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Transformational Leadership in STEM-Focused High Schools

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Abstract

Over the past decade, high schools have become increasingly focused on addressing the academic needs of their students in science, technology, engineering, and mathematics (STEM) (Hansen, 2014). The emergence of STEM-focused-schools has enabled K-12 institutions to focus on STEM fields and prioritize academics in science, technology, engineering, and mathematics (Hansen, 2014). The purpose of this study was to explore the leadership qualities of principals serving in STEM-focused schools. The research has shown that teachers of science, mathematics, and other STEM subjects in traditional high schools have not received direct instructional support from their principals regarding their content areas (Lochmiller & Acker-Hocevar, 2016). In exploring the role of principals' instructional leadership within the STEM-focused schools, this population of school administrators' leadership was examined. The researcher used a qualitative approach to determine the transformational leadership styles of principals at STEM-focused schools and how they work to support the instructional needs of their teachers. Data were collected using the MLQ-5X survey tool and semi-structured phone interviews. Three findings emerged from the study. First, principals in STEM-focused schools work as transformational leaders and demonstrate these qualities as well. Second, principals of STEM-focused high schools work carefully to craft the environment and culture of their institution to operate at its highest standard. Third, principals of STEM focused high schools work to support their teachers through professional development, instructional coaching, and supporting teachers' development.

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Dedication

I would like to express gratitude to my mother and father for instilling a passion for education in me from an early age. My parents, Millie and Jim Denaker, have always supported my educational endeavors and have been cheering me along this journey. Over the years, my parents have served as my rock, and it is through their ongoing support that I am the person I am today. I would also like to thank my close friends for their encouragement and excitement as I pursued this degree. I've enjoyed sharing with everyone, each step of the way, and all of the items that went into producing this dissertation. To SDM3, and Cohort 12, thank you for all of the laughs and friendship through the years. I am grateful for the support of my dissertation committee, including my chair, Dr. Susan Schultz, and my committee member, Dr. Michelle M. Ryan. Thank you for all of you help, inspiration, and encouragement along this path. I am incredibly thankful for everyone's support.

Biographical Sketch

Steven L. Denaker has worked in education for over 10 years. He began his journey as an AIS Math Resource Teacher in Webster Central School District. Over the years, he has worked as a second- and fifth-grade teacher, Technology Enrichment Specialist, and a STEM Curriculum Mentor from Los Angeles to New York. After making the switch to administration, he worked as the Instructional Support Supervisor of STEM for GST BOCES and is currently the 7-12 Principal at Avoca Central School.

Steven has attended St. John Fisher College in Rochester, NY for several years. He completed his undergraduate degree in Math/Science/Technology Education and Childhood Education in 2006. Later, he returned and completed his Master of Science in Literacy (Birth-Grade 6) in 2009. When he wanted to get into school administration, he completed a Master of Science in Educational Leadership (SBL/SDL) in 2016.

Steven began his Doctor of Education in 2017 and completed his program of study in 2020. This is his fourth degree from St. John Fisher College. His research focused on the transformational leadership practices of STEM-focused school principals. His study was conducted under the direction of Dr. Susan Schultz and Dr. Michelle Ryan.

Abstract

Over the past decade, high schools have become increasingly focused on addressing the academic needs of their students in science, technology, engineering, and mathematics (STEM) (Hansen, 2014). The emergence of STEM-focused-schools has enabled K-12 institutions to focus on STEM fields and prioritize academics in science, technology, engineering, and mathematics (Hansen, 2014).

The purpose of this study was to explore the leadership qualities of principals serving in STEM-focused schools. The research has shown that teachers of science, mathematics, and other STEM subjects in traditional high schools have not received direct instructional support from their principals regarding their content areas (Lochmiller & Acker-Hocevar, 2016). In exploring the role of principals' instructional leadership within the STEM-focused schools, this population of school administrators' leadership was examined.

The researcher used a qualitative approach to determine the transformational leadership styles of principals at STEM-focused schools and how they work to support the instructional needs of their teachers. Data were collected using the MLQ-5X survey tool and semi-structured phone interviews.

Three findings emerged from the study. First, principals in STEM-focused schools work as transformational leaders and demonstrate these qualities as well. Second, principals of STEM-focused high schools work carefully to craft the environment and culture of their institution to operate at its highest standard. Third, principals of STEM-

focused high schools work to support their teachers through professional development, instructional coaching, and supporting teachers' development.

Table of Contents

List of Tables

Chapter 1: STEM Leadership Introduction

Over the past decade, the focus of high schools has been centered on addressing the academic needs of their students in science, technology, engineering, and mathematics (STEM) (Hansen, 2014). This call to action for STEM has been rooted in statewide, national, and international testing that has highlighted the need for improved academics in the STEM areas. The emergence of STEM-focused schools has enabled K-12 institutions to focus their priorities into the STEM fields and prioritize academics in science, technology, engineering, and mathematics (Hansen, 2014). When discussing STEM education, former President Barack Obama said:

> One of the things that I've been focused on as President is how we create an all-hands-on-deck approach to science, technology, engineering, and math. . . . We need to make this a priority to train an army of new teachers in these subject areas, and to make sure that all of us as a country are lifting up these subjects for the respect that they deserve. (White House, 2013)

Today, promoting STEM-focused educational programs is seen as a way to keep students in the United States competitive on the world stage (Hansen, 2014). Federally, there is a surge of interest in supporting STEM-focused programs in public schools to address concerns within the school system. This includes recent changes in mathematics and science standards established nationwide and adopted by many states (Hansen, 2014).

Problem Statement

In exploring the literature on STEM-focused schools aligned to principal leadership practices, there is a dearth of research established in this area. Individually, there are vast amounts published about STEM and principal leadership/instruction, however, the merge between the two areas has little published to date. STEM schools follow 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" (Mizell & Brown, 2016, p. 52).

School principals are accountable for the instruction delivered to students within their building. This responsibility means that principals should be investing their time into assessing and improving teachers' pedagogical abilities (Liu, Ritzhaupt, & Cavanaugh, 2013). While successful principal instructional leadership has been linked to increased student achievement and teacher support, there are also links between principals' lack of content knowledge of STEM fields and lack of support for those teachers (Lochmiller & Acker-Hocevar, 2016). Further research is necessary to find the connections between successful STEM-focused schools and their principal's leadership traits driving that success within the school.

Principals serve as the main instructional leader for a building, in addition to serving to meet the needs of the bureaucracy, including facility management, discipline, and other duties. While managerial tasks and matters of supervision often take time and attention from principals, they often can overwhelm and overrun the instructional leader aspects of the job (Lochmiller & Acker-Hocevar, 2016; Terosky, 2016). Traditional high

school principals have struggled to attend to the varying instructional needs of staff in areas where the principal is not a content specialist. Specifically, principals have been shown to struggle to support the instructional needs of teachers from STEM fields when the principal does not have an existing background in the field (Lochmiller & Acker-Hocevar, 2016).

Principal leadership in a school setting has an effect on the academic outcomes of the school (Katterfield, 2013; Lochmiller & Acker-Hocevar, 2016). A change over past years has occurred that encourages the principal to serve in the role of instructional leader, in addition to the more traditional manager role. A principal's leadership and expectations for success plays a larger role in the effectiveness of classroom instruction. As the role of the principal has evolved, principals have been expected to help support the classroom instructional practices and ensure that teachers are using the best practices (Katterfeld, 2013).

STEM Educational History

STEM, as an educational focus, emerged out of international competition. With Russia's success in the space program in the 1960s, an intense study of the educational system in Russia was conducted to see what could be replicated in the United States. The discovery of the importance of science, engineering, technology, research, and mathematics in Russian schools led the United States to attempt to imitate the Russian system within our schools (Sobel, 1978).

Later, in 1983, the National Commission on Excellence in Education, created by the Secretary of Education, released a report from the United States Department of Education entitled *A Nation at Risk* which continued the focus on STEM-specific subjects

(USDOE, 1983). Here, the commission highlighted concerns that students in the United States were being outperformed by students from other countries. Citizens feared the United States does not perform as well when compared to other countries' successes noted in *A Nation at Risk*:

> Our Nation is at risk. Our once unchallenged preeminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world. This report is concerned with only one of the many causes and dimensions of the problem, but it is the one that undergirds American prosperity, security, and civility. We report to the American people that while we can take justifiable pride in what our schools and colleges have historically accomplished and contributed to the United States and the well-being of its people, the educational foundations of our society are presently being eroded by a rising tide of mediocrity that threatens our very future as a Nation and a people. What was unimaginable a generation ago has begun to occur—others are matching and surpassing our educational attainments. (1983, p. 5)

The fear at the time was that without educational intervention, our society would erode. The report stressed that students in the United States are declining in science and mathematics achievement. Notably, students from other counties were spending three times as much time in mathematics and science instruction than students in the United States. At the same time, the report stated that demands for technological abilities in the workforce are increasing.

