorized the Elementary and Secondary Education Act (ESEA). Primary changes in the ESEA include (a) raised standards in English language arts and mathematics, (b) reformed assessments aligned with college and career readiness standards (CCRS), and (c) structured reward system for schools and districts. The blueprint for changes to the ESEA also suggested a support system, which would include (a) improved support for teachers through professional development workshops, (b) enriched instruction for less successful schools, and (c) increased flexibility for schools and districts. Finally, this blueprint suggested every state continue implementing science standards and assessments. Researchers have yet to determine if the changes made in the ESEA have prepared students for college and career.

In 2008, the Texas legislature passed the “Advancement of College Readiness in Curriculum” bill to increase the number of students ready for college and career (Educational Policy Improvement Center [EPIC], 2009). In accordance with the bill, a team of experienced educators and university faculty gathered to define new CCRS for English language arts, mathematics, science, and social studies courses. The purpose of new CCRS in Texas was to prepare students to succeed in college. These courses, designed according to CCRS, help students gain a set of core knowledge and skills, so that they can succeed in any chosen college major. According to authors of the CCRS, students actualizing each standard would be prepared for college and career.

The focus for the new generation of specialized STEM schools is to reduce disparities among underrepresented groups and prepare these students for college and career. Specialized STEM schools achieve this focus by: (a) admitting higher rates of students from historically underrepresented groups, (b) encouraging female students to participate in extracurricular activities related to STEM, and (c) cooperating with role models from historically underrepresented groups. Specialized STEM schools reflecting the focus of reducing disparities among historically underrepresented groups are described as inclusive STEM schools. Means et al. (2013) compared the college-related interests of students attending inclusive STEM schools and traditional schools. Research findings from 1,719 9th graders in inclusive STEM schools and 3,359 in traditional schools suggested students from inclusive STEM schools are more interested in STEM subjects than students from traditional schools. These students (i.e., students from inclusive STEM schools) were also more confident about graduating from high school and earning a baccalaureate degree. Other differences between inclusive STEM schools and traditional high schools identified in the comparison indicated students from inclusive STEM schools enrolled in more college preparatory courses in STEM disciplines, showed more interest in graduate school education (44% and 33%, respectively), and were more likely to enroll as engineering majors in college (26% and 18%, respectively).

Findings from another study on students' achievement in the state of Texas showed students in 9th grade from T-STEM academies performed slightly better on the mathematics state test and 10th grade students performed better on both the mathematics and science state tests. However, effect sizes showed differences were not very big, ranging from 0.12 to 0.17. Also, 9th grade students in T-STEM academies were 1.8 times more likely to meet the benchmarks of Texas Assessment of Knowledge and Skills (TAKS) mathematics and reading comparing to other schools. Similarly, 10th graders in T-STEM academies were 1.5 times more likely to pass TAKS in all four domains. In addition, 9th grade students in T-STEM academies were 0.8 times less likely to be absent from school. For other grade levels, there were no statistically significant differences between students in T-STEM academies and comparison schools. All the findings in this study suggest students benefit from T-STEM academies in certain subjects instead of an overall improvement (Young et al., 2011).

In another study of schools in the NCSSSMST, 1,032 students in specialized STEM schools were followed post graduation (Thomas, 2000; Thomas & Love, 2002; Thomas & Williams, 2010). For all participants, 75% indicated a desire to continue education beyond high school and 40% planned to obtain a doctorate degree. 51% of students who graduated from specialized STEM schools pursued a science major in college. Results from this study suggested 10% of students who graduated from specialized STEM schools went on to major in mathematics. In addition, results of this study indicated 60% of college freshman participants expected to earn a STEM degree and 55% of college senior participants were about to earn a STEM degree (Thomas, 2000).

Conceptual Framework for Specialized STEM Schools

Demographic studies confirm that a number of schools in the 21st century have focused on STEM disciplines. Many researchers in the last decade have studied these schools. These schools were first introduced by education leaders and policymakers at the beginning of 20th century (Thomas & Williams, 2010). Both groups (i.e., researchers as well as education leaders and policymakers) now express concern about the adequacy of existing specialized STEM schools meeting the needs of the U.S. workforce (U.S. Department of Commerce, 2011). Unfortunately, education leaders and policymakers differ with researchers on how to meet the needs of the workforce with future schools.

If the problem of adequacy is related to quantity, education leaders and policymakers believe opening (1000 schools) new specialized STEM schools would be an effective response (PCAST, 2010). Conversely, if the problem is related to quality, researchers believe increasing the quality of existing specialized STEM schools would be equally effective (Lynch et al., 2013). Regardless, the problem of adequacy is likely to persist. Mindful that each specialized STEM school should have a learning environment specific to itself, as stated at the beginning of this literature review, I synthesized the literature related to specialized STEM schools and conceptualized an effective learning environment for future directions of these schools.

In my conceptual framework, I modify Weaver-Hightower's (2008) ecology metaphor for learning environments. This ecological metaphor addresses learning environments as systems with components of actors, contextual factors, and actions working interdependently. As within natural systems in which living organisms interact among themselves; actors within school learning elements also interact among themselves. For example, students and teachers interact to achieve a common learning goal. In addition, contextual factors such as boundaries are facets of ecosystems in which actors perform actions. For example, classrooms are contextual factors for formal learning. Finally, actions in ecosystems such as cooperation are transferable in understanding the complex interactions among actors. For example, students cooperate in groups to finalize a project (Erdogan, Bozeman, & Stuessy, 2013).

As I identified in the Background of Specialized STEM Schools section, these schools were created by stakeholders (i.e., education leaders and policymakers) to address STEM education. However, in doing so, other stakeholders (i.e., researchers) claim these same schools have failed to address all STEM disciplines. This claim has led researchers to suggest new conceptual frameworks (Lynch et al., 2013; Marshall, 2010).

These frameworks create environments, which contribute to students' outcomes. In this theoretical study, I combine components of specialized STEM schools into my conceptual framework. I name this conceptual framework "collaborative actions of community" (see Figure 2.2).

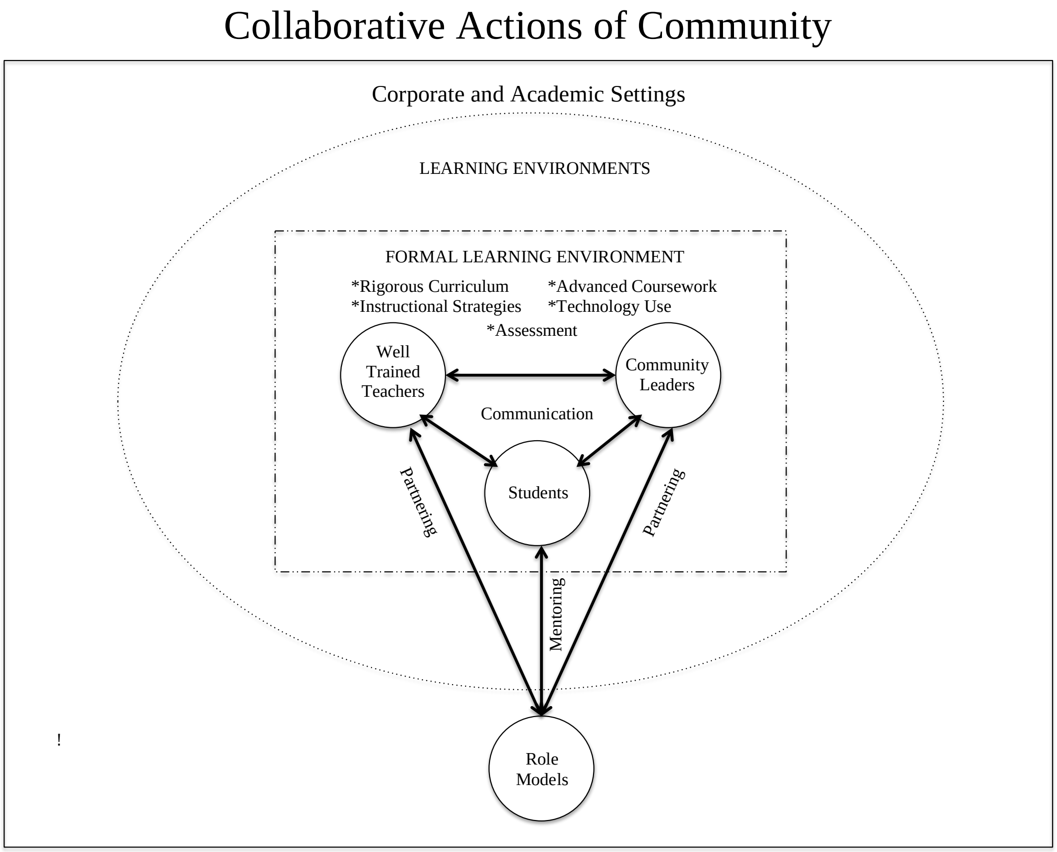

Figure 2.2. Conceptual framework of effective learning environments for specialized STEM schools.

In the school ecology framework, the components of specialized STEM schools can be grouped under three categories: (a) Actors, (b) Contextual Factors, and (c) Actions (Erdogan et al., 2013; Weaver-Hightower, 2008). These three categories in my framework constitute the skeletal structure of a specialized STEM school (Eisenhart, 1991). This framework, as a guide for establishing specialized STEM schools, can be read top-down. To better understand the conceptual framework, a closer look is necessary.

Actors

Actors within an ecosystem play individual roles while also depending on others (Weaver-Hightower, 2008). In schools, as well, actors perform social roles in carrying out the process of education. Actors in this framework include students, teachers, community leaders, and role models (see Figure 2.2). Students serve as the primary actors in this framework whereas teachers, administrators, and other actors serve as support for the development of students. It should also be noted an actor can perform more than one role at a time (Weaver-Hightower, 2008). For example, teachers can teach students in the classroom and be trained by role models outside the classroom.

Students, as actors, are at the center of my school ecology framework (see Figure 2.2). Rallis (1995) indicated a learner-centered school provides students with the truest opportunities for asking questions and finding solutions under the supervision of teachers. This would suggest in such a school that curiosity would lead students to (a) pose questions, (b) make observations, (c) collect data, (d) interpret data, (e) take risks, (f) test conclusions, and (g) be creative. Teachers, in such a school, would be more flexible in tolerating students' mistakes from taking these opportunities. Finally, as this framework suggests, actors in a learner-centered school would be more likely to accept change but not likely to accept the status quo (Rallis, 1995).

Teachers, as actors, are another component in the framework (see Figure 2.2). Rallis, Rossman, Phlegar, and Abeille (1995) stated well-trained teachers in specialized STEM schools are expected to (a) master domain and instructional strategies, (b) dedicate themselves to teaching, (c) facilitate learning in the classroom, (d) challenge students' minds, (e) connect students with the community, (f) use technology effectively in the classroom, and (g) become school leaders. Teachers, in such a school, may be given opportunities to update knowledge and skills by attending professional development workshops. Finally, in this framework, actors are likely to accept teachers as the leaders of change (Rallis, 1995).

Other actors within the school ecology framework include community leaders (see Figure 2.2), which include, but are not limited to, student leaders, teacher leaders, staff, administrators, and parents. Community leaders form a unique school culture around meaningful goals and shared values to reach learning, reform, and achievement (Deal & Peterson, 1999). They also may link students, teachers, staff, administrators, parents, and other actors of the community. For a better learning environment, community leaders may especially encourage teachers to take responsibilities by (a) communicating, (b) supporting, (c) giving more power, (d) involving in decision-making process, and (e) appreciating them. When teachers take these responsibilities, they are likely to improve teaching and learning conditions, lead reforms, and exalt the profession of teaching (Barth, 1988). Finally, community leaders and teachers can be trained by or partner with other actors, role models who are another essential component of this framework.

Role models within the framework include, but are not limited to, university faculty members, technicians in labs, business or industry leaders, other STEM professionals, and parents (see Figure 2.2; Lynch et al., 2013). Role models may represent a motivational factor and guidance for students and teachers. Role models can interact with students and teachers via an internship or apprenticeship program regardless of school boundaries. Immersing students in a real life experience via internship with role models may be the most effective way to show the implementation of what they learn in classrooms. Immersion can also be beneficial to maintain students' interest in STEM and keep it as high as possible (Lee, 2011; Marshall, 2010; Subotnik et al., 2011). As well as actors, the contextual factors are important to fully grasp the school ecology framework.

Contextual Factors

Contextual factors within an ecosystem provide extant conditions (i.e., boundaries, pressures, inputs, and consumption; Weaver-Hightower, 2008). In schools, the primary contextual factors in my school ecology framework are the learning environments (see Figure 2.2). In specialized STEM schools, formal and informal learning environments should not be separated with certain boundaries. Instead, actors should use them in harmony (Lynch et al., 2013; Marshall, 2010; Subotnik et al., 2011). In the framework, a rectangular shape with dashed line was used to define formal learning environment and an elliptical shape with dashed line for informal learning environment. Dashed lines represent the idea that learning should not be limited with the schools. Students, as this framework suggests, should be encouraged to seek knowledge in other environments as well. For example, students who are seeking solution for a problem may carry out their projects after school hours and get help from a role model. These projects can determine students' grades and later they can present their projects in a science fair in the school. Lastly, within the formal learning environment, other contextual factors are likely to play vital roles.

Other factors in the framework are rigorous curriculum and instructional strategies (see Figure 2.2; Lynch et al., 2013; Marshall, 2010; Subotnik et al., 2011). Setting standards high may not create any change unless a rigorous curriculum integrating STEM disciplines accompany them (Haycock, 2001). A rigorous curriculum should (a) prioritize standards, (b) name each unit, (c) assign standards to the units, (d) construct a calendar, (e) include effective teaching strategies, (f) integrate formative assessment, (g) create pre- and post-unit summative assessment, and (h) provide remediation intervention before each unit (Ainsworth, 2010). Instructional strategies, such as project-based learning, emerged with reforms and aligned with rigorous curriculum are also essential components of this framework. Teaching and learning in STEM disciplines may require such instructional strategies that provide immersion and continuity. In addition, integrating one or more STEM disciplines may not be actualized with traditional instructional strategies. Finally, the framework suggests rigorous curriculum and instructional strategies of change should meet in advanced coursework.

Another contextual factor in this framework is advanced coursework in which connections made among STEM disciplines (see Figure 2.2). Such coursework is necessary to prepare students for college (Lynch et al., 2013; Subotnik et al., 2011). In college, students may not complete their program when they are faced with challenging curriculum. Studies also show students who take advanced coursework are performing better on standard tests (NAEP) and are more likely to obtain STEM degrees (Haycock, 2001; Schmidt, 2011; Tyson et al., 2007). Looking from the reverse perspective, students who take low level coursework perform lower on standard tests (NAEP; Haycock, 2001). Lastly, as this framework suggests, integration of technology into advanced courses may increase efficiency of learning.

Technology resources are another contextual factor in the school ecology framework (see Figure 2.2). Researchers have indicated technology is highly important when teaching and learning occur based on inquiry (Lynch et al., 2013; Marshall, 2010; Subotnik et al., 2011). In a technology driven society, technologically driven practices need to be included in the classroom practice. With the help of technology, students can quickly access information and their mentors while conducting research. Unlike the days when technological devices were rare, teachers and students are likely to have easy access to computers and other tools today. Therefore, the lack of technology is not presently a problem. However, the problem is how teachers integrate technology into their practices (Richardson, 2012). For this aim, the framework suggests teachers should be well trained with technology use in their classrooms. Finally, they should receive constant instructional guidance from professionals. All the contextual factors mentioned above are meaningful when actors in the school ecology framework use them in collaboration.

Collaborative Actions

Collaborative actions within an ecosystem are defined as relationships of actors (Weaver-Hightower, 2008). Collaborative actions of actors, in the school ecology framework, include teaching, learning, immersion, communication, partnering, mentoring, support, and assessment (see Figure 2.2). All actions in the framework emerge as a result of cooperation and symbiosis among actors rather than competition and predation as in the natural sciences (Weaver-Hightower, 2008).

Communication, one of the actions coming into prominence in the framework, can be established inside and outside the classroom (see Figure 2.2). Research shows two exemplifying characteristics of highly successful and highly diverse schools are open communication channels and shared responsibilities (Erdogan et al., 2013). Another research states students take advantage of learning opportunities when teachers explicitly indicate the rules and norms for classroom behavior and academic achievement (Lee, 2011). Finally, actors outside the school, in this framework, can also be in this communication loop.

Partnering is another prominent action in the school ecology framework (see Figure 2.2). Particularly, teachers and community leaders partner with role models (Lee, 2011; Marshall, 2010; Subotnik et al., 2010). Inquiry and research in cross-disciplinary STEM areas require more support not only from teachers but also from parents and other STEM professionals (Marshall, 2010). For example, teachers and community leaders within the framework can partner with university faculty members, technicians, business/industry leaders, other STEM professionals, and parents. Finally, role models in partnering organizations help students decide to pursue STEM majors and careers.

Mentoring can be counted as one of the collaborative actions in the school ecology framework (see Figure 2.2; Brody, 2006). Subotnik et al. (2010) indicated students have stereotypes that discourage them from pursuing a STEM degree. Therefore, mentoring can positively affect the scientist image in students' minds. Also, supporting students from underrepresented groups via mentoring may ensure they will pursue STEM majors and careers (Lynch et al., 2013). In addition, mentor-guided studies prepare students for college. Finally, another form of support, as this framework suggests, is assessment.

Both formative and summative assessments are essential collaborative actions in this framework (see Figure 2.2). Duschl, Schweingruber, and Shouse (2007) stated formative assessment is important to facilitate teaching and learning rather than to measure students' learning. Therefore, teachers can use their formative assessment skills by integrating them into their instructional practices. Researchers indicated formative assessment addresses each student's needs and moves them toward meaningful learning goals (Duschl et al., 2007; Minstrell et al., 2011). Therefore, using formative assessment as a support for students' development may help teachers to close the achievement gap in the classroom. For validation of students' learning, summative assessment can still be used. However, a variety of summative assessment, such as open-ended questions, multiple choice tests, essays, reports, portfolios, presentations, and oral examinations, may be necessary to allow for student improvement (Harlen & James, 1997).

Implications of The School Ecology Metaphor

Weaver-Hightower (2008) used an ecology metaphor to describe school policy ecology. Stakeholders (i.e., education leaders, policymakers, and researchers) with an interest in STEM education can use this same metaphor to describe specialized STEM schools. This metaphor, used as a school ecology framework, provides benefits for stakeholders in STEM education who wish to (a) define strategies to solve problems from a broader perspective, (b) identify actors and actions in learning environments, (c) respond to key arguments from actors within the different learning environments, (d) reveal relationships among and between the actors, and (e) determine strategic flaws or opportunities in the system. Taken together, these benefits should help education leaders, policymakers, and researchers analyze the school ecology metaphor. Education leaders, policymakers, and researchers should not forget; specialized STEM schools are dynamic. As a result, these schools are likely to change. However, these stakeholders should also not forget; making a single change in one dimension of the school ecology can have large-scale effect. Therefore, education leaders, policymakers, and researchers should consider interventions at many levels within the school ecology (Weaver-Hightower, 2008).

Conclusion

In this literature review, I focused on specialized STEM schools to answer six questions. These questions were related to the historical background of and learning environments found within these schools as well as the demographic characteristics and college and career readiness of students within these schools. I found these schools are unique and comprehensive environments. In addition, I found critical design components for these schools. Also, three common models are used to describe these schools. Students from all ethnic backgrounds are likely to benefit from attending these schools but may not necessarily pursue STEM education in college. Finally, students attending specialized STEM schools are more likely to actualize college goals when compared to peers from regular schools.

Scholars' theoretical ideas and empirical findings contributed to this literature review. Participatory research on these schools provides engagement and negotiation for researchers. I contend the school ecology metaphor can contribute to expanding definitions for these schools and understanding of who is involved in learning environments. However, caution must be used when making inferences for specific learning environments from broad generalizations about actors, contextual factors, and actions. Unintended consequences may result without regard for the specific environments.

In the next chapter, I examine the achievement outcomes for students attending ISHS. In examining these outcomes, I use students' high-stake test results and demographic variables to compare students attending either T-STEM or traditional schools. I conclude this chapter with recommendations for stakeholders involved in the reform of STEM education.

CHAPTER III

EXAMINING INCLUSIVE STEM SCHOOLS' ROLE IN THE COLLEGE AND CAREER READINESS OF STUDENTS: A MULTI-GROUP ANALYSIS OF STUDENTS' ACHIEVEMENT OUTCOMES

Occupations in the 21st century increasingly require science, technology, engineering, and mathematics (STEM) knowledge (NRC, 2011). This demand is projected to continue during the next decade. However, the education system in the U.S. has not prepared enough students to fill those occupations requiring STEM knowledge (National Science Foundation [NSF], 2012; U.S. Department of Commerce, 2011). Until recently, U.S. businesses have managed to fill these occupations by importing students from other countries. However, this strategy has become outdated because of increased opportunities for similar occupations in other countries (Atkinson, Hugo, Lundgren, Shapiro, & Thomas, 2007). As a result, the shortage of workers with STEM knowledge has caused stress on U.S. businesses.

Policymakers in the U.S., realizing the importance of the situation, developed new strategies for increasing the number of students to fill occupations requiring STEM knowledge (NRC, 2011). The first of these strategies included: (a) improving the degree of training for STEM related careers, (b) increasing the number of people for the workforce, and (c) generating a more scientifically literate population (NRC, 2011). With these and other strategies, specific recommendations for increasing students, included: (a) creation of state-level mathematics and science standards, (b) recruitment and training of 100,000 STEM teachers over the next decade, (c) recognition for STEM teachers, (d) expansion of educational technology, (e) creation of extra-curricular opportunities for students, (f) creation of 1,000 new STEM-focused schools, and (g) provision of strong and strategic leadership (PCAST, 2010). The PCAST authors identified specialized STEM schools as the most prominent recommendation.

In the last decade, most stakeholders (i.e., education leaders, policymakers, and researchers) agreed specialized STEM schools provided an optimum way for addressing the issue of reform for STEM education within the U.S. education system. In describing these schools, the NRC adopted a typology for identifying specialized schools. The NRC (2011) categorized specialized STEM schools under three headings: (a) selective STEM schools, (b) inclusive STEM schools, and (c) schools with STEM-focused career and technical education (CTE). Selective STEM schools serve students with aptitude and interest in STEM knowledge. These schools have certain admission criteria (e.g., past academic achievement; NRC, 2011; Subotnik et al., 2011). Inclusive STEM schools serve similar students; however, these schools have no admission criteria (NRC, 2011; Young et al., 2011). Schools with STEM-focused CTE serve at-risk students for dropping out of school and accept students based on no criteria (NRC, 2011; Stone III, 2011).

Based on the above discussion, two problems arise to guide this study. The first problem is the blurred success of these schools at preparing students for college and career in STEM fields. Although a large amount of money has been invested in these schools, the success of these schools in preparing students is an unanswered question.

The second problem involves better understanding of how students' demographics correspond with students' success on different achievement measures. These two problems suggest stakeholders have more to learn about the success of specialized STEM schools and the influence of students' demographics on students' performance on achievement measures.

The purpose of this study is to measure the college readiness of inclusive STEM high school (ISHS) graduates in comparison to traditional high school graduates. Schools classified as ISHS were chosen to represent a new school typology having the potential to direct females, minorities, and students with disabilities into STEM related careers. While evaluations and research are limited (Means et al., 2013; Thomas & Williams, 2010; Young et al., 2011), policymakers continue to promote and expand STEM schools across the U.S. (PCAST, 2010). In order to explore the success of these schools, this study will be guided by the following research questions:

1. How do students from ISHS and traditional high schools in Texas compare on achievement outcomes in reading, mathematics, and science?
2. For students attending ISHS in Texas, how do gender, ethnicity, socioeconomic status, and special education status associate with their achievement measures? Are these associations comparable to students attending traditional high schools in Texas?

Figure 3.1 demonstrates the multi group model for this study, linking students' achievement outcomes and demographics. This figure helps visualize how achievement outcomes of students in each school will be compared and how students' demographics correspond with these outcomes. A detailed explanation is presented in the data analysis section.

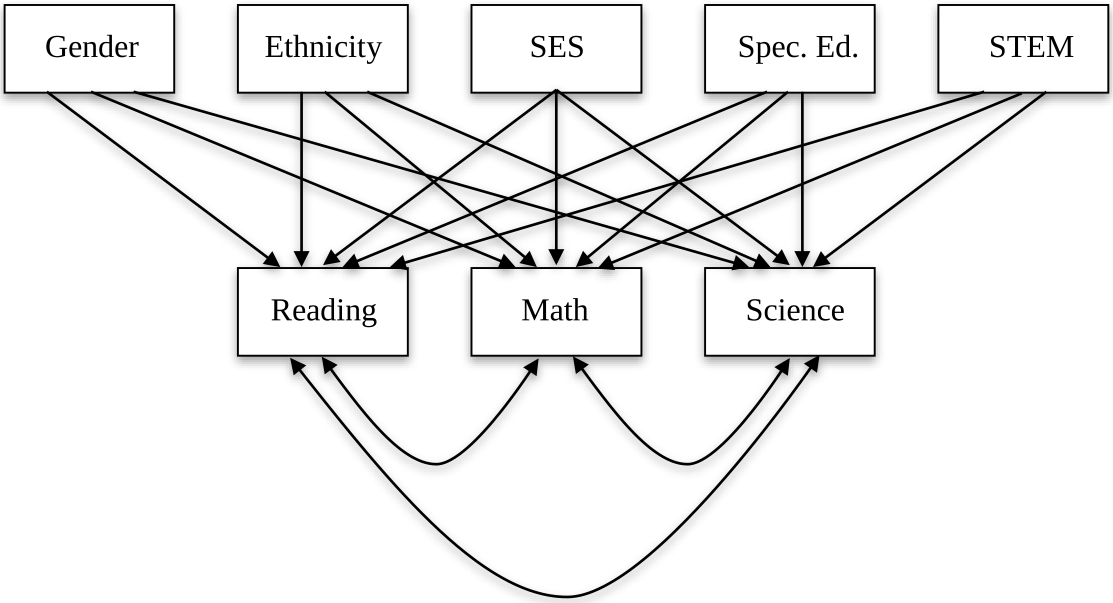

Figure 3.1. Diagram for multi group model.

Literature Review

The primary objective of all specialized STEM schools is to prepare students for college and careers in STEM fields, especially those students from historically underrepresented populations. To understand how these schools perform, Young et al. (2011) compared achievement outcomes of students attending either inclusive STEM or traditional schools in Texas. When comparing students in grade 9 attending inclusive STEM or traditional schools, Young et al. found students from inclusive STEM schools performed slightly better on mathematics high-stake test, were 1.8 times more likely to meet benchmarks for reading and mathematics high-stake tests, and were 0.8 times less likely to be absent from school. In addition, students in grade 10 attending inclusive STEM schools performed better on both mathematics and science high-stake tests and were 1.5 times more likely to meet benchmarks for reading, mathematics, science, and history high-stake tests. Effect sizes indicated these differences, although statistically significant, were small. Finally, there were no statistically significant differences at any other grade level, suggesting limited benefit from inclusive STEM schools.

In another study, Means et al. (2013) compared students attending either inclusive STEM or traditional schools on interest in STEM subjects and college matriculation. Results indicated students in grade 9 attending inclusive STEM schools were more interested in STEM subjects than similar students attending traditional schools. In addition, students attending inclusive STEM schools exhibited more confidence about earning high school and college diplomas than students attending traditional schools. Other findings in this study revealed students from inclusive STEM schools enrolled in more college preparatory courses within STEM disciplines, exhibited more interest in graduate school, and were more likely to enroll as STEM majors in college.

Thomas and Williams (2010), in another study, tracked students had graduated from specialized STEM schools situated in the U.S. Of the 1,032 students in their study, 75% planned to continue formal education after high school and 40% planned to earn a doctorate degree. For these same participants, 51% pursued a science major and 10% pursued a mathematics major in college. Finally, findings showed 60% anticipated earning a STEM degree as college freshman while 55% earned a STEM degree as college seniors.

T-STEM Schools

Currently, high schools in Texas serve over one million students of which at least 80% are categorized as Hispanic or White (TEA, 2014b). The focus of this study is on the inclusive STEM schools initiative in Texas, which emphasizes the STEM education of historically underrepresented student populations. These schools also emphasize the students' college readiness and preparation for careers in STEM occupations. As a result of the STEM schools initiative, seven T-STEM schools were founded in Texas during the 2006-07 academic year. As of the 2013-14 academic year, 65 of these schools exist in Texas to serve a population of over 35,000 students. Funding for these schools has reached $133 million to date, which is more than same size traditional schools received, and turned these schools into the largest investment for inclusive STEM high schools (ISHS) in the larger U.S. education system. Also, T-STEM schools are supported by partnerships with seven T-STEM centers, helping to create instructional materials and provide professional development workshops for over 2,800 teachers (TEA, 2013). The T-STEM schools were designed and implemented using a detailed blueprint, requiring students to (a) participate in a college preparatory curriculum, (b) develop real world relevant practices, (c) learn in a strong academic support system, and (d) master a wide range of STEM coursework (Avery, Chambliss, Pruiett, & Stotts, 2010; NRC, 2011; Young et al., 2011). The primary objective in the mission statement for these schools is to prepare students for college and careers in STEM fields.

College and Career Readiness Standards

In 2010, U.S. Department of Education set a clear goal for America's educational system, college and career ready high school graduates. However, state standards for college and career readiness did not align with the knowledge and skills necessary for success post graduation. Statistics showed 40% of college freshman students from both 2- and 4-year institutions enroll in remedial courses (U.S. Department of Education, 2010). Although states also designed new assessments along with standards, these assessments were deemed inadequate at measuring students' knowledge and skills (U.S. Department of Education, 2010). To tackle the problem, the U.S. federal government developed a new approach. This approach included (a) supporting state standards for college and career readiness, (b) rewarding schools making progress, and (c) paying specific attention to the lowest-performing schools. The governments' first action in support of this approach was to reauthorize the Elementary and Secondary Education Act (ESEA; U.S. Department of Education, 2010). Essential changes in the ESEA included (a) rigorous standards in English language arts and mathematics, (b) reformed assessments aligned with college and career readiness standards (CCRS), and (c) structured reward system for schools and districts. Other changes in the ESEA recommended a support system, including: (a) improved support for teachers through professional development workshops, (b) enriched instruction for lowest-performing schools, and (c) increased flexibility for schools and districts. Final recommendation for states was to continue implementing science standards and assessments (U.S. Department of Education, 2010). Yet, the efficacy of the new approach has yet to be evaluated in terms of preparing students for college and career.

In 2008, Texas focused on increasing the number of high school graduates who were college and career ready. Despite the progress Texas' students have made in elementary and middle schools, the state trails other states in preparing students for college and career. Therefore, the Texas legislature passed the "Advancement of College Readiness in Curriculum" bill (EPIC, 2009). This bill required authorities to gather a team of experienced educators and university faculty to develop CCRS in English language arts, mathematics, science, and social studies. The main objective of these standards was to help students gain knowledge and skills necessary for college and career. Specifically, the courses designed with CCRS are intended to give students a set of core knowledge and skills across four subject areas (i.e., English, Social Studies, Mathematics, and Science). According to the CCRS team, the more standards students actualize, the more likely they would be ready for college and career (EPIC, 2009).