On the 30th anniversary of the United States landing on the moon, the Secretary of Education, Richard Riley, appointed a 25-member committee made up of politicians,

educators, businessmen, and scientists to the National Commission on Mathematics and Science Teaching for the 21st Century (Glenn, 2000). The group was charged with investigating the current state of mathematics and science education in the United States and to make recommendations for improvement (Glenn, 2000). Their report made a series of recommendations for the country in regards to mathematics and science education. These suggestions include establishing continuous improvement systems for K-12 math and science teaching, increasing the number of math and science teachers and improving their preparation programs, and improving the environment for teachers to make the field more attractive to prospective educators.

In 2012, President Obama appointed leading scientists and engineers to a group identified as the President's Council of Advisors on Science and Technology (PCAST). This group was formed to advise the President's office, cabinet and other federal agencies about STEM issues facing our country. PCAST's report made recommendations about STEM education including creating 1,000 STEM-focused schools in the United States over the next 10 years (PCAST, 2012). Additionally, the report calls for the government to recruit, train, and support 100,000 new STEM middle/high school teachers. One of the outlined goals for PCAST was one million additional STEM-field college graduates over the next 10 years (PCAST, 2012).

As STEM instruction has been increasing throughout the country, as challenged by President Obama in 2013, the need for instructional leadership within the STEM fields continues to grow. The emergence of STEM-focused schools has resulted in a population of school principals who oversee the operations within these schools. This study will focus upon principal leadership in STEM-focused high schools.

Theoretical Rationale

Transformational leadership can be defined as the bond between leadership and followership. This connection is notably different from transactional leadership, in that there is no tangible exchange for followership. Instead, the leader invests and connects with followers in meaningful ways, which creates an intrinsic motivation for followers to aspire. There are critical areas of focus for transformational leadership, including the categories of a charismatic leader, inspiring motivation, intellectually stimulating, and individualization for followers. The goal of the transformational leadership process is to facilitate followers reaching their greatest potential (Northouse, 2016).

The transformational leadership theory can be broken down into the "Four I's" which includes idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration. The area of idealized influence centers on how the leader will act as a role model for the followers. Followers show great respect and admiration for the leader and this is the greatest connection to the charismatic leadership theory. Inspirational motivation enthuses followers to become committed to the shared vision or goals of the organization. Motivational or "pep" talks by the leader inspires followers to succeed in a given situation (Northouse, 2016). Moving followers from engagement to empowerment is a focus of leadership at this stage. A transformational leader must instill a sense of purpose and validation for the follower's work (Burns, 2003). In intellectual stimulation, leaders will push their followers to be creative and search for innovative ways to address organizational concerns. The transformational leader encourages staff to try new approaches to problems and supports followers through their work. Individualized consideration is crucial to transformational leadership theory, as it centers

upon the followers' personalized needs. This aspect of leadership strengthens the relationship between leaders and followers (Northouse, 2016). Burns (2003) asserts that:

> The leader's self-actualizing qualities are turned outward. He empathetically comprehends the wants of followers and responds to them as legitimate needs, articulating them as values. He helps followers transform them into hopes and aspirations, and then into more purposeful expectations, and finally into demands. (p. 43)

Individualized consideration highlights the connection between the two parties and demonstrates to the follower that the leader is interested in addressing the specific concerns or needs of the follower. Here, the leader can act as a coach and plan specifically for the success of each member of the team (Northouse, 2016). The transformational leader "defines public values that embrace the supreme and enduring principles of a people. These values are the shaping ideas behind constitutions and their interpretation" (Burns, 2003, p. 29). This study connects with transformative leadership theory as the principal arguably serves as the charismatic leader that drives the focus of the instruction, carrying the vision and mission forward with followers, or staff. This drive toward a positive path will enable the school and students to be successful in their studies.

Transformational leadership first emerged in the early 1970s and 1980s. This idea was first brought up by James Downton (1973) and was further developed by James McGregor Burns (1978). Burns continued his research into this field, investigating key leaders throughout history who highlighted this model of motivating followers (Northouse, 2016). At around the same time, another theory on leadership emerged—

charismatic leadership—as postulated by Robert House in 1977. This model focused upon the charisma of the leader and their effects on the followers. The charismatic leadership theory was found to parallel the ideas of transformational leadership, as a leader must exemplify charismatic aspects, and arguably could be considered embedded within the ideas of transformational leadership (Northouse, 2016). Later, in 1985, Bass expanded on the ideas of Burns and House. By combining ideas of charisma, and building a leadership continuum, Bass furthered the development of the transformational leadership theory. In researching transformational leadership, Northouse (2016) found in his meta-analysis that "people who exhibited transformational leadership were perceived to be more effective leaders with better work outcomes than those who exhibited only transactional leadership" (p. 169). Likewise, followers of transformational leaders accomplish more than what is expected of them (Burns, 2003).

Statement of Purpose

The purpose of this study was to explore the leadership qualities of principals serving in STEM-focused schools. The research has shown that teachers of science, mathematics, and other STEM-focused subjects in traditional high schools have not received direct instructional support from their principals regarding their content areas (Lochmiller & Acker-Hocevar, 2016). In exploring the role of the principals' instructional leadership within the STEM-focused schools, this population of school administrators' leadership was examined.

Research Questions

This study has two guiding questions: Do principals of STEM-focused high schools demonstrate transformational leadership? How do principals in STEM-focused

schools who utilize transformational leadership support their teachers' academic instruction?

Potential Significance and Importance of the Study

Continued attention on STEM education has persisted over the last several years. Teachers in traditional high schools have struggled with the instructional leadership and guidance afforded to them from the school principals, as they are often consumed with managerial work and less focused on the instruction (Terosky, 2016). The emergence of STEM-focused high schools is one method school systems are using to meet the changing needs of our educational programs. The principal is the leader of the building, and in a STEM-focused school, the program is unique from traditional high schools. Exploring the leadership of STEM-focused high school principals may draw attention to unique leadership traits within specialized schools that exhibit student success.

Definition of Terms

STEM—An acronym for science, technology, engineering, and mathematics.

STEM Education—A learning environment in which academic standards are combined with concrete examples and activities as students utilize STEM learning in ways that connect their school, home, and global communities (Mizell & Brown, 2016).

STEM-focused School—A school that prepares students in science, technology, engineering and/or mathematics disciplines needed to be successful in STEM careers or STEM college programs using a curriculum more rigorous in STEM subjects than required for state graduation.

Transactional Leadership—A style of leadership focused on compliance with both rewards and punishments for followers.

Transformational Leadership—The bond between leadership and followership.

Chapter Summary

This chapter provided a broad overview of STEM education and its history in the United States. Additionally, the chapter also provides an overview of principal leadership and function within a school building. Transformational leadership was defined and framed as a theoretical approach for this research. Using transformational leadership as a lens, principal leadership can be explored as a way to ensure that teachers in STEM-focused schools are able to work to their full potential (Northouse, 2016).

The research questions examine both whether the principal demonstrates transformational leadership and how principal leadership within STEM-focused schools helps to foster improvement in the building and with the teachers led by the building principal.

In Chapter 2, literature relevant to the study is discussed. This lays the groundwork for the methodology described in Chapter 3. Themes, and subthemes are explored from the research completed in Chapter 4. Chapter 5 will describe the research findings from the study and share recommendations and limitations.

Chapter 2: Literature Review

Introduction

This chapter presents a review of the empirical studies regarding STEM-focused schools and principal instructional leadership. Furthermore, a review of the methodologies utilized commonly for principal leadership and STEM-focused school analysis is presented. Literature gaps are identified, and the research study proposal is placed in context of the identified gaps.

STEM-focused Middle/High Schools

President Obama, in 2013, stated it should be a priority for schools to "train an army of new teachers" in science, technology, engineering, and mathematics, while making sure "that all of us as a country are lifting up these subjects for the respect they deserve" (Mizell & Brown, 2016, p. 52). While exploring STEM programming, several trends appeared within the literature. Notably, academic benefits, including higher testing scores and better attendance for students, are often highlighted in STEM-focused school literature (Burton et al., 2014; Erdogan & Stuessy, 2015; Hanson, 2014; Means, Wang, Young, Peters, & Lynch, 2016; Young et al., 2016). Additionally, STEM-focused schools often highlight the connections to the STEM college and career pipeline (Almarode et al., 2014; Herring, 2013; Means et al., 2016; Scott, 2012). Attendance rates for students within STEM-focused schools has been a draw of attention (Erdogan & Stuessy, 2015; Young et al., 2016). Finally, the school cultural experience within STEM-focused schools

has also been studied (Almarode et al., 2014; Burton et al., 2014; Tofel-Grehl & Callahan, 2014).

A common focus of school attention has been the academic achievement of students. Within STEM-focused schools, several studies have highlighted the academic achievements of students attending these schools (Burton et al., 2014; Erdogan & Stuessy, 2015; Hanson, 2014; Means et al., 2016; Young et al., 2016). Student school performance indicators are a closely monitored aspect of STEM schools as a way to monitor STEM program successes (Scott, 2012). STEM-focused high schools are able to meet the demands of the Department of Education's goal of preparing students to meet the demands of the 21st-century economy (Scott, 2012). Additionally, students enrolled in STEM-focused schools outperformed students from traditional high schools in mathematics and English by an average of 13% in English and 12.78% in mathematics (Scott, 2012).

Utilizing a comparative case-study method, 10 STEM schools were studied on various program aspects. In the case study, all aspects of the school were closely reviewed and analyzed, including programs, student demographics, school vision, and any entrance requirements (Scott, 2012). To begin the study, 10 STEM schools were selected for the research based on United States' schools that promoted themselves as a STEM-focused school, while also being inclusive to everyone, and not schools designed for primarily gifted or advanced academic students. Schools that included rigorous entrance requirements or standards were excluded from the study, as they were not as inclusive. Of the selected schools for the study, four had been operating for some time and six were new schools that had a new building, staff, and vision. The four schools that

were in operation had readjusted their focus to STEM, and the school's culture changed with this shift. Furthermore, two of the schools operated outside of a traditional school building and were set up in outside industry. Data were collected from publicly available information about the schools, as well as phone and e-mail interviews. The data collected were analyzed using a categorization analysis and followed up with a cross-case synthesis of the collected information. In the study, students attending STEM-focused high schools outperformed students in traditional high schools on their year-end assessments in both mathematics and English.

Furthermore, the STEM-focused school cultural experiences for students has been researched and shown to suggest that STEM-focused schools project a positive school culture (Almarode et al., 2014; Burton et al., 2014; Tofel-Grehl & Callahan, 2014). Almarode et al. found that students' feelings of intellectual capacity in their high school programs were strongly associated with their ability to earn a degree in STEM later. This specifically was noted with students' feelings of being able to be a mathematician or scientist (Almarode et al., 2014). In Burton et al.'s research, the STEM-focused high school provided students opportunities that are not present in other schools. As a smaller, rural STEM-focused school, the researched building provides a sense of pride in the community (2014). In Tofel-Grehl and Callahan's 2014 research on STEM-focused schools, the team found a unique culture compared to other local high schools. The cultural beliefs included a social similarity among students and a value on intellectual success. The research did not address if the leader of the STEM-focused school was trained in a STEM-specific subject area.

A concern for many schools has been the rate at which students are completing and passing their exams in mathematics. Young et al. (2016) studied STEM-focused schools in the state of Texas and found that mathematics achievement increased in students that were enrolled in these STEM-focused school programs, including the rate at which students pass the ninth-grade Algebra I exam, and the likelihood of passing 10^{th} grade mathematics (Young et al., 2016). The research done by Young et al. paralleled the findings by Scott (2012) in mathematics. Young et al.'s research was based on a 4-year longitudinal case study on principals, teachers, and students at Texas-STEM (T-STEM) schools, as well as a quasi-experimental research program into the achievement of students enrolled in these schools (Young et al., 2016). These researchers determined that STEM-focused schools were successful in assisting their students to pass their state exams in mathematics, which has been a concern for many high schools.

Burton et al. (2014) conducted a case study on a rural STEM-focused school, as he noted there was little research into STEM-focused schools in rural settings. In the research study, it was found that students enrolled in this rural STEM-focused school saw higher scores on their biology, algebra, and English exams than of those students in similar local schools (Burton et al., 2014). This finding corroborated previous research by Scott (2012) and Young et al. (2016) in which student achievement in mathematics and science was higher for students enrolled in STEM-focused schools compared to students enrolled in traditional high schools.

However, Burton et al. (2014), Scott (2012), and Young et al.'s (2016) findings were different than those of Hansen (2014), who completed a quantitative two-state longitudinal study on STEM education. Using Florida and North Carolina schools,

Hansen used state databases to compile and calculate mathematics and science success. This study calculated the value-added estimates over two school years in both states. The mathematics and science value-added estimates were calculated using information from the Florida Education Data Warehouse for Florida STEM-focused schools and the North Carolina Education Research Center for the North Carolina STEM-focused schools. One limitation of the study was determining which schools conducted a STEM-based program. This data was collected by hand for both states by exploring websites and determining if the STEM keywords were present in the school's program. One outcome of Hansen's study was that there is no significant academic difference in mathematics performance between STEM-focused schools and traditional high schools. In Florida STEM schools, the mathematics achievement was identical between STEM-focused schools and traditional high schools (Hansen, 2014). This is significant as it challenges the notion that STEM education would be a more effective model for student success than traditional high school models (Hansen, 2014).

Similar to Hansen's (2014) study, Erdogan and Stuessy (2015) focused on the T-STEM Schools of Texas and the academic achievement of the students. In Texas, the Texas High School Project led to the T-STEM initiative, which created 51 inclusive STEM academies. This model was open to any students and did not require screening or proficiency in mathematics or science to attend. Scaffolds were put in place to support students who needed assistance to meet the demands of the coursework. In this study, Erdogan and Stuessy found no academic score differences between students at the STEM-focused school compared to students at traditional high schools in mathematics, science, and reading (Erdogan & Stuessy, 2015).

In an evaluation of the program, some positive student outcomes emerged in some sub-sections of mathematics. Students were able to pass the 10th-grade exams and the algebra exams by higher margins than the traditional high school student populations. The researchers acknowledged that while the T-STEM schools showed progress in some areas of mathematics, the results for other areas varied, due to the vagueness of the model and its different implementations throughout the state, and local district's pressure on influence over the model (Erdogan & Stuessy, 2015). Researching the academic success of students in STEM-focused schools, Erdogan and Stuessy (2015) utilized a quasi-experimental design to explore the achievement differences between students enrolled in STEM-focused high schools with students enrolled in traditional high school programs. A total of 53 STEM-focused schools were selected, and of the 1,309 Texas public schools, 53 were chosen. Using available demographic information, racial profiles of student enrollment were matched to STEM schools to ensure equal sampling through probability-stratification (Erdogan & Stuessy, 2015). This program focused on schools in the state of Texas, and that followed the T-STEM program model. Information was collected from the Texas Education Agency, and the Texas Assessment of Knowledge and Skills, which indexes achievement for students in reading, mathematics, and science programs (Erdogan & Stuessy, 2015). In exploring subgroups, there were some results that highlighted the work of the STEM-focused schools; however, the effect-size was minimal. These results included higher scores for males in science and mathematics testing, higher scores in reading and mathematics for female students, as well as Hispanic and White students attending STEM-focused schools performing better than Hispanic and White students in traditional high schools (Erdogan & Stuessy, 2015).

In preparation for future STEM careers, and entry into STEM college fields, a focus on high schools has been in the access to more advanced STEM courses and real-world experiences. Means et al. (2016) researched student experiences in STEM-focused high schools, as well as their achievement and the STEM program that facilitates these achievements and interests. This research was done in North Carolina with 12 STEM-focused schools and 16 traditional high schools. Using the state education database, STEM-focused schools were identified, and then prioritized. Alternative schools for drop-out students, special education-based schools, closed schools, and schools without at least a 35% minority population were eliminated. Principals completed surveys that highlighted their schools' climate and practices. Additionally, seniors from these schools also completed surveys to review the climate and culture of the schools. The sample size for STEM-focused schools was 655, and the sample size for traditional high schools was 2,199 (Means et al., 2016). They found that students attending STEM-focused high schools in North Carolina have access to more advanced mathematics and science courses than students in traditional high schools. The students also reported more content integration and more college support. Additionally, these students also reported having more extracurricular access to STEM-focused experiences in a real-world setting (Means et al., 2016).

Additionally, Means et al. (2016) determined that STEM-focused schools are better designed to allow students to learn at an advanced-skill level and often integrate subjects more consistently than traditional high schools (Means et al., 2016). All of the STEM-focused schools studied by Scott (2012) reported a requirement for students to take part in an internship and/or capstone project. This work was important to the

curriculum of the STEM-focused school, enabled the students to connect with industry, and learn more about STEM careers. These projects required additional support from the school faculty (Scott, 2012).

In exploring STEM schools, a focus on college preparation for students as they transition has emerged. Another model of STEM-focused high schools is the Ohio school known as the Metro Early College High School (MECHS). This school is an early college high school in Columbus, Ohio that is focused on STEM programming. Students come from 16 area school districts and there are roughly 400 students in the school from freshmen through seniors. A 2013 study by Herring (2013) investigated college library use by early college high school students (n=104). A result of the library study indicated that roughly two-thirds of students believe the library has made it easier and prepared them for academic research after having attended the MECHS (Herring, 2013). This model of instruction in the STEM-focused school has better prepared students for successful academic research as they progress into college or other postsecondary options (Herring, 2013).

A common goal of STEM-focused schools is to address the gaps in the workforce in STEM fields. As a means to encourage more students entering college into STEM fields, some of these STEM-focused high schools have emerged. In exploring the effect of STEM-focused schools on STEM majors in college, Almarode et al. (2014) found that students who graduated from STEM-focused high schools completed an undergraduate degree in a STEM field at a rate of 49.8% compared to students from traditional high schools who complete a STEM undergraduate degree at a rate of 22.6%. Almarode et al. (2014) conducted a quantitative retrospective research study into college programs of

students who graduated from STEM-focused schools compared to students who graduated from traditional high schools. This study was done using publicly available data, as well as online surveys. In this study, 3,536 students who had graduated from a STEM-focused or specialized science high schools were surveyed, and their information was also matched to publicly available college program and entrance statistics through print or online documents (Almarode et al., 2014).