Methodology

A quasi-experimental design was used to compare student outcomes from two different school types, T-STEM and traditional high schools (Campbell, Stanley, & Gage, 1963). In an attempt to answer the research questions listed above, I obtained achievement data through the Public Information Request system of TEA for 28,159 students in grade 11 attending one of 106 schools identified as either T-STEM or traditional. In addition, students' demographic information was collected from the TEA using the same procedure. Student achievement was measured using scores on the Texas Assessment of Knowledge and Skills (TAKS) for reading, mathematics, and science. To examine associations between students' achievement and demographic variables, I used both descriptive and multi group analysis. In the next sections, I present information regarding this study's participants, measurements, data analyses, and limitations.

Participants

The participants for my analyses came from two separate data streams within the TEA. Participants included 28,159 students in grade 11 and 106 schools identified as either T-STEM or traditional. Student level data included students' TAKS scores and demographic information. The TAKS scores represent standardized measures for students' mastery of reading, mathematics, history, and science content. Students' demographic information included values for (a) gender, (b) ethnicity, (c) socioeconomic status, (d) English language proficiency, (e) English as second language, (f) special education status, and (g) at risk status. After obtaining data for both participant sets, I compiled all data into two linked datasets.

Although 65 T-STEM schools have been founded under the Texas High School Project (THSP), only 53 such schools were identified from the student dataset. Data for students in grade 11 from the student dataset were chosen because students at this grade level take three of the four state achievement tests (i.e., reading, mathematics, and science). Variables of no concern to this study were removed from the dataset. Variables of concern were categorically coded, including students' gender (Female=1, Male=0), socioeconomic status (Free meals, reduced-price meals, other economical disadvantages=1, Not disadvantaged=0), and special education status (Special education=1, Not special education=0). The variable for students' ethnicity was dummy coded by declaring White ethnicity as the reference.

In a quasi-experimental study, results for the treatment group often find more meaning when a comparison of these results is conducted using data from a common or well-known group (Creswell, 2013). In my analyses, a sample of traditional schools from the population of all Texas schools not designated as T-STEM, but likely designated as high school, were used for comparative purposes. As a result, all schools (*N*=8,529) in Texas were identified from the TEA website. After elimination of elementary, middle, charter, and alternative schools (i.e., night schools, T-STEM schools, Early College High Schools, recovery schools, and magnet schools), 1,309 schools remained. For analysis purposes, I chose a sample of 53 schools from the population of 1,309 traditional schools serving students in grade 11. I applied a probability stratified sampling procedure by dividing T-STEM schools into four groups according to White student percentage (1=0-24%, 2=25%-49%, 3=50%-74%, 4=75%-

100%). The first group had 34 T-STEM schools, the second group had 9 such schools, the third group had 7 schools, and the fourth group had 3 schools. The 1,309 traditional schools were grouped using the same method. From each group a similar number of traditional schools were randomly selected. After 53 traditional schools were identified, achievement and demographic data for students in grade 11 at these schools were pulled from the TEA student dataset. Variables for comparison schools were also coded using the same method as in the T-STEM school dataset. In these two datasets, the new variable “STEM” was created to distinguish T-STEM schools from traditional schools. Finally, the two datasets were combined into one database for conducting analyses.

Tables 3.1 through 3.4 presents cross distributions for students’ school type and demographic categorizations (i.e., gender, ethnicity, socioeconomic status [SES], and special education status). Each of the tables provides information describing relationships between students’ school type and common demographic categorizations found in many education policy studies (Bozeman, Scogin, & Stuessy, 2013). The information in these tables suggests traditional schools serve more students but similar distributions across the categorizations for gender, ethnicity, SES, and special education status.

Table 3.1

Cross Distribution of School Type and Gender

School Type	Student Gender Male	 Female	Total
Traditional	9,646	9,509	19,155
T-STEM	4,647	4,357	9,004
Total	14,293	13,866	28,159

Table 3.2

Cross Distribution of School Type and Ethnicity

	Student Ethnicity							
School Type	Asian	African American	Hispanic	Indian	Pacific Islander	Two or More Races	White	Total
Traditional	685	2,900	11,608	66	21	265	3,610	19,155
T-STEM	501	1,413	5,251	31	11	121	1,676	9,004
Total	1,186	4,313	16,859	97	32	386	5,286	28,159

Table 3.3

Cross Distribution of School Type and Socioeconomic Status

	Student Socioeconomic Status		
School Type	No	Yes	Total
Traditional	7,564	11,591	19,155
T-STEM	3,308	5,696	9,004
Total	10,872	17,287	28,159

Table 3.4

Cross Distribution of School Type and Special Education Status

	Student Special Education Status		
School Type	No	Yes	Total
Traditional	17,565	1,590	19,155
T-STEM	8,329	675	9,004
Total	25,894	2,265	28,159

Measurements

High-stake tests have been used for a number of decades to direct education policy (Heubert & Hauser, 1998). Results from high-stake tests have specifically been used to determine the success for students' schools, programs, and classrooms. These tests have also been used as indicators for students' college and career readiness. Until recently, the high-stake test accepted by most stakeholders in Texas was the Texas Assessment of Knowledge and Skills (TAKS; TEA, 2014a). TAKS measures students' achievement from grade 3 through graduation across four academic disciplines (i.e., reading, mathematics, science, and social studies). However, these disciplines are not assessed at each grade. For example, students' achievement in the science discipline is assessed at grades 5, 8, 10, and 11. In this study, I chose grade 11 because students' achievement in three disciplines (i.e., reading, mathematics, and science) are assessed contemporaneously. TAKS results for these three disciplines can be a useful indicator to make decisions regarding students' college and career readiness. The TEA replaced TAKS with the State of Texas Assessments of Academic Readiness (STAAR) in 2012. However, this replacement was progressive, as a result in the 2012-13 academic year 11th graders were still taking the TAKS exam. Therefore, I used TAKS results instead of STAAR. In the next section, I discuss missing data methods applied in this study.

Missing Data

As in most quasi-experimental studies using large datasets, my study has missing data. The missing data in my study are found within both independent variables and dependent variables. To address missing data within independent variables, I chose the listwise deletion method for the 32 cases missing data describing gender, ethnicity, SES, or special education. To address missing data within dependent variables, I considered four options: (a) listwise deletion, (b) mean replacement, (c) maximum likelihood, and (d) multiple imputation. I chose multiple imputation as this method provides unbiased parameter estimates while addressing missing data (Graham, Olchowski, & Gilreath, 2007). To implement this method I used Mplus version 7 (see Appendix A). The strategy to analyze this dataset is described in the next section.

Data Analyses

Two analysis methods were used to answer the two research questions in this study: descriptive and multi group analyses. For this purpose, I used Mplus 7 to calculate means and standard deviations (*SD*) as well as conduct the multi group analysis. I chose descriptive analysis to describe the center and spread of continuous data and frequency distribution of categorical data. I chose multi group analysis because of the following reasons: (a) similar outcome variables for participants from different groups, (b) individual differences that remove the possibility of responding to outcome measures in similar way, and (c) STEM applications that change the conceptual frame of reference against which a group responds to outcome measures over time (Muthén, 2002). In this analysis gender, ethnicity, SES and special education variables were identified as independent variables while reading, mathematics, and science TAKS scores were identified as dependent variables.

As introduced earlier in Figure 3.1, various student groups were compared using demographic variables. When comparing these groups, the Wald test was used because of the test's robustness with large sample sizes. If we assume we have K independent populations and Y_{1j}, Y_{2j}, …, Y_{nij} samples drawn from jth population, where $j = 1, 2, \ldots, K$, $M_j = \mathrm{E}(Y_{ij})$ will be the jth population mean, where $i = 1, 2, \ldots, n_j$. Then, the formulation of these comparisons can be written:

$$H_0: M_1 = M_2 = \ldots = M_K \tag{3.1}$$

Where the alternative is H_1: $M_j = M_j$, and $j = j'$. In the next section, I discuss the limitations of the methods described in this chapter.

Limitations

As with all studies, this one has multiple limitations. In this section, I identify four limitations. The first limitation is the absence of longitudinal data. The absence of data measuring students' college and career readiness prevents me from conducting a longitudinal study. However, longitudinal data of this nature is not readily available.

The second limitation is sampling of traditional schools. To complete my comparative analyses, I randomly selected 53 traditional schools. As criteria for stratified sampling, I first used size and White student percentage for each school. However, a large group of T-STEM schools were small. Therefore, I used only White student percentage when selecting the 53 traditional schools.

The third limitation is categorization and definitions of certain variables. For example, in the original data, SES had four categories (i.e., Free meals = 1, reduced-price meals = 2, other economic disadvantages = 9, Not identified as economically disadvantaged = 0). However, in my analyses, I categorized 1, 2, and 9 as economically disadvantaged and 0 as not disadvantaged to simplify discussion.

The fourth limitation is missing data. Approximately 25% of data used in conducting my study was missing. To reduce bias and provide accurate results, a procedure was applied for missing data. For reasons listed above, I chose multiple imputation method. Therefore, I did not lose data or information regarding T-STEM and traditional schools' success at preparing students for college and career.

Although this study has limitations, I answered questions addressing the specialized STEM schools' success at preparing students for college and career using student level data. The data for 28,159 students in grade 11 from 53 T-STEM and 53 traditional schools included students' high-stake test (i.e., TAKS) scores and demographic information. To examine the association between variables, I used descriptive and multi group analyses. Missing data in this dataset were handled with multiple imputation method. The next section presents results from analyses.

Results

Means, standard deviations, Wald statistics, and effect sizes were provided in Table 3.5 for the whole sample. Wald test results showed there was no statistically significant difference between students in traditional and T-STEM schools on reading, mathematics, and science scores ($\text{Wald}_{\text{read}}= 0.875$, $p= 0.350$; $\text{Wald}_{\text{math}}= 2.307$, $p= 0.129$; $\text{Wald}_{\text{science}}= 0.704$, $p= 0.402$). On average, students in T-STEM schools had higher scores on reading, mathematics and science scores ($\text{mean}_{\text{read}}=2{,}555$, $\text{mean}_{\text{math}}=2{,}253$, and $\text{mean}_{\text{science}}=2{,}249$) than students in traditional schools

($\text{mean}_{\text{read}}$=2,245, $\text{mean}_{\text{math}}$=2,228, and $\text{mean}_{\text{science}}$=2,239). However, these differences on the mean scores were not significantly different. Although, Wald test results were not statistically significant, I calculated and reported effect sizes in Table 5. For a detailed analysis, the sample was split into subgroups.

Table 3.5

Cross Distribution of School Type and Average Score, Wald Statistic, and Effect Size on Achievement Measure for All Students

			Descriptive		Wald Statistic		
	N	School Type	*M*	*SD*	Score	*p*-value	Effect Size
Reading	19,155	Traditional	2,245	212	0.875	0.350	0.047
	9,004	T-STEM	2,255	216			
Math	19,155	Traditional	2,228	236	2.307	0.129	0.104
	9,004	T-STEM	2,253	246			
Science	19,155	Traditional	2,239	204	0.704	0.402	0.049
	9,004	T-STEM	2,249	208			

For gender subgroups, means, standard deviations, Wald statistics, and effect sizes were provided in Table 3.6. Wald test results revealed a statistically significant difference between male (M) students in traditional and T-STEM schools on reading, mathematics, and science scores ($\text{Wald}_{\text{maleread}}$= 6.132, *p*= 0.013; $\text{Wald}_{\text{malemath}}$= 10.295, *p*= 0.001; $\text{Wald}_{\text{malescience}}$= 7.058, *p*= 0.008). On all three scores male students in T-STEM schools performed better than male students in traditional schools. Results were similar for female (F) students except on the science score ($\text{Wald}_{\text{femaleread}}$= 3.884, *p*= 0.049; $\text{Wald}_{\text{femalemath}}$= 6.619, *p*= 0.010; $\text{Wald}_{\text{femalescience}}$= 3.424, *p*= 0.064). The effect sizes were relatively small, ranging from 0.020 to 0.128. Each of the effect size values suggests higher mean scores on all TAKS tests for students in T-STEM schools when compared to students in traditional schools. The next analysis was run for ethnic subgroups.

Table 3.6

Cross Distribution of School Type and Student Gender for Average Score, Wald Statistic, and Effect Size on Achievement Measure

				Descriptive		Wald Statistic		
	Gender	*N*	School Type	*M*	*SD*	Score	*p*-value	Effect Size
Reading	F	9,509	Traditional	2,263	209	3.884	0.049	0.042
	F	4,357	T-STEM	2,272	217			

Table 3.6 (continued)

				Descriptive		Wald Statistic		
	Gender	*N*	School Type	*M*	*SD*	Score	*p*-value	Effect Size
Reading	M	9,646	Traditional	2,226	214	6.132	0.013	0.060
	M	4,647	T-STEM	2,239	214			
Math	F	9,509	Traditional	2,228	226	6.619	0.010	0.081
	F	4,357	T-STEM	2,247	238			
	M	9,646	Traditional	2,228	245	10.295	0.001	0.128
	M	4,647	T-STEM	2,260	252			
Science	F	9,509	Traditional	2,233	194	3.424	0.064	0.020
	F	4,357	T-STEM	2,237	201			
	M	9,646	Traditional	2,246	214	7.058	0.008	0.065
	M	4,647	T-STEM	2,260	214			

Note. F represents female students and M represents male students.

For ethnic subgroups, means, standard deviations, Wald statistics, and effect sizes were provided in Table 3.7. Wald test results revealed statistically significant differences between Hispanic (H) and White (W) students in traditional and T-STEM schools on reading, mathematics, and science scores ($\text{Wald}_{\text{H\_read}}= 7.037$, $p= 0.008$; $\text{Wald}_{\text{H\_math}}= 11.743$, $p= 0.001$; $\text{Wald}_{\text{H\_science}}= 6.846$, $p= 0.009$; $\text{Wald}_{\text{w\_read}}= 5.217$, $p= 0.022$; $\text{Wald}_{\text{w\_math}}= 9.411$, $p= 0.002$; $\text{Wald}_{\text{w\_science}}= 6.250$, $p= 0.012$). However, Wald test results were not significantly different between Asians (A), African Americans (AA), Indians (I), Pacific Islanders (P) and students from two or more (T) ethnic backgrounds in traditional and T-STEM schools. Although on average, students in T-STEM schools performed better, these differences were not statistically significant. In fact, African American students and students from two or more ethnic backgrounds from traditional schools performed better than counterparts in T-STEM schools on reading and science scores. The effect sizes for Hispanic and White student subgroups were fairly small as well, ranging from 0.022 to 0.117. The next analysis was run for students' socioeconomic status.