Student attendance. Student attendance is an ongoing issue facing many schools. In exploring STEM-focused schools, the attendance rates vary in positive ways. While exploring STEM-focused schools attendance records, Erdogan and Stuessy (2015) found that student absences were below the national average in STEM-focused schools when compared to traditional public high schools nationwide. This fact was true for schools that matched the profiles of students attending the STEM schools in their respective states (Erdogan & Stuessy, 2015; Young et al., 2016).

School culture. Finally, in the literature on STEM-focused schools, school culture is an often-addressed topic. In research on STEM-focused school culture, it was noted that these schools demonstrate a commonality that the involved stakeholders including teachers, administrators, and students, all of whom share a common vision for the school's culture (Tofel-Grehl & Callahan, 2014). Inquiry as a pedagogical approach is foundational within STEM-focused schools. Student discovery as an important part alongside traditional lecture-based learning is a common practice, according to the research on STEM-focused schools. Students often participate in lengthy extended investigations that enable students to use critical thinking techniques to solve real-world problems (Tofel-Grehl & Callahan, 2014).

A study conducted by Tofel-Grehl and Callahan (2014) explored the experiences of teachers, and students at STEM-focused schools. To select participating schools, the National Consortium for Specialized Secondary Schools of Mathematics, Science, and Technology (NCSSSMST) directory was referenced, as well as state department of education websites to determine STEM-focused schools. A purposeful sampling of six from the 358 schools was determined to meet best practice standards. This represented a range of STEM type (residential, non-residential, part time pull-out, and university-connected) as well as a range in geography throughout the United States, and various enrollment sizes, from less than 300 to more than 900 (Tofel-Grehl & Callahan, 2014). Data were collected through classroom observations, both group and individual interviews, as well as documents and public website information. Data were collected, coded, triangulated, and sorted by theme (Tofel-Grehl & Callahan, 2014). The themes included school culture, teacher workload, intelligence, research projects, authenticity of experiments, critical thinking, argumentation, inquiry, testing, independent learning, student workload, and student stress. These themes were defined and matched to data collected that helped to formulate the final, crystallized themes that included: school culture, research experiences, inquiry and thinking, and independent learning/responsibility (Tofel-Grehl & Callahan, 2014). Everyone involved in STEM-focused schools works to build a sense of community within their school building and are aware that this effort improves learning and engagement in school. Moreover, STEM-focused schools allowed students time for research. While the amount of time allowed varied between the schools, the stress and importance of conducting real-word, hands-on research boosted learning outcomes for the students involved.

STEM-focused schools create a specialized environment that enables students to interact more often with like-minded peers interested in STEM disciplines. Positive attitudes towards mathematics and science depend upon the support and interest from family and friends. By attending a STEM-focused school, students can build positive relationships that enable the students to persist in this pathway. Students' success in attaining undergraduate degrees in STEM fields are strongly associated with the students' confidence in regard to mathematics and science from their high school experience (Almarode et al., 2014).

Student confidence. Student confidence in their own mathematical and scientific abilities has been another area in which researchers have explored. STEM-focused high schools have been shown to have a positive effect on students' self-efficacy in mathematics, science, or engineering. As a part of a longitudinal STEM study, high school seniors enrolled in STEM-focused schools reported an intellectual capacity to become a scientist, mathematician, or engineer at 81%, a number pointedly higher than students in traditional schools that reported the same capacity to be at 67% (Almarode et al., 2014).

Many of the studies conducted on STEM-focused high schools explore schools designed within urban or suburban areas. However, Burton et al. (2014) completed a case study on a rural STEM school. To examine rural STEM schools, researchers were given funding from the National Science Foundation. The researchers were looking for established STEM-focused schools. In North Carolina, there was already a STEM-focused school initiative in play, and the school selected for this study had already received funding from the Bill and Melinda Gates Foundation (Burton et al., 2014). Once

the school was selected, data were collected through multiple sources including observations, focus groups of teachers, focus groups of students, and interviews with all stakeholders. All data collected were transcribed and triangulated. Segmenting and coding the data led to the emergence of themes, including school design, coursework, student performance, early college experiences, personalized instruction, and building a sense of community (Burton et al., 2014). In their work, the researchers found that the work of the STEM-focused school in a rural community parallels many of the findings of the larger schools. This rural school found itself with limited resources and a small staff but were able to successfully implement the STEM-focused high school program in conjunction with the local community college support. Additionally, they found that students, teachers, and the community were invested in the school's success and a strong culture was a large part of their success. Students in this school were able to participate in STEM-focused extracurriculars and worked in extended research projects and internships with real-world applications of their interests (Burton et al., 2014).

Gaps in the literature. A number of gaps within the literature were noted with respect to STEM-focused schools. These gaps included the newness of the program in many schools researched (Scott, 2012; Tofel-Grehl, 2014). Likewise, the extent to which a STEM-focused school implemented their program could influence the results studied (Young et al., 2016). An added limitation is found in the study of career pipeline preparedness (Erdogan & Stuessy, 2015). A reliance on students to apply to these programs also existed as a limitation within STEM-focused high schools (Means et al., 2016). Likewise, many students within the STEM-focused schools may have already had

a strong interest in STEM subjects, which may alter the results of STEM-specific subject assessment results (Almarode et al., 2014).

The novelty of the new school models and excitement among the staff may also play a role in the results in a way that could skew the data (Tofel-Grehl & Callahan, 2014). In some of the schools researched, the initial enthusiasm of finding like-minded and excited students, families, teachers, and staff for their school may have played a role in the academic successes of the schools more than the program itself could have manifested. A follow up study within the same schools after a period may better demonstrate the results of the school's effectiveness (Tofel-Grehl & Callahan, 2014).

With the emergence of STEM-focused schools, another limitation has been on the extent to which programs have been implemented and the rigor with which subjects are taught. In Young et al.'s study of T-STEM schools, the researchers noted that the implementation varied within the 58 schools. This could account for differences between mathematics and English performance between STEM-focused high schools and traditional high schools. A better measure of the degree to which the program is being executed would be beneficial to the study (Young et al., 2016).

Scott (2012) noted that the limited timeframe of the study, paired with the relative newness of the schools researched, would leave some questions about the long-term effects of the STEM-focused schools. Further research into the effects of the program after several years would be beneficial (Scott, 2012). Additional questions about the STEM-focused high schools remain, including whether students who graduate from STEM-focused high schools move onto STEM programs in college and STEM careers (Scott, 2012).

Often, it is difficult to determine the college and career readiness of students enrolled in STEM-focused schools in a snapshot. Erdogan and Stuessy (2015) recommend continued, longitudinal studies to ensure student success in the postsecondary experiences of STEM-focused high school students. Additionally, sampling traditional high schools and comparing these schools to the STEM-focused high schools posed a challenge, as the size of the schools varied greatly. Many of the traditional public high schools in Texas are quite large, while most of the T-STEM schools are significantly smaller. Finally, a noteworthy amount of data necessary to the schools studied was missing. In the research, 25% of the data collected from all schools was missing. Modifications to data analysis were made to ensure accurate results, however, the amount of data missing is a concern (Erdogan & Stuessy, 2015).

Many STEM-focused high schools rely on student applicants, rather than a population that is tied to a local community. Students must demonstrate an interest and apply separately to the schools, as indicated by Means et al. (2016). This is an inherit limitation in many studies of student success, college aspiration, and degree completion. A randomized control trial would be a better indicator of student success as a result of STEM-focused education; however, this is not the typical enrollment model for STEM-focused schools. Inherit in the data is the application bias for students that are already interested in STEM, or whose parents have driven the student to apply for these specialized schools (Means et al., 2016).

In exploring the link between STEM-focused schools and STEM undergraduate degrees, additional questions arise, regarding continued interest in STEM (Almarode et al., 2014). Could the interest be from the culture of the school, or perhaps a given

experience in a particular course? Further research is needed to determine the causation of continued interest in STEM (Almarode et al., 2014). Likewise, the self-reported capacity of students to continue into STEM fields may warrant additional studies into what causes this reported self-efficacy (Almarode et al., 2014).

A focus on rural STEM-focused schools was conducted as a case study on one particular school. This rural school was successful in their implementation of a STEM-focused curriculum with the help of a local community college. The researchers acknowledged that without a community college in close proximity to the school, the outcomes of the rural STEM program would have been very different. Researchers were hesitant to use this case study as a model for all potential STEM-focused schools, as the role of the community college was so significant (Burton et al., 2014).

In sum, a review of the literature of STEM-focused schools demonstrates an abundance of relevant topics. Academic success is often highlighted as a benefit of STEM-focused schools (Burton et al., 2014; Erdogan & Stuessy, 2015; Hanson, 2014; Means et al., 2016; Young et al., 2016). Another topic of concern in the research on STEM-focused schools revolves around the school's ability to support the STEM college and career pipeline (Almarode et al., 2014; Herring, 2013; Means et al., 2016; Scott, 2012). Finally, attendance rates for students within STEM-focused schools has been shown to be an advantage to the STEM-focused school program (Erdogan & Stuessy, 2015; Young et al., 2016).