Table 3.7

Cross Distribution of School Type and Student Ethnicity for Average Score, Wald Statistic, and Effect size on Achievement Measure

				Descriptive		Wald Statistic		
	Ethnic	*N*	School Type	*M*	*SD*	Score	*p*-value	Effect Size
Reading	A	685	Traditional	2,327	237	0.012	0.914	0.025
	A	501	T-STEM	2,333	240			
Math	A	685	Traditional	2,372	272	1.765	0.184	0.192
	A	501	T-STEM	2,424	269			
Science	A	685	Traditional	2,334	246	0.817	0.366	0.076
	A	501	T-STEM	2,352	228			
Reading	AA	2,900	Traditional	2,209	202	0.403	0.526	-0.024
	AA	1,413	T-STEM	2,204	209			
Math	AA	2,900	Traditional	2,168	220	1.643	0.120	0.041
	AA	1,413	T-STEM	2,177	211			

Table 3.7 (continued)

				Descriptive		Wald Statistic		
	Ethnic	*N*	School Type	*M*	*SD*	Score	*p*-value	Effect Size
Science	AA	2,900	Traditional	2,203	193	0.935	0.334	-0.010
	AA	1,413	T-STEM	2,201	181			
Reading	H	11,608	Traditional	2,241	193	7.037	0.008	0.067
	H	5,251	T-STEM	2,254	196			
Math	H	11,608	Traditional	2,220	216	11.743	0.001	0.095
	H	5,251	T-STEM	2,241	224			
Science	H	11,608	Traditional	2,229	186	6.846	0.009	0.058
	H	5,251	T-STEM	2,240	193			
Reading	I	66	Traditional	1,531	197	0.334	0.563	0.112
	I	31	T-STEM	1,553	195			

Table 3.7 (continued)

				Descriptive		Wald Statistic		
	Ethnic	*N*	School Type	*M*	*SD*	Score	*p*-value	Effect Size
Math	I	66	Traditional	1,608	226	0.348	0.550	0.174
	I	31	T-STEM	1,647	222			
Science	I	66	Traditional	1,696	200	0.208	0.648	0.087
	I	31	T-STEM	1,713	191			
Reading	P	21	Traditional	1,815	215	0.532	0.466	0.271
	P	11	T-STEM	1,871	197			
Math	P	21	Traditional	2,033	226	0.390	0.532	0.236
	P	11	T-STEM	2,085	215			
Science	P	21	Traditional	2,039	188	0.297	0.586	0.200
	P	11	T-STEM	2,077	192			

Table 3.7 (continued)

	Ethnic	N	School Type	Descriptive M	Descriptive SD	Wald Statistic Score	Wald Statistic p-value	Effect Size
Reading	T	265	Traditional	2,194	263	0.010	0.922	-0.097
	T	121	T-STEM	2,169	255			
Math	T	265	Traditional	2,201	286	0.213	0.644	0.021
	T	121	T-STEM	2,195	280			
Science	T	265	Traditional	2,215	264	0.000	0.997	-0.128
	T	121	T-STEM	2,183	236			
Reading	W	3,610	Traditional	2,291	234	5.217	0.022	0.043
	W	1,676	T-STEM	2,301	233			
Math	W	3,610	Traditional	2,292	256	9.411	0.002	0.117
	W	1,676	T-STEM	2,323	273			

Table 3.7 (continued)

				Descriptive		Wald Statistic		
	Ethnic	*N*	School Type	*M*	*SD*	Score	*p*-value	Effect Size
Science	W	3,610	Traditional	2,300	225	6.250	0.012	0.022
	W	1,676	T-STEM	2,305	227			

Note. A represents Asian students, AA represents African American students, H represents Hispanic students, I represents Indian students, P represents Pacific Islander students, T represents students from two or more ethnic background, and W represents White students.

For socioeconomic subgroups, means, standard deviations, Wald statistics, and effect sizes were provided in Table 3.8. Wald test results showed statistically significant differences between economically disadvantaged (Y) students in traditional and T-STEM schools on reading, mathematics, and science scores ($Wald_{Y\_read}$= 6.141, *p*= 0.013; $Wald_{Y\_math}$= 11.286, *p*= 0.001; $Wald_{Y\_science}$= 8.271, *p*= 0.004). On average, economically disadvantaged students in T-STEM schools performed better than counterparts in traditional schools. However, this is not true for other (N) students except on the mathematics score ($Wald_{N\_read}$= 3.830, *p*= 0.050; $Wald_{N\_math}$= 6.729, *p*= 0.001; $Wald_{N\_science}$= 3.038, *p*= 0.081). The effect sizes for economically disadvantaged students were again small, ranging from 0.044 to 0.105. The next analysis was run for students' special education status.

Table 3.8

Cross Distribution of School Type and Student Socioeconomic Status for Average Score, Wald Statistic, and Effect Size on Achievement Measure

				Descriptive		Wald Statistic		
	SES	*N*	School Type	*M*	*SD*	Score	*p*-value	Effect Size
Reading	N	7,564	Traditional	2,282	221	3.830	0.050	0.074
	N	3,308	T-STEM	2,298	221			
	Y	11,591	Traditional	2,221	203	6.141	0.013	0.044
	Y	5,696	T-STEM	2,230	210			
Math	N	7,564	Traditional	2,273	246	6.729	0.001	0.133
	N	3,308	T-STEM	2,307	264			
	Y	11,591	Traditional	2,199	224	11.286	0.001	0.105
	Y	5,696	T-STEM	2,222	229			

Table 3.8 (continued)

	SES	*N*	School Type	Descriptive *M*	Descriptive *SD*	Wald Statistic Score	Wald Statistic *p*-value	Effect Size
Science	N	7,564	Traditional	2,279	213	3.038	0.081	0.038
	N	3,308	T-STEM	2,287	222			
	Y	11,591	Traditional	2,214	194	8.271	0.004	0.067
	Y	5,696	T-STEM	2,227	196			

Note. N represents students who are not economically disadvantaged and Y represents students who are economically disadvantaged.

For special education subgroups, means, standard deviations, Wald statistics, and effect sizes were provided in Table 3.9. Wald test results revealed no statistically significant difference between special education (Y) students in traditional and T-STEM schools on reading, mathematics, and science scores ($\text{Wald}_{\text{Y\_read}}$= 2.550, p= 0.110; $\text{Wald}_{\text{Y\_math}}$= 3.140, p= 0.076; $\text{Wald}_{\text{Y\_science}}$= 1.400, p= 0.237). On average, special education students in T-STEM schools performed slightly better than counterparts in traditional schools on reading and mathematics scores. However, special education students in traditional schools performed slightly better on science scores. Results were similar for other (N) students on reading scores but not on mathematics and science scores ($\text{Wald}_{\text{N\_read}}$= 3.499, *p*= 0.061; $\text{Wald}_{\text{N\_math}}$= 7.550, *p*= 0.006; $\text{Wald}_{\text{N\_science}}$= 4.192, *p*= 0.041). The effect sizes for special education students were small, ranging from -0.015 to 0.025. Results reported in this section will be supported and explained with literature and integrated into the theoretical framework in the conclusion.

Table 3.9

Cross Distribution of School Type and Student Special Education Status for Average Score, Wald Statistic, and Effect Size on Achievement Measure

				Descriptive		Wald Statistic		
	Spec. Educ.	*N*	School Type	*M*	*SD*	Score	*p*-value	Effect Size
Reading	N	17,565	Traditional	2,260	202	3.499	0.061	0.044
	N	8,329	T-STEM	2,269	208			
	Y	1,590	Traditional	2,075	250	2.550	0.110	0.020
	Y	675	T-STEM	2,080	242			
Math	N	17,565	Traditional	2,246	224	7.550	0.006	0.105
	N	8,329	T-STEM	2,270	234			

Table 3.9 (continued)

	Spec. Educ.	*N*	School Type	Descriptive *M*	*SD*	Wald Statistic Score	*p*-value	Effect Size
Math	Y	1,590	Traditional	2,039	278	3.140	0.076	0.025
	Y	675	T-STEM	2,046	284			
Science	N	17,565	Traditional	2,255	193	4.192	0.041	0.046
	N	8,329	T-STEM	2,264	196			
	Y	1,590	Traditional	2,076	251	1.400	0.237	-0.015
	Y	675	T-STEM	2,072	257			

Note. N represents students who are not in special education program and Y represents students who are in special education program.

Conclusion

Stakeholders in STEM education recognize the need to address the issue of preparing students for college and career. However, the solution to this issue (i.e., specialized STEM schools) offered by stakeholders has yet to prove its value as a national resource. Hence, educational leaders across the nation are curious whether specialized STEM schools are outperforming traditional schools. Through this study, I have presented a multi group analysis to compare students' achievement outcomes from traditional and T-STEM schools to understand the college and career readiness of students. A multi group analysis provides opportunities to analyze similar outcome variables for different groups, to distinguish individual differences, and take into account changes in responses of a group over time because of an intervention (e.g., STEM curriculum; Muthén, 2002). In conducting multi group analysis results from Wald test was preferred. The Wald test is a robust test when sample size is very large as in this study.

Investments made in T-STEM schools can influence researchers decision-making process. Many studies have suggested establishing new specialized STEM schools to address the issue of STEM education in the U.S. (Lynch et al., 2013; Marshall, 2010; NRC; 2011; PCAST, 2010). Many researchers attempt to find differences between students in traditional and T-STEM schools because of these suggestions. Because other null hypothesis tests have had inadequate controls for large sample size, the Wald test was the best option to prevent Type I error in such a comparison.

In response to research question one, based on data describing the state's high-stake test results, I found no statistically significant difference between students in traditional and T-STEM schools on reading, mathematics, and science scores. Although Wald test results were not significant, mean scores for students in T-STEM schools were higher than counterparts in traditional schools. However, effect size values reflecting the mean differences were very small, confirming the earlier findings of Young et al. (2011).

One might expect reforms instituted in T-STEM schools would result in some significant differences in at least mathematics or science scores. There are possibly a number of reasons might have influenced the inability to find statistically significant differences across school types. For example, the model tested in the current study failed to account for differences in teachers across the school types. In addition, a large part of school effects may be related to students' interest toward STEM subjects rather than overall improvement on students' scores on high-stake tests (Means et al., 2013). Finally, one should consider that the T-STEM schools in this study were founded in urban areas and mostly populated by students from historically underrepresented populations, suggesting these students' performance might be similar to students in traditional schools and actually could represent a benefit. This consideration requires further qualitative analysis.

In response to research question two, the student sample was broken into subgroups based on students' demographics (e.g., gender). Results indicated, on one hand, males in T-STEM schools performed better than counterparts in traditional schools on reading, mathematics, and science scores. On the other hand, females in T-STEM schools performed slightly better than counterparts in traditional schools on reading and mathematics scores. However, effect size values for both subpopulations were very small. In addition, Hispanic and White students in T-STEM schools performed better than counterparts in traditional schools with relatively small effect size values. Other ethnic subpopulations did not exhibit any significant differences. Economically disadvantaged students in T-STEM schools also performed better than counterparts in traditional schools; however, once again, effect size values were very small. Finally, students in special education program from T-STEM school showed no significant differences in reading, mathematics, and science scores.

These achievement results between subgroups are promising because several target subpopulations (i.e., female, diverse, and disabled; NRC, 2011, NSF, 2013, PCAST, 2010; U.S. Department of Commerce, 2011) exhibited significant differences in achievement for specific subject areas. For example, female, Hispanic, and economically disadvantaged students' performance in comparison with counterparts exhibited improvements on achievement scores in reading, mathematics, and science. However, work still remains for African Americans, Indians, Pacific Islanders, students from two or more ethnic backgrounds, and students in special education program. Although work remains for these last student subgroups, one should consider that in Texas Hispanic and White student populations constitute the majority of the total student population.

College readiness of T-STEM graduates could be examined using various indicators. In this study, I used results from reading, mathematics, and science high-stake tests because these indicators were readily available through state agencies. Despite the findings for T-STEM schools from this study, our knowledge of T-STEM schools' effects is limited. Other relevant variables may guide researchers to explore the successes of T-STEM schools at preparing students for college and career (Young et al., 2011). Also, cross-sectional research designs as employed in this study offer limited explanations of T-STEM schools’ effects on college readiness of students. Longitudinal research designs, however, offer a more powerful and stable explanation of these schools’ effects (Willms & Raudenbush, 1989). Finally, results from this study indicated an in depth qualitative study of T-STEM schools’ effect is required to understand the potential of these schools.

In the next chapter, I examine the achievement outcomes for students attending ISHS. In examining these outcomes, I use students’ high-stake test results, students’ demographic variables, and school level indicators to measure college readiness of students attending either T-STEM or traditional schools. I conclude this chapter with recommendations for stakeholders involved in the reform of STEM education.

CHAPTER IV

COLLEGE ENTRY INDICATORS FOR STUDENTS FROM INCLUSIVE STEM SCHOOLS: AN HLM ANALYSIS OF STUDENTS' ACHIEVEMENT OUTCOMES AND SCHOOL LEVEL INDICATORS

In the last half century, the average annual growth rate for occupations requiring science, technology, engineering, and mathematics (STEM) knowledge in the U.S. was 3.3%, while the annual growth rate for the total workforce was only 1.5% (National Science Foundation [NSF], 2012). According to the U.S. Department of Commerce's (2011) estimation, between 2008 and 2018 the combined growth rate for occupations requiring STEM knowledge will be 17%. However, the U.S. education system has not graduated sufficient numbers of students for occupations requiring STEM knowledge. In 2008 alone, only 31.4% of all college graduates in the U.S. earned a baccalaureate degree in a STEM field. Compared to Japan (60.6%), China (50.7%), and South Korea (41.1%), this percentage is significantly lower (NSF, 2012). Until recently, the strategy used by the U.S. education system to fill this gap included attracting international students to remain in the U.S. post graduation (Atkinson, Hugo, Lundgren, Shapiro, & Thomas, 2007). However, this strategy has become less effective as international students are more likely to return to their countries of origin for increased opportunities in occupations requiring STEM knowledge. Consequently, some U.S. business leaders have expressed concern with a potential shortage of graduates with STEM knowledge for the future U.S. workforce (NRC, 2011).

The current problem for STEM education in the U.S. goes beyond college education because students do not possess high levels of STEM knowledge in earlier grades (i.e., k-12). Schmidt (2011) investigated National Assessment of Educational Progress data from 2009 and found only 33% of students in grade 4 and 26% of students in grade 8 were proficient in mathematics. Although these percentages exhibited an increase from 1996 results —19% and 20%, respectively— almost three out of four 8th graders advance to high school without being proficient in mathematics (NRC, 2011; Schmidt, 2011). As a result, Schmidt and others believe the failure of STEM education in the U.S. is threatening the future of the U.S.

International studies also reveal U.S. students do not exhibit high levels of STEM knowledge in comparison with students from other countries. Results from the Trends in International Mathematics and Science Study (TIMSS) in 2011 indicate only 7% of U.S. 8th graders met the advanced international benchmark in mathematics, much lower than percentages for Chinese Taipei (49%) and Singapore (48%; Provasnik et al., 2012). Results were similar for science scores. Results from the Programme for International Student Assessment (PISA) in 2009 indicated U.S. students at the age of 15 exhibited average performance in both mathematics and science among 65 countries (Fleischman, Hopstock, Pelczar, & Shelley, 2010).

To address the issue of reform in STEM education within the U.S. education system, policymakers have provided specific suggestions (NRC, 2011; PCAST, 2010). The NRC (2011) set three goals to improve STEM knowledge for individuals in the U.S. workforce. These goals included: (a) improving the degree of training for STEM related careers, (b) increasing the number of people for the workforce, and (c) generating a more scientifically literate population (NRC, 2011). To meet the NRC and other goals, PCAST made specific suggestions, including: (a) creation of state-level mathematics and science standards, (b) recruitment and training of 100,000 STEM teachers over the next decade, (c) recognition for STEM teachers, (d) expansion of educational technology, (e) creation of extra-curricular opportunities for students, (f) creation of 1,000 new STEM-focused schools, and (g) provision of strong and strategic leadership (PCAST, 2010). In PCAST's report, authors further emphasized the unique role of specialized STEM schools as a national resource for improving the STEM workforce.

In recent years, stakeholders (i.e., education leaders, policymakers, and researchers) have founded a number of specialized STEM schools to address problems in STEM education and the STEM workforce. As a result, the NRC adopted a typology for identifying these specialized schools. The NRC (2011) categorizes specialized STEM schools under three headings: (a) selective STEM schools, (b) inclusive STEM schools, and (c) schools with STEM-focused career and technical education (CTE). Selective STEM schools serve students with aptitude and interest in STEM knowledge. These schools have certain admission criteria (e.g., past academic achievement; NRC, 2011; Subotnik et al., 2011). Inclusive STEM schools serve similar students; however, these schools have no admission criteria (NRC, 2011; Young et al., 2011). Schools with STEM-focused CTE serve at-risk students for dropping out of school and accept students based on no criteria (NRC, 2011; Stone III, 2011).