Teacher Preparation for STEM Instruction

A concern within the educational field is the lack of teachers prepared to teach in the STEM disciplines (Erdogan & Stuessy, 2015; Nadelson et al., 2015). Many schools

struggle to hire teachers who have the preparation and certification needed to teach in a STEM field (Erdogan & Stuessy, 2015). There is a need for new teachers to be prepared for STEM instruction in the classroom. Numerous teachers beginning in the STEM programming are ill-equipped to teach the STEM curriculum offered in many schools (Nadelson et al., 2013). When researching teacher comfort with engineering principles, for example, the resulting evidence showed that the longer a teacher had been working, the more positive the attitudes demonstrated towards engineering design. Additionally, knowledge of STEM grew over time. New teachers with less than 1 year of experience reported the least knowledge of STEM, while teachers with more years of experience teaching reported a better understating of STEM (Nadelson et al., 2013). In one study, researchers selected 33 participants from a school district with multiple elementary schools (Nadelson et al., 2013). The study was conducted over 2 years, and with two cohorts. Participants completed multiple survey instruments throughout the research. These survey instruments included demographics, confidence in STEM, efficacy in STEM, and attitudes towards engineering. A 3-day professional development course was offered in STEM for the participants. The program was focused on inquiry-based instruction in the various aspects of STEM programming.

As a result of the 2-year study with the 3-day summer professional development, teachers reported higher confidence in their ability to teach STEM content, as well as their effectiveness in STEM and positive attitudes towards engineering practices (Nadelson et al., 2013). In the summer, professional development program teachers were taught how to use various program elements including building bricks, STEM learning concepts, and STEM instructional practices. For follow-up, teachers received

communications about continued opportunities in STEM and ideas for lessons, as well as an observation in a STEM lesson (Nadelson et al., 2013).

When researching the need for STEM support for newly certified teachers, a limitation acknowledged in the study was that all of the participants were from the same school district. This two-year study may need to be replicated at various school districts to determine if there might be similar findings. Additionally, the participants in the study were recruited and there may have been a pro-STEM bias within the groupings. This convenience sampling may have affected the results (Nadelson et al., 2013).

In reviewing of the literature about teacher preparation for STEM specific subjects, the need for specific teacher professional development and instructional support is shown to be beneficial and has been shown to boost teachers' confidence in STEM, as well as their understanding of STEM subjects (Erdogan & Stuessy, 2015; Nadelson et al. 2015).

Principal Instructional Leadership

Principals carry a large role in the overall success of schools. Their day-to-day duties can be quite diverse, and these tasks often can take a principal in many directions. Inside of a school, the principal wears the hat of the "change agent" and are often expected to drive new initiatives throughout the building. Likewise, building administrators are required to create and grow the school culture. These tasks are demanding on a principal, and yet, their overarching task is to drive the instructional pathway for student progress, while still completing the managerial and bureaucratic work at the same time (Liu et al., 2013).

A priority shift has occurred over past years that require principals to serve as instructional leaders as their main role (Terosky, 2016). This shift can be difficult for many building administrators who find themselves often burdened with managerial tasks and duties and leave themselves little time to focus on building instruction (Katterfeld, 2013; Terosky, 2016). There are direct correlations between student academic success, teacher confidence, and instructional improvements when the focus of a principal's duties shift to attention to classroom instruction (Liu et al., 2013; Terosky, 2016).

In Terosky's (2016) qualitative study, urban, kindergarten through 12th grade principals were selected using purposeful sampling utilizing the New York City Department of Education's recommendations for outstanding principal instructional leaders. Utilizing two publicly available databases, the School Survey and the School Quality Review, 20 principals were invited to participate in the instructional leadership study, and of those, 18 accepted the invitation and became the study participants (Terosky, 2016). The principals ranged from high school to elementary school, and had served 2-20 years as an administrator (Terosky, 2016).

Data were collected via semi-structured interviews with the principals which included tours of the schools and classroom observations. Following the interviews, a self-reported time usage survey was completed by 72% of the participants. This explored how the principals utilized their daily time in the building by category of work including logistics, personnel, budget, instructional leadership, students, families, and community relations. Next, the researcher shadowed the administrators through a day at their jobs. Finally, additional information was collected from publicly available sources (Terosky, 2016).

In the analysis of the data, coding was conducted in three ways: descriptive coding, pattern coding, and finally grouped into themes based off the first two levels of coding. The groupings of perspectives from interviews, and observed actions in practice, enabled the researcher to better understand the role of the principal as the instructional leader. Five areas emerged in the analysis of successful instructional leader principals. These included that leadership should be based in learning, influenced by teachers, allow for teacher empowerment, require time for planning, and an understanding of teachers' aspirations (Terosky, 2016).

In Terosky's (2016) study of principals' instructional leadership, a noted limitation of the study was the method by which data were collected. As the information gathered was self-reported through surveys and interviews, it could be assumed that sections of the survey, including by which principals report how they spend their time, may have skewed results, as principals would want to report more time invested in areas that are desirable (Terosky, 2016).

Principal leadership in STEM subjects. While exploring principal leadership, a separate strand of the literature focused on STEM yielded studies that specifically address leadership within the scope of STEM. In one study, it was noted that many principals have a lack of content knowledge for STEM, specifically science and mathematics (Lochmiller & Acker-Hocevar, 2016). This contributes to principals being careful in their hiring practices of teachers within the STEM fields, leaning towards those who may not need as much guidance.

According to some researchers, principals view the problem of supervising mathematics and science teachers as a human resource concern (Lochmiller & Acker-

Hocevar, 2016). As the participants of Lochmiller and Acker-Hocevar's (2016) study reported, many principals in traditional high school models have a lack of competence in many STEM content areas. As such, the principals, when overseeing STEM content areas, will follow less direct approaches to working with teachers from STEM fields (Lochmiller & Acker-Hocevar, 2016). In their study of principals and vice-principals from traditional high schools, many school administrators felt they could not offer teachers of STEM areas suggestions to improve their pedagogy (Lochmiller & Acker-Hocevar). Lochmiller and Acker-Hocevar conducted a qualitative study of principal leaders from five high schools. The participants were purposely chosen based on recommendations from a math/science organization. These schools were identified by this organization as leaders in math and science education. The researchers explored the schools' improvement plans and reviewed the demographics (Lochmiller & Acker-Hocevar, 2016). The participants included five principals and 16 assistant principals. Out of the 21 administrators, all had previous experience as a classroom teacher, but only three had served as a mathematics or science teacher. In this study, data were collected by semi-structured interviews. Formal questions with additional probes were utilized to ensure consistency across multiple sites. Interviews were audio-recorded and later professionally transcribed.

The administrators' perceived timidity of the concepts in mathematics and science classrooms limited their instructional assistance to these teachers, and this, resulted in administrators sending teachers out of the school to professional development opportunities to get the instructional guidance needed (Lochmiller & Acker-Hocevar, 2016). Additionally, the researchers noted that the mathematics and science departmental

cultures often served as barriers to successful discourse and improvement. The administrators that lacked content knowledge had a difficult time engaging and understanding the disagreements that arose between staff members within a department and would focus their time on helping the teachers to better facilitate effective communication rather than focus on the content issues themselves.

Principals reported that it is important to hire the right mathematics and science teachers, as they themselves are uncertain about these content areas. By hiring teachers who have strong backgrounds in mathematics and science, the principals hope that they will not need as much instructional guidance going forward (Lochmiller & Acker-Hocevar, 2016). Likewise, principals reported looking for new hires in mathematics and science who are able to communicate well within their departments. These people would help bring unity to the science or mathematics departments and could help resolve conflict with a working knowledge of the content and effective communication skills. The principals were essentially looking for teachers who could fill the role of the teacher leader, or department chair, in their hiring (Lochmiller & Acker-Hocevar, 2016).

Instructional experts and outside consults are another pathway that school administrators have utilized to counteract their lack of instructional expertise in mathematics and science. Many principals felt that bringing in a consultant would enable them to show the mathematics and science teachers support while not having to carry the burden of being the content expert (Lochmiller & Acker-Hocevar, 2016). Additionally, principals may rely on outside experts or consultants to address staff about mathematics or science. In one example, the staff had gathered for a meeting about their math assessment results. Once the principal had greeted and introduced the consultant, the

principal did not speak to the audience again for the duration of the meeting, leaving the work of addressing the results and plan of action to the consultant.

Additionally, studies have explored principal leadership when needed to enact change within STEM-specific subjects (Peled, Kali, & Dori, 2011; Terosky, 2016; Wenner & Settlage, 2015). At times, the principal of a building needs to make administrative decisions that will result in changes to the building's culture and teaching practices. Wenner and Settlage (2015) studied minority students and the fifth-grade science assessment to identify effective leadership strategies at schools that outperformed neighboring schools on this exam. Outlier schools were identified where success of students far exceeded the overall negative trends found. These positive outliers were studied for their principal leadership values. Using publicly available state test and demographic results, schools were identified. Following identification of schools, semi-structured interviews were conducted with positive-outlier school principals (n=9). Interviews were recorded and transcribed; all interviews lasted between 40 and 75 minutes (Wenner & Settlage, 2015).