With regards to efforts in creating STEM schools, researchers have sought answers for two questions. The first of these questions relates to the success of specialized STEM schools at preparing students for college and career in STEM fields. Stakeholders keep investing in these schools; however, their success has yet to be proven. The second of the questions centers on students' demographics and schools' characteristics corresponding with students' success in STEM disciplines. In essence, success of specialized STEM schools at preparing students for college and career has been unidentified and stakeholders have more to learn about these schools.

The purpose of this study is to measure the college readiness of inclusive STEM high school (ISHS) graduates in comparison to traditional high school graduates. Schools classified as ISHS were chosen to represent a new school typology having the potential to direct females, minorities, and students with disabilities into STEM related careers. While evaluations and research are limited (Means et al., 2013; Thomas & Williams, 2010; Young et al., 2011), policymakers continue to promote and expand STEM schools across the U.S. (PCAST, 2010). In order to explore the success of these schools, this study will be guided by the following research question: How do students from ISHS and traditional high schools in Texas compare on student and school level indicators for college readiness?

The notation developed by Raudenbush and Bryk (2002) was used to demonstrate the data structure used to answer the research question (Figure 4.1). In the stratified sampling strategy, 53 traditional schools were selected to compare with 53

ISHS, classified as level 2 (between) units. Then, within each traditional schools and ISHS, students were identified as level 1 (within) units.

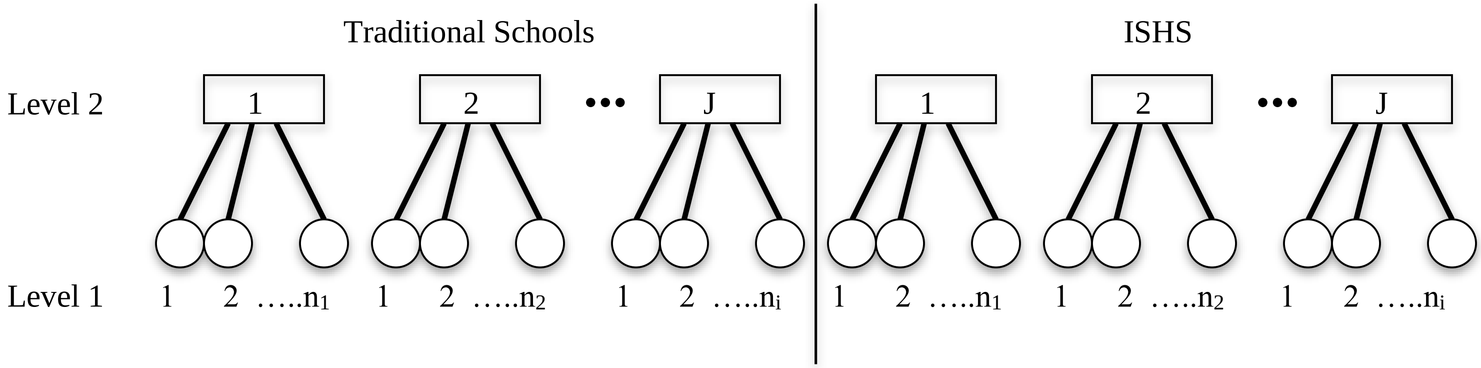

Figure 4.1. Data structure for the two-level hierarchical model of ISHS and traditional schools.

Literature Review

A purpose for stakeholders establishing specialized STEM schools is preparing students for college and career in STEM fields, especially those students from historically underrepresented populations (i.e., female, diverse, and disabled; PCAST, 2010). Research indicates occupations requiring STEM knowledge are disproportionately dispersed among U.S. citizens (NSF, 2013). As an example, U.S. males are three times more likely than females to work in occupations requiring STEM knowledge. In addition, regardless of gender, U.S. White citizens are three times more likely than other citizens to work in occupations requiring STEM knowledge. Taking these results into account, stakeholders have emphasized the importance of underrepresented populations in the STEM workforce (Atkinson et al., 2007; NRC, 2011).

Many specialized STEM schools focus on reducing disparities among students from underrepresented populations (Avery et al., 2010) and preparing these students for college and career in STEM fields (PCAST, 2010). For this purpose, specialized STEM schools admit more students from underrepresented populations, promote STEM extracurricular activities for female students, and cooperate with role models from underrepresented populations. However, there are a limited number of studies evaluating the success of these schools. Thomas and Williams (2010) followed 1,032 students after graduation from specialized STEM schools across the U.S. Results from this study indicated 75% of the students planned for higher education upon graduation from high school and 40% imagined earning a doctorate degree. Of the students in the study, 51%

pursued science majors in college whereas 10% pursued mathematics majors. Finally, 60% of freshman participants foresaw earning a STEM degree and 55% of senior participants earned a STEM degree.

Means et al. (2013) compared students in inclusive STEM or traditional schools focusing on interests related to college and STEM subjects. Outcomes of this study revealed 9th graders in inclusive STEM schools were more interested in STEM subjects than counterparts in traditional schools. In addition, students from inclusive STEM schools indicated more confidence about graduating from high school and college in comparison with students from traditional schools. Finally, students from inclusive STEM schools took more college preparatory courses in STEM disciplines, indicated more interest in graduate school, and were more likely to choose STEM majors in college.

Although comparing students from STEM schools with students from traditional schools, these studies were more focused on students' interests rather than achievement. Young et al. (2011) are the only researchers to use achievement in comparing students from STEM and traditional schools. Results from their study indicate 9th graders from inclusive STEM schools in Texas perform slightly better on mathematics high-stake test, are more likely to meet benchmarks of reading and mathematics high-stake tests, and less likely to be absent from school than counterparts from traditional schools. Also, 10th graders from inclusive STEM schools perform better on both mathematics and science high-stake tests and are more likely to meet benchmarks on reading, mathematics, science, and history high-stake tests. However, effect sizes for these differences are small. Finally, all other results at any grade level in the Young et al. study were not statistically significant, implying a limited benefit from attending inclusive STEM schools to students.

T-STEM Schools

T-STEM schools are inclusive STEM schools created through the STEM school initiative by stakeholders in Texas during the 2006-07 academic year. In the first year of the initiative, seven T-STEM schools were established. As of the 2012-13 academic year, 65 T-STEM schools serve a population of over 35,000 students. Since the beginning of this initiative, approximately $133 million public monies were allocated for these schools, which is more than same size traditional schools received. These schools, therefore, represent the largest monetary investment for inclusive STEM high schools (ISHS) in the U.S. In addition, T-STEM schools partner with seven T-STEM centers situated in public and private universities. These centers help T-STEM schools create instructional materials and provide professional development workshops for over 2,800 teachers (TEA, 2013). A detailed blueprint guides design and implementation process of T-STEM schools (Avery et al., 2010). This blueprint requires schools to provide a college preparatory curriculum, real world relevant practices, a strong academic support system, and a wide range of STEM coursework (NRC, 2011; Young et al., 2011). The primary objective in the mission statement for these T-STEM schools is to prepare students for college and careers in STEM fields.

College and Career Readiness Standards

The U.S. Department of Education, in 2010, created a blueprint for educational reform focused on college and career readiness standards. The impetus for this reform was from the fact 40% of college freshman students in U.S. universities were enrolled in remedial courses (U.S. Department of Education, 2010). The reform efforts for college and career readiness standards included reauthorization and changes to the Elementary and Secondary Education Act (ESEA; U.S. Department of Education, 2010). Changes to the ESEA included (a) higher standards for English language arts and mathematics, (b) improved assessments aligned with the college and career readiness standards (CCRS), and (c) structured reward system for schools and districts. Other changes to the ESEA included (a) improved support for teachers through professional development workshops, (b) enriched instruction for lowest-performing schools, and (c) increased flexibility for schools and districts. The final recommendation of this blueprint for states was to continue implementing science standards and assessments (U.S. Department of Education, 2010). Researchers have yet to determine if the changes made to the ESEA have resulted in students better prepared for college and career.

The Texas legislature, in 2008, passed the "Advancement of College Readiness in Curriculum" bill to increase the number of college and career ready high school graduates (EPIC, 2009). Under the guidance of this bill, authorities gathered a team of experienced educators and university faculty to identify new CCRS for English language arts, mathematics, science, and social studies. The focus for these CCRS was to help students gain knowledge and skills necessary for success in college. Courses designed with the CCRS provide core knowledge and skills on all subjects, fundamentals of literacy, and fundamentals of basic mathematics to be successful in any chosen college major. CCRS team indicates each standard is a step toward college and career readiness (EPIC, 2009).

Methodology

A quasi-experimental design was used to compare student outcomes from two different school types, T-STEM and traditional high schools (Campbell et al., 1963). In an attempt to answer the research question mentioned above, I obtained data through the Public Information Request system of TEA for 28,159 students in grade 11 attending one of 106 identified as either T-STEM or traditional. In addition, students' demographic information was collected from the TEA using the same procedure. Student achievement was measured using scores on the Texas Assessment of Knowledge and Skills (TAKS) for reading, mathematics, and science. School level indicators of college readiness were obtained separately. Using Academic Excellence Indicator System, I downloaded school level data from TEA website. To examine the association between schools' success and students' achievement, I used both school and student level results from a descriptive analysis and a Hierarchical Linear Modeling (HLM) analysis. In the next sections, I present information regarding this study's participants, measurements, data analyses, and limitations.

Participants

The participants for my analyses came from two separate data streams within the TEA. Participants included 28,159 students in grade 11 and 106 schools identified as either T-STEM or traditional. Student level data included students’ TAKS scores and demographic information. The TAKS scores represent standardized measures for students’ mastery of reading, mathematics, history, and science content. Students’ demographic information included values for (a) gender, (b) ethnicity, (c) socioeconomic status, (d) English language proficiency, (e) English as second language, (f) special education status, and (g) at risk status. School level data included (a) percentage of students taking Scholastic Aptitude Test (SAT) or American College Testing (ACT), (b) percentage of students passing SAT/ACT criterion, (c) percentage of students taking Advance Placement (AP) or International Baccalaureate (IB) courses, (d) percentage of students passing AP/IB end of course exam, and (e) percentage of students dropping out of school. After obtaining data for both participant sets, I compiled all data into two linked datasets.

Although 65 T-STEM schools have been founded under the Texas High School Project (THSP), only 53 such schools were identified from the student dataset. Data for students in grade 11 from the student dataset were chosen because students at this grade level take three of the four state achievement tests (i.e., reading, mathematics, and science). Variables of no concern to this study were removed from the dataset. Variables of concern were categorically coded, including students’ gender (Female=1, Male=0), socioeconomic status (Free meals, reduced-price meals, other economical disadvantages=1, Not disadvantaged=0), and special education status (Special education=1, Not special education=0). The variable for students’ ethnicity was dummy coded by declaring White ethnicity as the reference.

In a quasi-experimental study, results for the treatment group often find more meaning when a comparison of these results is conducted using data from a common or well-known group (Creswell, 2013). In my analyses, a sample of traditional schools from the population of all Texas schools, not designated as T-STEM but likely designated as high school, were used for comparative purposes. As a result, all schools (*N*=8,529) in Texas were identified from the TEA website. After elimination of elementary, middle, charter, and alternative schools (i.e., night schools, T-STEM schools, Early College High Schools, recovery schools, and magnet schools), 1,309 schools remained. For analysis purposes, I chose a sample of 53 schools from population of 1,309 traditional schools serving students in grade 11. I applied a stratified sampling procedure by dividing T-STEM schools into four groups according to White student percentage (1=0-24%, 2=25%-49%, 3=50%-74%, 4=75%-100%). The first group had 34 T-STEM schools, the second group had 9 such schools, the third group had 7 schools, and the fourth group had 3 schools. The 1,309 traditional schools were grouped using the same method. From each group a similar number of traditional schools were randomly selected. After 53 traditional schools were identified, data for students in grade 11 at these schools were pulled from the TEA student dataset. Finally, variables for comparison schools were coded using the same method as in T-STEM school dataset.

After preparation of the two student level datasets, I pulled school level data from the TEA website for the 53 T-STEM and 53 traditional schools. The student level dataset and the school level dataset for each school were combined into two datasets. In these two datasets, the new variable “STEM” was created to distinguish T-STEM schools from traditional schools. Finally, the two datasets were combined into one database for conducting analyses.

Tables 4.1 through 4.4 presents cross distributions for students' school type and demographic categorizations (i.e., gender, ethnicity, socioeconomic status [SES], and special education status). Each of the tables provides information describing relationships between students' school type and common demographic categorizations found in many education policy studies (Bozeman, Scogin, & Stuessy, 2013). The information in these tables suggests traditional schools serve more students but similar distributions across the categorizations for gender, ethnicity, SES, and special education status.

Table 4.1

Cross Distribution of School Type and Gender

	Student gender		
School type	Male	Female	Total
Traditional	9,646	9,509	19,155
T-STEM	4,647	4,357	9,004
Total	14,293	13,866	28,159

Table 4.2

Cross Distribution of School Type and Ethnicity

	Student ethnicity							
School type	Asian	African-american	Hispanic	Indian	Pacific islander	Two or more races	White	Total
Traditional	685	2,900	11,608	66	21	265	3,610	19,155
T-STEM	501	1,413	5,251	31	11	121	1,676	9,004
Total	1,186	4,313	16,859	97	32	386	5,286	28,159

Table 4.3

Cross Distribution of School Type and Socioeconomic Status

	Student socioeconomic status		
School type	Not disadvantaged	Disadvantaged	Total
Traditional	7,564	11,591	19,155
T-STEM	3,308	5,696	9,004
Total	10,872	17,287	28,159

Table 4.4

Cross Distribution of School Type and Special Education Status

	Student special education status		
School type	No	Yes	Total
Traditional	17,565	1,590	19,155
T-STEM	8,329	675	9,004
Total	25,894	2,265	28,159

Measurements

High-stake tests have been used for a number of decades to direct education policy (Heubert & Hauser, 1998). Results from high-stake tests have specifically been used to determine the success for students' schools, programs, and classrooms. These tests have also been used as indicators for students' college and career readiness (Heubert & Hauser, 1998). Until recently, the high-stake test accepted by most stakeholders in Texas was the Texas Assessment of Knowledge and Skills (TAKS; TEA, 2014a). TAKS measures students' achievement from grade 3 through graduation across four academic disciplines (i.e., reading, mathematics, science, and social studies). However, these disciplines are not assessed at every grade level. For example, achievement in the science discipline is assessed at grades 5, 8, 10, and 11. In this study, I chose grade 11 because three disciplines (i.e., reading, mathematics, and science) are assessed contemporaneously. TAKS results for these three disciplines can be a useful indicator; however, these results may not be enough to make a decision regarding students' college and career readiness. The TEA replaced TAKS with the State of Texas Assessments of Academic Readiness (STAAR) in 2012. However, this replacement was progressive, as a result in the 2012-13 academic year 11th graders were still taking the TAKS exam. Therefore, I used TAKS results instead of STAAR.

In the college admission process, students' college entrance examination scores play a large role (Heubert & Hauser, 1998). Many learning institutions (i.e., universities and colleges) in the U.S. create an index based on currently enrolled students' data, including college entrance examination scores (Kobrin, 2007). This index is used to determine the likelihood of students’ success in college courses. The SAT and ACT exams are commonly used by these institutions (Heubert & Hauser, 1998). To make a decision regarding schools’ success at preparing students for college and career, I used percentage of students taking and passing the SAT and ACT.

Another criterion for college admission is students’ success in advanced courses, such as AP or IB (U.S. Department of Education, 2010). The index created by the previously mentioned institutions also uses passing scores on these courses to determine students’ college readiness (Kobrin, 2007). The AP and IB courses are commonly taken by students likely to pursue a STEM college major and/or career (Sahin, Erdogan, Morgan, Capraro, & Capraro, 2012). Both AP and IB courses offer a challenging curriculum and an exam at the end of each course. The percentage of students taking and passing the AP and IB courses were also used in the analyses of students’ college and career readiness.

Dropout rate is another way of assessing schools’ performance on preparing students for college and career (Christle, Jolivette, & Nelson, 2007; Rumberger & Palardy, 2005). Dropout rate is simply defined as the percentage of students who leave school before graduation. However, the term has several definitions in the literature. Rumberger and Palardy (2005) indicated using multiple indicators, such as aggregated student performance on tests or dropout rates, at school level is a necessity for two reasons. First, schools may have to make a decision to focus on one outcome (e.g., raising test scores or lowering dropout rates) because of limited resources. Second, schools’ decisions may create a conflict with other outcomes (e.g., low test scores for the school because low achievers did not leave the school). In the next section, I discuss the missing data methods applied in this study.

Missing Data

As in most studies, my study has missing data. The missing data in my study are found within independent variables of level-1, dependent variables of level-1, and independent variables of level-2. To address the missing data within independent variables of level-1, I chose the listwise deletion method because there were only 32 cases missing data describing gender, ethnicity, SES, or special education. To address the missing data within dependent variables of level-1 and independent variables of level-2, I had four options, including: (a) listwise deletion, (b) mean replacement, (c) maximum likelihood, and (d) multiple imputation. I chose multiple imputation because this method provides unbiased parameter estimates while addressing missing data for both levels simultaneously (Graham et al., 2007). To implement this method I used Mplus version 7 (see Appendix A). The strategy to analyze this dataset is described in the next section.

Data Analyses

Two analysis methods were used to answer the research question in this study: descriptive and HLM. For this purpose, I used Mplus 7 to calculate means and standard deviations (*SD*) as well as conduct the HLM. I chose descriptive analysis to describe the center and spread of continuous data and frequencies of categorical data. I chose HLM because I wished to model the nested structure of student achievement in reading, mathematics, and science within school performance (Raudenbush & Bryk, 2002). In this analysis gender, ethnicity, SES and special education variables were identified as level-1 independent variables while percentage of students taking and passing the SAT and ACT at each school, the percentage of students taking and passing the AP and IB courses, school type, and dropout rates were identified as level-2 independent variables. Finally, reading, mathematics, and science TAKS scores were identified as level-1 dependent variables. I also added school type, identified as T-STEM or traditional, into the model.

As introduced earlier in the notation of Raudenbush and Bryk (2002), the within-school level model can be written:

$$Y_{ij} = \beta_{j0} + \beta_{j1}X_{ij1} + \beta_{j2}\,X_{ij2} + \ldots\ldots + \beta_{jK-1}\,X_{ijK-1} + R_{ij} \tag{4.1}$$

where Y_{ij} is the outcome score for student $i(i = 1, 2, \ldots, n_i)$ in school j $(j = 1, 2, \ldots, J)$. There are $k = 1, 2, \ldots, K\text{-}1$ independent variables, X_{ijK}, which describe students' demographics. The β_{jK} are within-school regression coefficients, and the R_{ij} are student level residuals. If the demographic variables, X_{ijK}, are centered around their means for the entire system, then the estimates of the intercepts, β_{j0}, are the demographic-adjusted school means. Therefore, they indicate how well a student with sample-average demographics might be anticipated to score in each school type, either traditional or T-STEM.

I am interested in whether these estimates of adjusted school performance, β_{j0}, are a function of certain school characteristics. Therefore, the between-school model regresses the β_{j0} on these school level variables:

$$\beta_{j0} = \phi_0 + \phi_1 DROP_j + \phi_2 APT_j + \phi_3 APP_j + \phi_4 SATT_j + \phi_5 SATP_j + \phi_6 STEM_j + U_j \quad (4.2)$$

where $DROP_j$ represents dropout rates, APT_j represents percentage of students taking the AP and IB courses, APP_j represents percentage of students passing the AP and IB courses, $SATT_j$ represents percentage of students taking the SAT and ACT at each school, $SATP_j$ represents percentage of students passing the SAT and ACT at each school, and $STEM_j$ represents whether schools' STEM status. The U_j in this formula represents the unexplained contribution of each school by the school level variables in this model. In the next section, I discuss the limitations of the methods described in this chapter.

Limitations

As with all studies, this one has multiple limitations. In this section, I identify four limitations. The first limitation is the absence of longitudinal data. The absence of this data measuring students' college and career readiness prevents me from conducting a longitudinal study. However, longitudinal data of this nature is not readily available.

The second limitation is sampling of traditional schools. To complete my comparative analyses, I randomly selected 53 traditional schools. As criteria for stratified sampling, I first used size and White student percentage of each school. However, a large group of T-STEM schools were small. Therefore, I used only White student percentage when I selected 53 traditional schools.

The third limitation is categorization and definitions of certain variables. For example, in the original data, SES had four categories (i.e., Free meals = 1, reduced-price meals = 2, other economic disadvantages = 9, Not identified as economically disadvantaged = 0). However, in my analyses, I categorized 1, 2, and 9 as economically disadvantaged and 0 as not disadvantaged to simplify discussion. A review of literature reveals the definition for dropout rates is complex and measured using multiple methods. In 2005-06, TEA began to use the National Center for Education Statistics' (NCES) definition for dropout. According to the NCES,

> "a dropout is a student who is enrolled in grades 7-12, does not return to public school the following fall, is not expelled, and does not: graduate, receive a General Educational Development (GED), continue school outside the public school system, begin college, or die". (TEA, 2014c)

Currently, the TEA calculates both longitudinal and annual dropout rates. In this study, I used annual dropout rate because my study is cross-sectional and includes only 2012-13 academic year. Annual dropout rate is the ratio of students who dropped out in a single academic year to students who enrolled in that school year.

The fourth limitation is missing data. Approximately 25% of data used in conducting my study was missing. To reduce bias and provide accurate results, a procedure was applied for missing data. For reasons listed above, I chose multilevel multiple imputation. Therefore, I did not lose data or information regarding T-STEM and traditional schools' success at preparing students for college and career.

Although this study has limitations, I answered the question addressing the specialized STEM schools' success in preparing students for college and career using student and school level data. Student level data for 28,159 students in grade 11 from 53 T-STEM and 53 traditional schools included students' high-stake test (i.e., TAKS) scores and demographic information. School level data included percentages of students taking and passing SAT or ACT, students taking and passing AP or IB courses, and students dropping out of school. To examine the association between variables, I used descriptive and HLM analyses. Missing data in this dataset were handled with multiple imputation method. The next section presents results from analyses.

Results

Descriptive Analysis

The comprehensive analysis of descriptive data was conducted for students attending either T-STEM or traditional schools. Overall mean scores for students attending T-STEM schools on reading, mathematics, and science were higher than mean scores for their counterparts in traditional schools (Table 4.5). However, mean differences between the groups were not large. In both groups, mathematics scores were more dispersed than reading and science scores. For all three scores, effect sizes were small.

Table 4.5

Mean, Standard Deviation, and Effect Size for Students' Achievement Measures by School Type

Achievement measure	School type	*N*	*M*	*SD*	Effect size
Reading	Traditional	19,155	2,245	212	0.047
	T-STEM	9,004	2,255	216	
Math	Traditional	19,155	2,228	236	0.104
	T-STEM	9,004	2,253	246	
Science	Traditional	19,155	2,239	204	0.049
	T-STEM	9,004	2,249	208	

Comparison of female and male subgroups revealed a similar pattern as reflected in the overall scores (Table 4.6). However, in this case range for mean differences changed significantly. For example, on one hand, female (F) students attending T-STEM schools were performing better on mathematics than their counterparts in traditional schools but not as well on science. On the other hand, male (M) students in T-STEM schools performed better than their counterparts in traditional schools on all three scores.

Table 4.6

Mean, Standard Deviation, and Effect Size for Students' Achievement Measure by School Type and Student Gender

Achievement measure	School type	Student gender	*N*	*M*	*SD*	Effect Size
Reading	Traditional	F	9,509	2,263	209	0.042
	T-STEM	F	4,357	2,272	217	
	Traditional	M	9,646	2,226	214	0.060
	T-STEM	M	4,647	2,239	214	
Math	Traditional	F	9,509	2,228	226	0.081
	T-STEM	F	4,357	2,247	238	

Table 4.6 (continued)

Achievement measure	School type	Student gender	*N*	*M*	*SD*	Effect Size
Math	Traditional	M	9,646	2,228	245	0.128
	T-STEM	M	4,647	2,260	252	
Science	Traditional	F	9,509	2,233	194	0.020
	T-STEM	F	4,357	2,237	201	
	Traditional	M	9,646	2,246	214	0.065
	T-STEM	M	4,647	2,260	214	

Note. F represents female students and M represents male students.

The trend in favor of students attending T-STEM schools continued among ethnic subgroups, except African American (AA) students and students from two or more (T) ethnic backgrounds (Table 4.7). Mean differences for Asian (A), Hispanic (H), and White (W) students were in favor of students attending T-STEM schools and were fairly small on all three scores. However, mean differences for Indian (I) and Pacific Islander (P) students on all three scores were large and consistently in favor of students attending T-STEM schools. While mean differences for African American students and students from two or more ethnic backgrounds on reading and science were in favor of students attending traditional schools, this pattern was exactly opposite on mathematics scores. These differences were small for both African American students and students from two or more ethnic backgrounds. The most dispersed scores appeared on mathematics scores, especially among Asian students and students from two or more ethnic backgrounds. Lastly, effect sizes for all ethnic subgroups were relatively small.

Table 4.7

Mean, Standard Deviation, and Effect Size for Students' Achievement Measure by School Type and Student Ethnicity

Achievement measure	School type	Student ethnicity	*N*	*M*	*SD*	Effect Size
Reading	Traditional	A	685	2,327	237	0.025
	T-STEM	A	501	2,333	240	
Math	Traditional	A	685	2,372	272	0.192
	T-STEM	A	501	2,424	269	

Table 4.7 (continued)

Achievement measure	School type	Student ethnicity	*N*	*M*	*SD*	Effect Size
Science	Traditional	A	685	2,334	246	0.076
	T-STEM	A	501	2,352	228	
Reading	Traditional	AA	2,900	2,209	202	-0.024
	T-STEM	AA	1,413	2,204	209	
Math	Traditional	AA	2,900	2,168	220	0.041
	T-STEM	AA	1,413	2,177	211	
Science	Traditional	AA	2,900	2,203	193	-0.010
	T-STEM	AA	1,413	2,201	181	
Reading	Traditional	H	11,608	2,241	193	0.067
	T-STEM	H	5,251	2,254	196	
Math	Traditional	H	11,608	2,220	216	0.095
	T-STEM	H	5,251	2,241	224	

Table 4.7 (continued)

Achievement measure	School type	Student ethnicity	*N*	*M*	*SD*	Effect Size
Science	Traditional	H	11,608	2,229	186	0.058
	T-STEM	H	5,251	2,240	193	
Reading	Traditional	I	66	1,531	197	0.112
	T-STEM	I	31	1,553	195	
Math	Traditional	I	66	1,608	226	0.174
	T-STEM	I	31	1,647	222	
Science	Traditional	I	66	1,696	200	0.087
	T-STEM	I	31	1,713	191	
Reading	Traditional	P	21	1,815	215	0.271
	T-STEM	P	11	1,871	197	
Math	Traditional	P	21	2,033	226	0.236

Table 4.7 (continued)

Achievement measure	School type	Student ethnicity	*N*	*M*	*SD*	Effect Size
Math	T-STEM	P	11	2,085	215	
Science	Traditional	P	21	2,039	188	0.200
	T-STEM	P	11	2,077	192	
Reading	Traditional	T	265	2,194	263	-0.097
	T-STEM	T	121	2,169	255	
Math	Traditional	T	265	2,201	286	0.021
	T-STEM	T	121	2,195	280	
Science	Traditional	T	265	2,215	264	-0.128
	T-STEM	T	121	2,183	236	
Reading	Traditional	W	3,610	2,291	234	0.043
	T-STEM	W	1,676	2,301	233	

Table 4.7 (continued)

Achievement measure	School type	Student ethnicity	*N*	*M*	*SD*	Effect Size
Math	Traditional	W	3,610	2,292	256	0.117
	T-STEM	W	1,676	2,323	273	
Science	Traditional	W	3,610	2,300	225	0.022
	T-STEM	W	1,676	2,305	227	

Note. A represents Asian students, AA represents African American students, H represents Hispanic students, I represents Indian students, P represents Pacific Islander students, T represents students from two or more ethnic background, and W represents White students.

Similar trend appeared when students were divided into subgroups according to their SES (Table 4.8). Students in T-STEM schools regardless of their SES earned higher scores than their counterparts in traditional high schools on reading, mathematics, and science. However, these mean differences were not very large for any of the subgroups and scores. Mathematics scores were also the most dispersed scores regardless of school type. This dispersion increased among students who were not economically disadvantaged. Finally, effect sizes were still relatively small.

Table 4.8

Mean, Standard Deviation, and Effect Size for Students' Achievement Measures by School Type and Student SES

Achievement measure	School type	Student SES	*N*	*M*	*SD*	Effect Size
Reading	Traditional	N	7,564	2,282	221	0.074
	T-STEM	N	3,308	2,298	221	
	Traditional	Y	11,591	2,221	203	0.044
	T-STEM	Y	5,696	2,230	210	
Math	Traditional	N	7,564	2,273	246	0.133
	T-STEM	N	3,308	2,307	264	
	Traditional	Y	11,591	2,199	224	0.105
	T-STEM	Y	5,696	2,222	229	
Science	Traditional	N	7,564	2,279	213	0.038
	T-STEM	N	3,308	2,287	222	
	Traditional	Y	11,591	2,214	194	0.067
	T-STEM	Y	5,696	2,227	196	

Note. N represents students who are not economically disadvantaged and Y represents students who are economically disadvantaged.

Results were not different when students were divided into subgroups according to special education program status (Table 4.9). Mean differences favored students attending T-STEM schools. The only break in this pattern occurred on science scores of special education students. Specifically, special education students (Y) attending traditional schools performed better than their counterparts in T-STEM schools. Again, the most dispersed scores were mathematics scores regardless of school type but this dispersion became more apparent among special education students. Yet, effect sizes were still small.

Table 4.9

Mean, Standard Deviation, and Effect Size for Students' Achievement Measure by School Type and Student Special Education

Achievement measure	School Type	Student spec. ed.	*N*	*M*	*SD*	Effect Size
Reading	Traditional	N	17,565	2,260	202	0.044
	T-STEM	N	8,329	2,269	208	

Table 4.9 (continued)

Achievement measure	School Type	Student spec. ed.	*N*	*M*	*SD*	Effect Size
Reading	Traditional	Y	1,590	2,075	250	0.020
	T-STEM	Y	675	2,080	242	
Math	Traditional	N	17,565	2,246	224	0.105
	T-STEM	N	8,329	2,270	234	
	Traditional	Y	1,590	2,039	278	0.025
	T-STEM	Y	675	2,046	284	
Science	Traditional	N	17,565	2,255	193	0.046
	T-STEM	N	8,329	2,264	196	
	Traditional	Y	1,590	2,076	251	-0.015
	T-STEM	Y	675	2,072	257	

Note. N represents students who are not in special education program and Y represents students who are in special education program.