A significant pattern emerging from these interviews was that principals must use their discretion to decide the best pathway to follow in delivering curricula and pedagogical changes to teachers. As best practices change over time, and new curriculum is rolled-out, many administrators are left with the task of informing their teachers about the new expectations. This practice is known as "buffering" and can be completed in a variety of ways (Wenner & Settlage, 2015). In their research study, changes in building policy in respect to science classrooms were observed throughout the school buildings. The focus in the study was the interaction of the school principal with the science

teachers in delivery of changes. In many cases, the principal would adjust the school's existing policies and procedures to fit the new demands before meeting with the teachers, and in other cases, the principal would try and negotiate with the central administration to protect the teachers from changes (Wenner & Settlage, 2015). Lastly, the principal would also blatantly ignore or try to block the teacher from the changes. As explained by the principals, often there is a feeling of extreme pressure from the changes demanded, while trying to protect teachers from the principal's self-determined viewpoint that changes were unnecessary. This professional "buffering" was utilized to maintain the integrity of the school's current programs (Wenner & Settlage, 2015).

In exploring the areas of instructional leadership, there are a variety of factors to consider as the principal enacts changes within their school's instructional practices. In a study of 18 urban, public K-12 principals who are notable in their instructional leadership, there are certain factors that come into play as these principals work. One of the primary concerns for leaders is time. The group in focus shared that balancing time when trying to enact building change was of the utmost importance. Instructional improvement must be built into the calendar or the other managerial tasks will take over the schedule. Likewise, all 18 principals felt it was imperative to be in-the-know with what was happening inside of the classrooms. None of the participants wanted to be disconnected from the classroom and this insistence against a lack of classroom knowledge helped to guide their instructional change. While time is important to the principals, it is likewise important to assign time for teachers to engage in instructional reflection and change. The team of principals noted the importance of time for teachers to meet professionally with colleagues and developed ways for their teachers to meet as

teams and learn from one another. Building time into the schedule for both the administrators and teachers has helped foster instructional improvements for schools (Terosky, 2016).

In reviewing principal attitude effects on teacher technology implementation, a longitudinal study conducted in 2011 researched principal' and teachers' attitudes towards implementing technology in their classroom following professional development about technology (Peled et al., 2011). This was a qualitative study conducted with junior high school principals and science teachers. This research took place over 7 years from 1998 to 2005 The focus was on teacher professional development (TPD) and effects after the professional development ended, with follow-up interviews in 2005 (Peled et al., 2011). 14 principals out of the original 16 completed the study, as well as 19 out of the original 60 teachers, using 14 schools. Data were collected through interviews that lasted approximately 1 hour, and a semi-structured interview process was followed. Questions revolved around the use of technology in the classroom, and perceptions about technology. The interviews were recorded and then transcribed. After the interviews were processed, the data were compiled into words and phrases that were identified as key points. Two independent educators reviewed the transcription and organization (Peled et al., 2011).

Rubrics were utilized to determine the teachers' and principals' attitudes towards technology integration (Peled et al., 2011). One determination was the type of teacher attitudes. These included: the initiator and pathfinder, the follower-conformist, the evader, and the objector-antagonist. Additionally, a rubric was utilized that classified the principals' support for technology integration. These categories included: the initiating

principal, the empowering principal, the permitting-yet-preventing principal, and the resisting principal. The principals were scored against these rubrics from data collected during interviews (Peled et al., 2011).

A matrix was built to demonstrate the changes in principals and teachers over the course of the longitudinal study (Peled et al., 2011). Three of the principals who originally were categorized as initiating principals continued this trend over the course of the study. Additionally, five principals who originally were categorized as empowering, continued this trend for the next several years. In certain exceptions, principals' perceptions changed over the longitudinal study, in some cases, becoming more empowering of technology-integration, while in other cases, becoming more wary and cautious of technology in the classroom. With principals who empowered teachers, the classroom teachers' technology integration and comfort with technology skyrocketed. Meanwhile, technology-cautious principals led to a regression in teachers who work with more technology-adverse principals (Peled et al., 2011).

These results were categorized into eight patterns. Difference in the eight patterns for teacher attitude were correlated with the principal's attitude towards technology (Peled et al., 2011). In the top two principal attitudes those with a positive view of technology, the teachers either stayed the same or improved in their view of technology. The opposite was true for schools in which the principal scored in the lower two categories for attitudes toward technology. In these schools, when a principal had a more negative attitude toward technology integration, teachers either stayed the same or had a regressive attitude towards technology. Principals who employed a positive view of technology encouraged their teachers for the same and the results showed that all teachers

improved in their attitudes about and use of technology in their classroom. For principals who were reluctant to use and incorporate technology, the schools lost ground and teachers' attitudes either stayed the same or became negative toward technology integration. Strong technology teachers get the feeling of "fighting windmills" when trying to promote successful integration of technology in schools where the leadership is hesitant or resistant to technology.

Principals' expectations for teachers have been researched as a connection between student success and principal instructional leadership. Katterfeld (2013) researched the relationship between classroom teachers' standards-based instructional practices in mathematics with principal vision and leadership. Two hypotheses for this study include teachers' perception of standards-based instruction of mathematics increases, when principals are more engaged in mathematics. Additionally, when the principal holds a strong instructional vision, the results for standards-based instruction in mathematics will be higher (Katterfeld, 2013). The study was qualitative and longitudinal with four urban school districts at the middle-school level. Each district chose between six and ten middle schools, which then selected five random mathematics teachers at each school. In total, the sample size was 30 principals and 122 teachers (Katterfeld, 2013). 60% of the teachers had no experience teaching mathematics, while 23% had five or more years of mathematics instruction (Katterfeld, 2013).

Data were collected through interviews, surveys, and observational data. This information was collected on an annual basis. All interviews were audio-recorded and transcribed to text. Teacher surveys focused on eight areas of principal and assistant principal leadership in relation to mathematics. In the principal interviews, questions

were focused around mathematics vision, which was aligned to the teachers' perceptions of the principal's vision (Katterfeld, 2013).

Throughout the study, distribution of leadership became more apparent. In many cases, supervision of the mathematics program fell to the assistant principals in seven of the schools studied (Katterfeld, 2013). As a result of the surveys and interviews, a principal leadership scale was formed. The formed survey focuses on principal leadership specifically in mathematics. The Cronbach's alpha reliability was 0.94 for this tool. This scale was leveled at zero, with teachers' perception of principal's mathematical leadership ranging from -4.17 to 4.46.

When exploring principals' vision for mathematics instruction, the interviews were coded using Munter's rubrics for vision (Katterfeld, 2013). This was broken down into different rubric scores from 1 to 4. Lower levels of the rubric were correlated to more traditional mathematics instruction, while higher scores served as an indicator for a vision of function-oriented instructional practices. As a method to ensure reliability, double coding was utilized on most of the principal interviews. Principals' visions were compiled from three areas of instructional vision.

The findings showed that most principals reported their own vision to be aligned to standard-based instructional practices (Katterfeld, 2013). However, the focus was typically in instruction rather than alignment of goals. Additionally, the teachers reported a 3.2 out of a 6-point scale that their principal's instructional expectations were aligned to standards-based instructional practices. Additionally, 24% of teachers reported that their principal's expectancies were not aligned with standards-based instruction. In teacher interviews, the larger themes that emerged from principal expectations were in classroom

management and higher test scores. Overall, 34% of teachers reported an expectation from the principal of at least one standard-based instructional strategy (Katterfeld, 2013). An additional 34% reported an expectation from the principal of at least two standards-based instructional strategies for their classroom. Principal expectations for function-oriented classrooms were reported in 4% of classrooms where the principal expected students posing questions to other students. Finally, one principal was reported to have expected students to be engaged in group discussions and presentations to the classroom. The expectation for students to understand, explain, and justify their answers was reported in just one classroom, or 1% of principals.

Principals' leadership and expectations for success play a larger role in the effectiveness of classroom instruction. In a study of mathematics classrooms, principals' vision for mathematics instruction was aligned with student success when the principal had a clear vision for what mathematics instruction should look like (Katterfeld, 2013). When a principal left most of the design and work to develop the classroom practices and procedures to the teachers, the student success fell, whereas, when the principal had an engaged and deep view of successful mathematics programming and was able to communicate these ideas to the teachers, the success rate rose. This was irrespective of the level of mathematics proficiency of the principal. The results did not corroborate that the principal's instructional leadership affected the mathematics instruction of the teachers. Furthermore, the next area of study was tied to principal vision enhancing his or her leadership. While principal vision did have a strong effect on teacher expectations from the school, it was not shown to correlate with standards-based instructional practices (Katterfeld, 2013).

While reviewing the body of literature on STEM-subject leadership by school principals, several items emerged as concerns or limitations within the studies. One limitation found was the selection of teachers to lead new change within a school. This selection of teachers could be tied to the effectiveness of the change (Peled et al., 2011). Additionally, a limitation of Lochmiller and Acker-Hocevar's (2016) principal leadership research was failing to include teacher interviews about their principals. Wenner's (2015) research about professional buffering did not explore instances in deciding when to use this buffering, which could be a useful extension of the study.