Additionally, an analysis of descriptive data was conducted for traditional and T-STEM schools. Mean percentages on all five school level indicators were calculated (Table 4.10). Dropout rates for both school types were very small and close to each other. Percentage of students taking AP/IB end of course exam differed between traditional and T-STEM schools. According to the mean percentage, students attending T-STEM schools were more likely to take AP/IB courses than their counterparts in traditional schools. However, this was not true for percentage of students passing AP/IB end of course exam and percentage of students taking SAT/ACT. In terms of these percentages, both school types were very similar. The mean percentage of students passing SAT/ACT criterion differed between traditional and T-STEM schools. Yet, this difference was small.

Table 4.10

Percent Values for School Level Indicators by School Type

School type	*N*	Dropout (%)	AP Tested (%)	AP Passed (%)	SAT Tested (%)	SAT Passed (%)
Traditional	53	1.6	22.2	40.9	69.5	16.9
T-STEM	53	1.3	31.9	39.9	69.9	19.6

HLM Analysis

Student level. Results at student level were mostly consistent across the three scores (Table 4.11). The STEM variable among school level indicators was not statistically significant; therefore, the following statements were valid for both school types. Controlling for all other student and school level indicators, female students performed better on reading scores than their male counterparts. However, female students were outperformed on mathematics and science scores by male students. In regard to ethnicity, on one hand, African Americans, Indians, and students from two or more ethnic backgrounds underperformed on reading, mathematics, and science scores in comparison to White students. On the other hand, Asian students outperformed White students on all three scores. However, Hispanics only underperformed on mathematics and science scores in comparison to White students, while performed similarly on reading. In addition, Pacific Islanders only underperformed on reading scores in comparison with White students, but not on mathematics and science scores. Results also indicated economically disadvantaged students underperformed on all three scores in comparison with students who were not economically disadvantaged. Finally, students in special education program underperformed on all three scores compared to their counterparts who are not in special education program.

School level. Unlike student level indicators, school level indicators revealed little or no association with reading, mathematics, and science scores (Table 4.11). Again the STEM variable among school level indicators was not statistically significant; therefore, the following statements were valid for both school types. Although dropout rates and percentage of students taking AP/IB end of course exam consistently showed statistical significance on all three scores, other school level indicators did not show similar association. Intraclass correlations were very small ($ICC_{read} = 0.041$, $ICC_{math} = 0.067$, $ICC_{science} = 0.050$). Therefore, estimated coefficients of most school level indicators across all three scores demonstrated no statistical significance. Covariance matrices for student and school levels and standardized model results were reported at the end of this article (see Appendix B, C, and D).

Controlling for all other student and school level indicators, including school type, dropout rates showed negative and statistically significant association with reading, mathematics, and science scores. In contrast, percentage of students taking AP/IB end of course exam revealed positive and statistically significant association with all three scores. In addition, the percentage of students taking SAT/ACT were positively and statistically significantly associated with reading and mathematics scores, but not statistically significantly associated with science scores. However, the percentage of students passing AP/IB end of course exam and the percentage of students passing SAT/ACT criterion did not statistically significantly associate with reading, mathematics, and science scores.

Table 4.11

Results of HLM Unstandardized Model Evaluating The Association of Student and School Level Indicators with Students' Reading, Mathematics, and Science Score

	Reading		Math		Science	
	Coeff.	*SE*	Coeff.	*SE*	Coeff.	*SE*
Intercept	2,224.18***	22.21	2,233.01***	23.97	2,295.57***	20.14
Student level indicators						
Gender	26.15***	2.72	-15.34***	3.37	-26.48***	2.72
Asian	32.70**	10.08	78.31***	10.00	31.25**	9.54
African American	-45.72***	6.61	-85.59***	7.14	-63.76***	6.061
Hispanic	-7.99	6.54	-34.66***	7.50	-34.45***	6.32
Indian	-733.68***	69.03	-658.51***	121.93	-580.45***	121.63
Pacific Islander	-460.82***	131.56	-258.35	171.94	-249.94	173.32
Two or more	-100.48***	25.40	-96.63***	25.49	-92.023***	22.37
SES	-43.51***	4.36	-40.92***	4.47	-34.62***	4.05

Table 4.11 (continued)

	Reading		Math		Science	
	Coeff.	*SE*	Coeff.	*SE*	Coeff.	*SE*
Student level indicators						
Special Education	-170.66***	9.08	-197.29***	10.78	-175.45***	8.47
School level indicators						
Dropout rate	-10.29**	3.22	-9.93*	4.43	-11.36***	3.24
AP tested	0.69*	0.27	1.36***	0.38	1.04***	0.27
AP passed	-0.01	0.29	0.05	0.35	-0.30	0.28
SAT tested	0.59*	0.28	0.88**	0.32	0.37	0.26
SAT passed	0.25	0.46	0.13	0.57	0.35	0.43
STEM	-0.16	8.09	4.10	11.42	-5.20	8.98

*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.

Conclusion

The need for educational reform in STEM education is supported by most stakeholders, especially those stakeholders whose focus is on preparing students for college and career. Specialized STEM schools are an important asset in achieving reform in STEM education. However, the success of these schools at preparing students for college and career is still blurred. Through this study, both descriptive and HLM analyses were employed to explore associations between student demographics and school characteristics with achievement outcomes of students attending either T-STEM or traditional schools. A descriptive analysis provides the opportunity to see the differences at first sight without complex analysis. An HLM analysis provides the opportunity to analyze the nested structure of student achievement in reading, mathematics, and science within school performance (e.g., performance of traditional or T-STEM schools; Raudenbush & Bryk, 2002).

I believe HLM analysis allows researchers to evaluate student achievement outcomes within the overall effect that can be attributed to specific school type. In conducting my HLM analysis, I used dropout rate, percentage of students taking and passing the SAT and ACT, and percentage of students taking and passing the AP and IB courses at each school as variables to describe student achievement outcomes within different school types (Christle et al., 2007; Heubert & Hauser, 1998; Kobrin, 2007; Sahin et al., 2012; Rumberger & Palardy, 2005). The results from the HLM analysis suggest small but important associations between students’ achievement outcomes and school level indicators but not school types.

Student achievement outcomes depend on both intrinsic and extrinsic variables. This is why school level indicators (e.g., percentage of students passing SAT/ACT) are as important as student variables (e.g. gender). The blueprint used in developing specialized schools in Texas required T-STEM schools to provide critical opportunities (e.g., a college preparatory curriculum) for students, which in turn informed schools' characteristics (Avery et al., 2010; NRC, 2011; Young et al., 2011). It is likely researchers would like to know how well and in what ways T-STEM schools implemented what the blueprint required; and therefore, how this implementation changed student achievement outcomes.

In response to the research question, results from my descriptive analysis suggest students from T-STEM schools have higher scores on reading, mathematics, and science when compared to students from traditional schools. In my analysis, the dispersion of mathematics scores was larger than reading and science scores, suggesting success in mathematics is less likely to be a result of students' school type. Performance of students attending T-STEM schools confirmed some of the earlier results from Young et al. (2011). For example, male students outperformed female students on all student performance measures. However, female students from T-STEM schools outperformed female counterparts from traditional schools. In terms of ethnic subpopulations, only Hispanic and White students in T-STEM schools exhibited a remarkable difference on reading, mathematics, and science scores. Other ethnic subpopulations in T-STEM schools performed similar to or worse than students in traditional schools. In addition, economically disadvantaged students performed better on all three measures than students in traditional schools. Differences for economically disadvantaged students attending either T-STEM or traditional schools were also noteworthy. However, this was not true for students in special education program. Although differences between the student subpopulations were observed, effect sizes for these differences were small. Finally, descriptive statistics for school level variables showed percentages of students taking AP or IB courses and passing the SAT or the ACT in T-STEM schools were higher than percentages of students in traditional schools. However, similar percentages of students in both school types dropped out of school, passed either the AP or the IB end of course exam, and took SAT or the ACT.

From the results of my descriptive analysis, the success of female, Hispanic, and economically disadvantaged students from T-STEM over counterparts from traditional schools is encouraging because these are the target student populations for many specialized STEM schools (i.e., female, diverse, and disabled; NRC, 2011, NSF, 2013, PCAST, 2010; U.S. Department of Commerce, 2011). However, this success is limited and needs to exhibit growth in the future. T-STEM schools show potential as a unique national resource for assisting in the growth and development of the STEM workforce. Stakeholders should revise current strategies in accordance with research results from studies such as the one presented in this study.

The results of my HLM analysis indicate differences between T-STEM schools and traditional schools are small. Based on the results of the HLM at student level, regardless of school type, female students performed better on reading measures whereas male students performed better on mathematics and science measures. These results confirm the likely continued existence of a gender gap in education, specifically in reading, mathematics, and science. Overall differences among ethnic groups were as expected. White and Asian students outperformed all other ethnic groups on performance measures. In addition, economically disadvantaged students and students in special education program were outperformed by students not identified as disadvantaged or learning disabled.

Based on the results of the HLM, regardless of school type, the dropout rate was negatively associated with students' reading, mathematics, and science scores. This association was an expected result because the more absences students have; the less they succeed in the school. It was also expected that educational reforms in STEM schools would create a difference; however, this study offers some evidence to the contrary. In addition, percentage of students taking AP/IB end of course exam had a positive association with reading, mathematics, and science scores. This positive association indicates the more AP/IB courses students enroll in, the more they succeed in the school and are prepared for college. This study emphasizes the importance of college level coursework one more time. Percentage of students taking SAT/ACT also demonstrated a positive association with reading and mathematics scores, but not science scores. This positive association shows students who took SAT/ACT had been through a preparation process for these exams, which also helped them succeed in the school. The reason why similar association was not observed is that SAT does not include a science section. Although ACT includes a science section, scores from this test have yet to be required for most college admissions whereas the scores from SAT have been required for almost all college admissions. Finally, other results of the HLM analyses at the school level revealed no association with reading, mathematics, and science scores, suggesting educational reforms in STEM schools are ineffective.

Although associations were found between some student and school level variables and achievement scores, these associations did not help to distinguish T-STEM schools from traditional schools. The blueprint requirements regarding a college preparatory curriculum, real world relevant practices, a strong academic support system, and a wide range of STEM coursework aims to influence these percentages (Avery et al., 2010). The blueprint proposes real world relevant practices and a strong academic support system to attract students from historically underrepresented populations and finally to decrease the dropout rates. Also, the blueprint proposes a college preparatory curriculum and a wide range of STEM coursework to increase the percentages of students taking and passing SAT/ACT and AP/IB courses. However, students from T-STEM schools are performing only slightly or no much better than counterparts in traditional schools. Finally, this question requires further analysis.

College readiness of students attending T-STEM schools was evaluated through measures on reading, mathematics, and science and other student and school level variables. Results from my analyses suggested there was little or no difference on measures of student achievement outcomes between students from T-STEM and traditional schools. Researchers, however, may find other relevant variables to evaluate the college readiness of students from T-STEM schools (Young et al., 2011). In addition, a longitudinal research design may be preferable over a cross sectional research design as the one used in this study to evaluate educational reforms. Finally, a qualitative follow-up study may help to better understand the benefits of these schools as measures such as high-stake tests offer limited explanations of schools' influence on students' college readiness.

In the next chapter, I synthesize my results from the previous three chapters. In synthesizing these results, I highlight problems in STEM education identified in national reports and solutions recommended by stakeholders in the literature. I then summarize my results from Chapters III and IV while incorporating those same results into the literature. Finally, I conclude this chapter with recommendations for stakeholders involved in the reform of STEM education.

CHAPTER V

SUMMARY OF RESULTS AND RECOMMENDATIONS FOR STAKEHOLDERS

Preparing students for college and career is one of the primary purposes of K-12 education. Within this period of time, high school education has the largest influence on students' preparation process for college and career. The value of each element (i.e., schools, teachers, and students) within high schools can be discussed separately to understand their roles. However, one should consider schools as a whole when discussing students' college and career readiness. Schools, from this perspective, should consider the demands of society when preparing students for college and career. The overarching goals of my dissertation were to first develop a conceptual framework for specialized STEM schools and second, to measure the college readiness of Inclusive STEM High School (ISHS) graduates in comparison to traditional high school graduates.

Statistics in governmental reports point to the need for improving the STEM workforce in the U.S. Projections from these reports indicate the growth in occupations requiring STEM knowledge will be 17% between 2008 and 2018. However, the U.S. education system is failing to prepare adequate numbers of students for these occupations. Especially when compared to other nations, fewer students in the U.S. are earning a college degree in one of the STEM fields. The basis for this failure in colleges may be found in U.S. high schools. International comparison studies indicate students in the U.S. are performing on average, which does not align with goals of stakeholders in the U.S. wishing to lead the world. Stakeholders noticing the shortage in STEM workforce have, therefore, urged for reform in STEM education within the U.S. education system.

Educational reform suggested by stakeholders includes (a) teaching STEM focused content and practices, (b) helping to create positive attitude toward STEM, and (c) raising lifelong learners. In this direction, policymakers make specific suggestions, including: (a) supporting states in creating mathematics and science standards, (b) recruiting new teachers, (c) recognizing and rewarding STEM teachers, (d) expanding the use of educational technology, (e) creating opportunities for students outside of school, (f) supporting administrators, and (g) creating new STEM-focused schools. In relation to my research, the most prominent suggestion among these is the STEM-focused schools because STEM-focused schools have the potential to become a unique national resource for the STEM workforce. However, the success of these schools at preparing students for college and career has yet to be fully investigated.

The purpose of this summary chapter is fourfold. First, I briefly describe the conceptual framework that I developed in Chapter II about effective learning environments for specialized STEM schools. Second, using results from my analyses, I review the comparison of students from ISHS and traditional high schools in Texas on student level indicators for college readiness. Third, I examine the association between schools' success and student achievement for both school types. Finally, I make specific recommendations for stakeholders, which should help in the decision-making process for the future of specialized STEM schools.

Learning Environments for Specialized STEM Schools

The first paper for this dissertation was the broadly based literature review on types of STEM schools, appearing as Chapter II in this dissertation. After the review, I proposed a conceptual framework of effective learning environments for specialized STEM schools using an ecology framework (see Figure 2.2; Erdogan et al., 2013; Weaver-Hightower, 2008). The purpose of this framework was to create environments contributing to students' outcomes. Being aware of unique learning environments for specialized STEM schools, I synthesized the literature and combined essential components of specialized STEM schools into my conceptual framework, "collaborative actions of community." In this framework, three categories encompass the essential components of specialized STEM schools: (a) Actors, (b) Contextual factors, and (c) Actions (Erdogan et al., 2013; Weaver-Hightower, 2008). These three categories provide the skeletal structure for specialized STEM schools.

Actors in the school ecology framework include students, teachers, community leaders, and role models (see Figure 2). As within any ecosystem, actors in this framework play individual roles, but also depend on others, to play multiple roles over time (Weaver-Hightower, 2008). Among actors, students define the center of this framework. Locating students as the center creates opportunities for students to ask questions and find solutions to questions through the collection and interpretation of data, taking risks, and being creative (Rallis, 1995). Well-trained teachers are actors, who are dedicated to teaching, experts in their domains, facilitators in the classroom, and leaders in the school (Rallis et al., 1995). In addition, teachers in this framework are expected to update their knowledge and skills through professional development. Community leaders include many actors such as student leaders, teacher leaders, staff, administrators, and parents. To reach learning, reform, and achievement goals, community leaders gather actors around the goals using shared values by forming unique school cultures (Deal & Peterson, 1999). Role models in this framework include university faculty members, technicians in labs, business or industry leaders, other STEM professionals, and parents. Role models represent a motivational factor while mentoring students and teachers through internship and apprenticeship programs. By emphasizing the role of actors in my framework, I highlight the importance of people in students' learning.

Contextual factors in the school ecology framework include learning environments, curriculum, instructional strategies, coursework, and technology (see Figure 2.2). As within any ecosystem, contextual factors in this framework provide extant conditions (i.e., boundaries, pressures, inputs, and consumption; Weaver-Hightower, 2008). The primary contextual factor in this framework is learning environments, where no certain boundaries exist between formal and informal learning. As an example, students should be able to seek solutions to their questions within formal learning environments and carry their struggles to informal learning environments where they can receive help from role models. Curriculum and instructional strategies are additional contextual factors, often aligned with standards (Haycock, 2001). Such curriculum and strategies provide for true integration of STEM disciplines. In addition, advanced coursework in this framework is necessary for integration, and to ultimately prepare students for college and career. Incorporation of technology into the practices is the final contextual factor. When teachers are well trained on technology use in learning environments, technology can be a great help for students to access information. Collaborative actions of actors, therefore, can define the value of contextual factors.

Collaborative actions in the school ecology framework include teaching, learning, immersion, communication, partnering, mentoring, support, and assessment (see Figure 2.2). As within any ecosystem, collaborative actions in this framework can be defined as relationships between actors (Weaver-Hightower, 2008). The primary action in this framework is communication existing among actors inside and outside the classroom (Erdogan et al., 2013). Clear communication between teachers and students or teachers and community leaders can advance students' learning opportunities. Partnering is also an action taking place particularly between teachers, community leaders, and role models (Marshall, 2010). Through partnering, more students can be directed to pursue STEM majors in college. In addition, mentoring in this framework can positively alter the image of scientists for students. Assessment, both formative and summative, is the final action in this framework. To facilitate teaching and learning, teachers benefit from formative assessment integrated into instructional practices. Teachers can also use summative assessment to understand levels of students' learning. In the next section, I will present my comparison of students from ISHS and traditional high schools in Texas on student level indicators for college readiness.

Specialized STEM Schools for College and Career

As I attempted to combine essential components of specialized STEM schools, I found administrators also look for these components while creating environments that will contribute to students' outcomes. The administrative authority in Texas, TEA, wrote a blueprint for the design and implementation phases of T-STEM schools. The blueprint has been used by T-STEM schools as a guide:

> to build and sustain [T-]STEM schools that address seven benchmarks: 1) mission driven leadership, 2) school culture and design, 3) student outreach, recruitment, and retention, 4) teacher selection, development and retention, 5) curriculum, instruction, and assessment, 6) strategic alliances, and 7) academy advancement and sustainability. (Avery et al., 2010, p. 2)

T-STEM schools are expected to differentiate themselves from other schools in accordance with the evaluation rubric provided in the blueprint. However, there are non-negotiable requirements under the seven benchmarks.

Although these seven benchmarks were set for T-STEM schools, they do not ensure student achievement outcomes or college and career readiness. In order to understand where T-STEM schools succeed and fail, researchers should evaluate these schools through different types of research (e.g., quantitative or qualitative). However, literature on the evaluation of specialized STEM schools is poor. The limited literature in this field suggests students in specialized STEM schools perform slightly better on high-stake tests in comparison to traditional schools (Young et al., 2011). However, the same literature also suggests these findings are limited to specific grades and disciplines.

Other literature regarding students' interest in STEM subjects suggests students in specialized STEM schools are more interested, confident, and enthusiastic in STEM subjects than students from traditional schools (Means et al., 2013). Recognizing the limited literature, in Chapter III, I compared students from T-STEM and traditional schools to understand the college and career readiness of students in T-STEM schools.

The comparison study, based on student level data describing high-stake test results, identified no significant difference between students in T-STEM and traditional schools on reading, mathematics, and science scores. However, mean scores of students in T-STEM schools were higher than mean scores of students in traditional schools. This comparison study for 11th graders supports similar findings of Young et al. (2011). High-stake test results is one way of examining the primary goal of T-STEM schools, the college and career readiness of students. After asking for the opinions of teachers and school leaders, Young et al. (2011) indicated high-stake test results is a critical indicator of success. Knowing the importance of high-stake test results on evaluation of teachers and schools, authorities in T-STEM schools pay special attention to students' performance on these tests. Although my study identified no significant differences for students, additional factors, such as differences in teachers across the school type or improvements in students' interests in STEM subjects rather than high-stake test results, may have influenced the results of my study. Though no statistical differences were found in my study, it is important to note that students from T-STEM schools live in urban areas and come from historically underrepresented populations; therefore, performing similar to students in traditional schools might be a promising finding.

Comparisons made by dividing the student sample into subgroups allowed me to identify significant differences between students from T-STEM and traditional schools. The most remarkable differences were found in factors related to students' gender, Hispanic status, and economically disadvantaged state. These differences are especially important as females, students from diverse cultural backgrounds, and economically disadvantaged students are part of the target population for many specialized schools, such as T-STEM schools (NRC, 2011, NSF, 2013, PCAST, 2010; U.S. Department of Commerce, 2011). Although these results are promising, authorities in T-STEM schools have a lot to do for other students from diverse backgrounds and those in special education programs. They should also strive to improve and expand these differences to other subject areas because these differences appear small and limited in scope. In the next section, I will present my reviews on comparison of students from T-STEM and traditional high schools on student and school level indicators for college readiness.

College Entry Indicators for Students in Specialized STEM Schools

The primary goal of T-STEM schools, college and career readiness, can be examined using indicators other than high-stake tests. Considering different dimensions of the preparation process for college and career, I identified three indicators available in state databases relevant to college and career readiness. These indicators included (a) percentage of students taking and passing the SAT and ACT at each school, (b) percentage of students taking and passing the AP and IB courses, and (c) dropout rates.

The three indicators were identified through my review of relevant literature. For example, higher education institutions in the U.S. have created an academic index to aid in the admission process (Kobrin, 2007). This index is created in accordance with currently enrolled students' performance on college courses and college entrance scores. Many of these institutions have identified indicators like percentage of students taking and passing the SAT and ACT at each school and percentage of students taking and passing the AP and IB courses as important for college and career readiness (Heubert & Hauser, 1998). In addition, dropout rate was identified as an indicator to examine the school performance at preparing students for college and career (Christle et al., 2007; Rumberger & Palardy, 2005) because this indicator may inform stakeholders as to what schools use resources and how these affect student achievement outcomes.

The blueprint for T-STEM schools also emphasizes the importance of these indicators through the seven benchmarks (Avery et al., 2010). The multilevel modeling analysis that I used to understand how well these benchmarks were met revealed T-STEM and traditional schools perform similar on all indicators. Therefore, I examined how these indicators were associated with student achievement outcomes regardless of school types. Dropout rates showed a negative association with reading, mathematics, and science scores of students. One might expect, therefore, for T-STEM schools to have lower dropout rates when compared to traditional schools because students attending T-STEM schools often choose these schools for advanced STEM knowledge (Young et al., 2011). However, reasons to leave T-STEM schools also exist such as high expectations or incompatible school culture. In addition, the percentages of students taking AP/IB and the end of course exam showed a positive association with reading, mathematics, and science scores of students. Although descriptive statistics indicated more students in T-STEM schools (31.9%) took AP/IB or the end of course exam than students in traditional schools (22.2%), multilevel modeling analysis showed this difference was not significant when controlling for other indicators. Also, percentages of students taking SAT/ACT showed a positive association with the reading and mathematics scores of students. The same association was not observed with science scores because SAT does not include a science section and most higher education institutions require students to take the SAT rather than the ACT. Positive associations between taking AP/IB or end of course exam and SAT/ACT and high-stake test results indicate the advantages of the preparation process for these exams. Finally, other indicators listed showed no significant association with students' reading, mathematics, and science scores.

In my multilevel modeling analysis, I also examined the association of students' demographics and achievement scores. When controlling for other indicators, such as school type, female students had higher reading scores whereas male students had higher mathematics and science scores. In addition, Asian students had the highest reading, mathematics, and science scores; White students followed Asian students; and students from other ethnic backgrounds had lower scores. Economically disadvantaged students and students in special education programs had lower scores in comparison to all other students. These findings suggest T-STEM schools do not create differences found in other schools. More in-depth data collection and analyses are needed to evaluate the success of T-STEM schools at preparing students for college and career. Data such as college enrollment, success in college, and graduation from college should be collected statewide and nationwide. Such data can help stakeholders in understanding how well and in what ways T-STEM schools prepare students for college and career. In the next section, I present a summary of Chapter V and directions for future research.

Summary and Recommendations

In my dissertation, after providing baseline information regarding specialized STEM schools, I created a conceptual framework describing a theoretically effective learning environment for specialized STEM schools. In addition, I compared student achievement outcomes from traditional and T-STEM schools to understand the college and career readiness of students. Also, I examined the association of students' demographics and school characteristics with achievement outcomes of students attending either T-STEM or traditional schools. After a review of literature and analyses, I have concluded specialized STEM schools have the potential to prepare college and career ready students, although results from my dissertation were not definitive.

Unique characteristics of specialized STEM schools make us aware of their potential. These characteristics include: (a) school culture, (b) college prep program, (c) academic support for students, (d) advanced coursework, (e) technology rich environment, (f) extracurricular activities, and (g) partnerships with businesses and universities. For specialized STEM schools, depending on the context and location of individual schools, one of these unique characteristics comes forward. Most T-STEM schools are newly founded and lack substantial history. Therefore, these schools are faced with challenges such as recruiting teachers, training inexperienced teachers, creating a new school culture, developing new curriculum and instruction, establishing new administrative organization, and collaborating with new organizations. Once all these challenges are dealt with carefully by stakeholders, I believe these schools will contribute significantly to student achievement outcomes. For this purpose, I have two recommendations for stakeholders, which I believe will assist in the decision-making process for the future of specialized STEM schools.

First, we still know very little about specialized STEM schools and their success. The data available for researchers is limited with only aggregated students' outcomes; however, specialized STEM schools aim to achieve more than these. Unlike traditional schools, these schools emphasize 21st century skills and students' interest in STEM for students' college education and future career. Yet, there are no measures to understand how well and in what ways these schools are helping students develop 21st century skills. Also, little is known as to how these schools affect students' interest in STEM or whether these schools are leading students to STEM majors in college. Therefore, I recommend stakeholders develop instruments to measure the outcomes that specialized STEM schools target.

Second, although specialized STEM schools have been founded across the nation, studies in the literature are limited within small contexts. In addition, not all U.S. states collect and maintain data for researchers to examine these schools in different contexts on a large scale. I believe comparing different types of specialized STEM schools (e.g., selective STEM schools vs. inclusive STEM schools) could contribute to our understanding of where these schools succeed and fail. Finally, long-term effects of specialized STEM schools are questionable. Therefore, I recommend stakeholders establish a nationwide monitoring system for students attending specialized STEM schools, from their enrollment in these schools untill graduation from college.

In summary, specialized STEM schools are the products of a solution to the problem of shortages in the STEM workforce. Stakeholders who created these schools should be aware of obvious and hidden challenges through this educational reform. Research on outcomes promised by these schools and with extended data is necessary to develop a strategy when faced with challenge of ensuring a large and sustained STEM workforce. I believe results from my analyses provide information for recognizing current challenges and developing future strategies to generate highly qualified education and learning environments in specialized STEM schools across the nation.

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APPENDIX A

```
TITLE:      Multilevel multiple imputation;

DATA:       FILE = origdata.dat;

VARIABLE:   NAMES = drop app apt satp satt stem
            read math sci spec gender h b a i p t ses
            clus;
            USEVAR = drop-ses;
            missing = *;
            BETWEEN = drop app apt satp satt stem;
            categorical = spec-ses;
            CLUSTER = clus;

!Comment school level independent variables: drop app apt satp satt stem
!Comment student level dependent variables: read math sci
!Comment student level independent variables: spec gender h b a i p t ses

ANALYSIS:   TYPE = TWO LEVEL BASIC;
            PROCESSORS = 2;
            Bconvergence = .01;
            DATA IMPUTATION:
            IMPUTE = read math sci app-satt ses (c) spec (c);
            VALUES = app-satt (0-100)
            read (1200-3300)
            math (1100-3000)
            sci (1100-3000);
            Ndata = 50;
            SAVE = datimp*.dat;
            thin = 2000;

!Comment Missing data on: drop app apt satp satt read math sci

OUTPUT:     TECH1 TECH8;
```

APPENDIX B

Covariance Matrix of Student Level Indicators

	Read	Math	Science	Gender	Asian	Afr. A.	Hispan.	Indian	Pacific	Two M.	SES	Spec. E.
Read	44018.2											
Math	30401.1	53952.0										
Science	26685.0	36923.2	40470.2									
Gender	8.6	-1.6	-4.6	0.2								
Asian	2.8	5.6	3.4	-0.1	0.1							
Afr. A.	-6.0	-9.3	-6.0	0.0	-0.1	0.1						
Hispan.	1.0	-3.1	-3.6	0.1	-0.1	-0.1	0.2					
Indian	-2.5	-2.1	-1.9	0.0	0.0	-0.1	-0.1	0.1				
Pacific	-0.5	-0.2	-0.2	0.0	0.0	0.0	-0.1	0.0	0.1			
Two M.	-1.0	-0.7	-0.7	0.0	-0.1	-0.1	-0.1	0.0	0.0	0.1		
SES	-12.0	-14.7	-12.5	0.1	-0.1	0.1	0.1	0.0	0.0	-0.1	0.2	
Spec. E.	-13.6	-15.3	-13.2	-0.1	-0.1	0.1	-0.1	0.0	0.0	0.0	0.1	0.1

APPENDIX C

Covariance Matrix of School Level Indicators

	Read	Math	Science	Dropout	AP tested	AP pass	SAT tested	SAT pass	STEM
Read	1844.0								
Math	2267.2	3637.9							
Science	1641.3	2424.5	2000.7						
Dropout	-35.6	-42.2	-38.1	2.4					
AP tested	438.4	742.6	513.4	-9.0	364.1				
AP pass	182.1	230.9	59.3	-8.1	36.2	504.3			
SAT tested	362.0	569.5	324.4	-4.3	151.4	58.6	364.9		
SAT pass	144.8	158.7	120.6	-7.8	29.0	183.1	8.5	166.5	
STEM	4.9	9.0	5.3	-0.1	4.6	0.5	0.3	0.8	0.3

APPENDIX D

Table D-1

Results of HLM Standardized Model Evaluating The Association of Student and School Level Indicators with Students' Reading, Math, and Science Score

	Reading		Math		Science	
	Coeff.	*SE*	Coeff.	*SE*	Coeff.	*SE*
Intercept	52.60***	6.48	37.18***	4.05	51.57***	6.49
Student level indicators						
Gender	0.06***	0.01	-0.03***	0.01	-0.07***	0.01
Asian	0.03**	0.01	0.07***	0.01	0.03**	0.01
African American	-0.08***	0.01	-0.13***	0.01	-0.11***	0.01
Hispanics	-0.02	0.02	-0.07***	0.02	-0.08***	0.02
Indian	-0.21***	0.02	-0.17***	0.03	-0.17***	0.04
Pacific Islander	-0.07***	0.02	-0.04	0.03	-0.04	0.03

Table D-1 (continued)

	Reading		Math		Science	
	Coeff.	*SE*	Coeff.	*SE*	Coeff.	*SE*
Two or more	-0.06***	0.01	-0.05***	0.01	-0.05***	0.01
SES	-0.10***	0.01	-0.09***	0.01	-0.08***	0.01
Special Education	-0.22***	0.01	-0.23***	0.01	-0.24***	0.01
School level indicators						
Dropout rates	-0.37***	0.10	-0.26*	0.11	-0.40***	0.09
AP tested	0.31*	0.12	0.43***	0.12	0.45***	0.12
AP passed	-0.01	0.15	0.02	0.13	-0.15	0.13
SAT tested	0.26*	0.12	0.28**	0.09	0.16	0.11
SAT passed	0.08	0.14	0.03	0.12	0.10	0.13
STEM	-0.01	0.10	0.04	0.10	-0.06	0.10

*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.