In exploring the role of technology integration and principal leadership, the researchers have found that principals should be involved in teachers' professional development opportunities, as well as continue their involvement in the creation of new and innovating programs (Peled et al., 2011). Additionally, principals should be careful in the selection of teachers to model and demonstrate technology use. Deliberate consideration for which teachers would best represent the technology potential to other teachers should lead the charge (Peled et al., 2011). A limitation noted from this study was the small participant number and the ever-changing technology landscape. Continued research into a larger pool of principals and teachers with current technology would further enhance the body of research.

When researching instructional leadership gaps between principals and the mathematics and science teachers, Lochmiller and Acker-Hocevar (2016) noted that their interviews, and observations were all conducted with principals and assistant principals. A possible further development of the study lies in surveying the teachers about their principal's leadership in mathematics and science content and pedagogy.

Principals who use "buffering" techniques often have positive results on their state assessments. In the 2015 study, Wenner and Settlage (2015) noted an extension of this research could be surrounding the decisions principals make about when to use buffering, and how they have learned to use this technique. Additionally, further research could address how science teachers themselves use buffering as a professional technique for academic success.

Notably absent from the body of literature are studies that discuss principal leadership within STEM-focused high schools. As the number of STEM-focused schools continues to grow, and the national conversation about STEM's importance is stressed, a continued need exists to learn more about the work within these STEM-focused schools. Addressing this gap in the literature would enable STEM-focused school leaders to better understand the unique characteristics of the role of the principal in a STEM-focused high school.

In reviewing the body of literature on principal leadership of STEM-subject areas, four major themes emerged. A concern for schools is the lack of STEM-specific knowledge from school principals, which resulted in diversionary practices in leadership (Lochmiller & Acker-Hocevar, 2016). As such, schools have become careful in their hiring practices of teachers within the STEM subjects and schools utilize subject-specific departments for content and leadership. Principals, who need to enact changes within STEM-specific subjects, have also been studied for their processes and professional buffering, and professional development for principals has been effective in the schools (Peled et al., 2011; Terosky, 2016; Wenner & Settlage, 2015). Additionally, principal expectations of STEM-specific teachers have also been studied, with the finding that

principals who have a more specific vision for success aligned with better student success (Katterfield, 2013).

Chapter Summary

An examination of the literature highlights the academic benefits for students attending STEM-focused high schools (Burton et al., 2014; Erdogan & Stuessy, 2015; Hanson, 2014; Means et al., 2016; Young et al., 2016). However, some studies did not show a significant difference in the academic success of students in STEM-focused high schools (Erdogan & Stuessy, 2015; Hansen, 2014). STEM-focused schools also foster connections to the STEM college and career pipeline (Almarode et al., 2014; Herring, 2013; Means et al., 2016; Scott, 2012). The cultural experience of the STEM-focused school was closely examined (Almarode et al., 2014; Burton et al., 2014; Tofel-Grehl & Callahan, 2014).

The school principal is responsible for instruction within the school building. Student academic success, teacher confidence, and classroom instruction improves when the focus of a principal's duties shift to attention to classroom instruction (Liu et al., 2013; Terosky, 2016). This can be difficult for an administrator, as it was noted in one study that many principals have a lack of content knowledge for STEM, specifically science and mathematics (Lochmiller & Acker-Hocevar, 2016).

While examining the body of literature, there is a need for additional information about the amalgamation of STEM-focused schools, particularly with respect to the principal's leadership practices. Principals have a responsibility to ensure the instruction of the building is meeting expectations. The idea of principals as exclusively managers has faded and the concept of the principal serving as the chief of instruction has

blossomed in schools (Katterfeld, 2013). Combining the vision of the STEM-focused school with the application of the notion that principal leadership drives the instructional practices of the school may facilitate varying leadership styles evident within STEM-focused schools.

Chapter 3 presents the research methodology of the study as the transformational leadership practices of STEM-focused school principals are explored.

Chapter 3: Problem Statement

Principals serve as the main instructional leaders for schools, in addition to serving to meet the bureaucratic work requirements of the job. It can be difficult to focus on the instructional leadership aspects of the principal job when more minor managerial tasks and matters of supervision often take time and attention away from the big picture (Lochmiller & Acker-Hocevar, 2016: Terosky, 2016). As the focus on STEM instruction has been increasing throughout the country, the need for instructional leadership within STEM continues to grow. STEM-focused school growth has resulted in a population of school principals who oversee the supervision and curriculum operations within schools that operate outside of the traditional model. This study focused on exploring principal leadership in STEM-focused high schools.

Research Questions

This study had two guiding questions: Do principals of STEM-focused high schools demonstrate transformational leadership? Secondly, how do principals in STEM-focused schools who utilize transformational leadership support their teachers' academic instruction?

Research Design

This research utilized a case-study design, completed in two parts. In the first part of the research, the MLQ (Multifactor Leadership Questionnaire) Survey was given to STEM-focused school principals interested in participating in the study. In addition, some demographic questions about the principals and their schools were also added to the

survey which included some short-answer questions. As this study focused upon the transformational leadership practices of STEM-focused school principals, only those who scored above a 2.0 on the four-point scale of transformational leadership were invited to participate in the second part of the study.

The second portion of the study explored STEM-focused schools' principal support of teachers and practices of leadership within their respective buildings. Data were collected by phone interviews with STEM-focused school principals who scored at least a 2.0 on the transformational leadership scale from the MLQ survey tool. The focus of the phone conversations was to determine ways in which these STEM-focused principals lead their buildings, staff, and guide their teachers in their practice. Likewise, data were also collected about hiring practices and school culture-building.

Research Context

The purpose of this study was to explore the transformational leadership qualities of principals serving in STEM-focused high schools. The sample population of STEM-focused school administrators was measured using a transformational leadership tool to determine the extent to which the administrators demonstrate these leadership qualities. Additionally, the STEM-focused school administrators were interviewed to determine ways in which they support their teachers in their buildings.

This study, which was conducted in New York State, identified STEM-focused high schools from various regions throughout the state. Within the state, there are 750 public high schools, 426 combined junior/senior high schools, 33 Pathways in Technology Early College High (PTECH) schools, and 88 K-12 schools that are considered STEM focused (NYSED, 2016). There are four schools that use the term

"STEM" in the name of the school (NYSED, 2016). These STEM schools are located throughout New York State, vary in population size, and are found in all geographic areas (NYSED, 2016). The schools are public and are approved by the New York State Education Department.

Research Participants

Participants were chosen utilizing purposeful sampling of STEM-focused high school principals from New York State. Here, using purposeful sampling, the study was able to focus attention on the schools that are STEM-focused and explore the leadership within these schools. Because there is no existing statewide database specific to STEM-focused schools, to determine if a school was STEM-focused, it either served as one of the New York State PTECH schools, self-identified on their website or title as being STEM-focused, or appeared on an external website list of STEM-focused schools for New York State, including U.S. News & World Report: Best STEM High Schools, or Niche.com Best Schools for STEM in New York State. The fidelity of STEM implementation may vary from school to school. At the start of the study, 52 schools were contacted for participation. Approval from the Institutional Review Board from St. John Fisher College was obtained prior to the start of the study.

Instrument Used for Data Collection

The survey instrument is a hybrid model of a locally developed demographic survey tool about principal leaders, their support of the teachers, and the school setting, as well as the Multifactor Leadership Questionnaire (MLQ-5X) developed by Bass and Avolio (1990). The MLQ-5X survey-use rights were purchased through MindGarden and were administered to STEM-focused principals on the MindGarden platform. The

qualitative phone interview questions were developed by the researcher to determine practices of supporting teachers in STEM-focused schools.

Demographic Survey

Principals invited to participate in the research were asked to complete a demographic profile of their leadership and history, as well as demographics about their school (Appendix A). This information included the number of years of principal leadership at a STEM school and number of total years of principal leadership, as well as teaching experience, STEM-focused background, and level of education. Additionally, information collected about the school included the school name, school grade levels, school population, and location. This demographic survey was given to principals as they self-rated.

Multifactor Leadership Questionnaire (MLQ*)*

The MLQ-5X has been used as a transformational leadership rating scale for over 25 years, in all types of companies, schools, government agencies, and not-for-profits throughout the world (Bass & Avolio, 1995, 1999; Bass, Avolio, & Atwater, 1996).

The survey measures a leader's abilities on various outcome scales, including five transformational leadership scales, three transactional leadership scales, and one laissez-faire leadership scale. The tool is comprised of 45 prompts that are measured on a 5-point Likert scale. The scale ratings vary from 0=not at all to 4=frequently, if not always. The "target raters" are school principal participants who self-evaluated.

Developed by Bass and Avolio (1995), this tool explores the extent to which a leader serves as a transformational leader. The transformational leader "defines public

values that embrace the supreme and enduring principles of a people. These values are the shaping ideas behind constitutions and their interpretation" (Burns, 2003, p. 29).

Semi-Structured Interviews

Selected principals who scored at least a 2.0 out of 4 on the transformational leadership scale from the MLQ-5X were called for a 30-minute phone interview. All eight STEM-focused school principals who completed the MLQ-5X met the criteria for the phone interviews. During the interview, questions about their leadership were asked, including: What, if any, challenges do you have in supporting your teachers in a STEM-focused school? From your experiences, what has allowed you to support teachers in a STEM-focused school? Do you see your leadership style different for STEM versus non-STEM faculty? How often do you utilize outside consultants or professional development? For what areas? How do you determine who to hire in your STEM-focused school? How do you convey your vision to your teachers and staff? Have you observed changes in school culture since you've started? Have there been changes in academic success of students since you've started? Have there been changes in student attendance since you've started?

The researcher kept notes during the phone calls, as well as used a phone recording service, *TapeACall Pro*. Immediately following phone interviews, the audio recordings were transcribed using the online platform Rev (www.rev.com). Due to a technical glitch, one phone call did not record in its entirety. Rev was able to transcribe some of the call, therefore the researcher supplemented this partial transcription with data collected from the researcher's phone call notes. Once the phone calls were transcribed, a priori codes were created that closely follow aspects of transformational and transactional

leadership aspects including charisma, motivation, individualism, rewards, and corrective. Next, the researcher conducted in vivo coding based on the audio transcriptions. The researcher explored the coding and themes for the transformational STEM-focused principals.

Procedures for Data Collection

The demographics survey and MLQ-5X were completed online at Mindgarden.com. Principals invited to take part in the survey were emailed an invitation to participate (Appendix C). If they chose to participate, they were emailed a link, allowing them to complete the survey at their own pace. Before they began the survey, the principals completed an online informed consent (Appendix B). A reminder to complete the survey was sent 1 week after the initial email to ensure all participants had a chance to contribute. An additional reminder was sent at week 2, and a reminder at week 3 notified participants of a "last call" for submissions. The survey window was open for 4 weeks to ensure adequate time for all participants to complete the work.

As principals completed the survey, the STEM-focused principals who scored at least a 2.0 in the transformational leadership scale from the MLQ-5X were contacted for a follow up 30-minute semi-structured interview (Appendix D). These interviews were conducted over the phone with the audio recorded while the researcher took notes in the event of technical issues. A total of 52 STEM-focused principals were invited to participate in the study. Of the STEM-focused principal pool, eight completed the MLQ-5X survey. Notably, almost 50 site licenses were used, indicating that many STEM-focused principals started the survey, but did not complete it. From the eight completed MLQ-5X principal respondents, five completed the phone interviews.

Data collected will remain with the online platform for a 36-month period of time. 3 years after the completion of the study, all data collected, electronic or paper, will be destroyed and deleted. Any survey that was only partially completed, or any principal MLQ-5X that did not complete the demographic information was discarded and not used in analysis. All information collected in the study, including the MLQ, demographic survey, and phone call records will be kept on the researcher's personal password-protected computer within a password-protected file.

All correspondence with participants included an email assuring them of anonymity, the voluntary nature of the study, and the ability to opt out at any point in the process. This was included at the initial email as well as all subsequent communications about the study to the participants.

At the conclusion of the study, a principal of a school that participated in the first part of the study received a copy of their leadership profile individual report, regardless of whether they participated in the second part of the study. This served as an incentive for participation in the study. Participants in the study remained confidential. School names and specific information were not utilized.

Reliability. The MLQ-5X reliability was measured using the 1995 MLQ Technical Report (n=2,154) in which the assessment was found to show the reliability for each subscale from 0.74 to 0.94. The MLQ-5X was found to be high when reviewing the reliability of the data tool (Bass & Avolio, 1999).

Validity. The MLQ-5X validity was measured using a data set of 3,786 respondents. This large and diverse dataset helped to address the multivariate normality assumptions. The confirmatory factor analysis resulted in the chi-square difference test

(P<.001). In the 1995 MLQ Technical Report, the initial validation results produced satisfactory fit indices.

Procedures for Data Analysis

Utilizing the demographic survey, preliminary data analysis of the principal demographics yielded results that demonstrated the general makeup of the responding school principals as well as their school backgrounds. This information was utilized to gain an understanding of the variety of schools and principal backgrounds that were included in the study. This demographic information was utilized to explore the leadership styles of principals of STEM-focused schools in a variety of ways including within PTECH schools, STEM-focused high schools, rural schools, and a variety of other combinations that were noted in the demographic profile information.

The MLQ-5X tool determines the leadership style of the principals. The measure is designed to determine the leadership style of the designated leader within three categories: transformational leadership, transactional leadership, and passive avoidance. This is determined by taking the mean of each subscale variable. The survey is designed with a variety of questions that are mixed subscale measures. The associated key determines which questions correspond with each variable. The data for each principal was merged together into a percentile score for each leadership subscale. Principal norms for each subscale were then compared to the normative database compiled by Avolio and Bass (2004). This database contains over 3,500 ratings compiled over a 20-year period. The ratings for the principals determined their leadership style. The categories of identified leadership traits include the following:

1. Transformational Leadership – Leaders are inspirational, challenging, and visionary. “Charismatic” leadership practices are part of a transformational leader. The leader in this setting is seen as a role model for their followers. Here, the leader demonstrates high expectations, and supports their followers on an individualized basis. Followers are challenged in new and innovative practices, with collaboration and support from the leader of the team or organization (Bass & Avolio, 1999).
2. Transactional Leadership – Management and leadership by compensation or management by exception (active) where there is a reward for goal achievement or consequence for mistakes and failures. Payoff is the incentive for work completion or task management. This also includes negative feedback loops and corrective criticism (Bass & Avolio, 1999).
3. Passive Avoidance – Laissez-faire leadership or management by exception (passive). A leader will only address a problem when it arises, or a very hands-off approach where no feedback is given, and there is no attempt to help or support followers in their work or addressing their goals at the workplace (Bass & Avolio, 1999).

The data collected about principal leadership styles when compared to the norms was utilized to determine the types of leadership demonstrated in STEM-focused schools. Merging the MLQ-5x results with the demographic survey also generated results that highlight specific STEM-focused school programming, such at the PTECH model as being more unique than the mainstream school data.

In coding the short responses from STEM-focused school principals on their leadership practices, the responses were gathered electronically and merged into a single Microsoft Excel document. A priori coding enabled the researcher to establish a foundation by which to begin coding (Saldana, 2016). A list of a priori codes were gathered in a codebook stored in Excel. The a priori codes closely followed aspects of transformational and transactional leadership aspects including charisma, motivation, individualism, rewards, and corrective. After reviewing the responses from the survey and coding using the a priori codes, the researcher went through the data a second time using open coding. Open coding enabled the researcher to determine if additional data should be coded using the a priori codes, or if there were data that should be coded into new collection points (Saldana, 2016). Participants and their schools were assigned a pseudonym and remain linked with the leadership style calculated from the MLQ-5x in the Excel data.

After the data were coded, the researcher looked for supercodes, and patterns within the codes. This helped the researcher determine the overall themes present from the data collected (Saldana, 2016).

Chapter Summary

An examination of the literature highlighted the need for additional information about the merger of STEM-focused schools with respect to the principal's leadership practices. Principals have a responsibility to ensure instruction within the building is meeting expectations. The idea of principals as exclusively managers has faded, and the concept of the principal serving as the chief of instruction has blossomed in schools (Katterfeld, 2013). This mixed-methods study utilizing the MLQ survey instrument

explored the transformational leadership style of STEM-focused high school principals within New York State and how they support their teachers. Joining the data collected about STEM-focused school principal leadership types, as well as the data collected on how principals provide instructional support to teachers, highlighted the leadership and supports for teachers in STEM-focused schools. This study contributes to the limited body of research focusing on leadership within STEM-focused schools.

Chapter 4: Findings

This chapter presents and discusses the findings of the study. The information collected and described comes from the MLQ-5X assessment tool and phone interviews with STEM-focused school principals. The purpose of the study was to determine the transformational leadership practices of STEM-focused school principals. This study had two guiding questions:

1. Do principals of STEM-focused high schools demonstrate transformational leadership?
2. How do principals in STEM-focused schools who utilize transformational leadership support their teachers' academic instruction?

Data Collection

An invitation to participate in this research was sent to New York State principals who are employed at STEM-focused high schools. In order to determine if a school was recognized as STEM-focused, it either functioned as a New York State PTECH school, self-identified on their website or title as being STEM-focused, or appeared on an external website list of STEM-focused schools for New York State, including U.S. News & World Report: Best STEM High Schools, or Niche.com Best Schools for STEM in New York State. In total, 52 high schools across the state were chosen and their principals were invited to participate in this study.

After the email invitations to participate in the study, principals were given a unique URL to complete their MLQ-5X survey. This tool was utilized to determine if the

STEM-focused principal was demonstrating transformational leadership. In all, eight principals completed the MLQ-5X survey tool and met the threshold of 2.0/4.0 in Transformational Leadership. From these eight principals, five agreed to complete the phone interviews. The phone interviews were the basis of the data collected to address the research questions. All phone interviews were recorded and transcribed.

Participants

The finalized list of participants included all STEM-focused high school principals who completed the MLQ-5X with a score of 2.0 or higher in Transformational Leadership, and who completed the phone interviews. In total, there were five participants in this study, as noted in Table 4.1. All participants were given pseudonyms for their name and school name.

Table 4.1

Demographics of Interview Participants and Schools

Name	Level of Education	Years as Principal in Current School	Years of Principal Total	Years in Education	School Grade Levels	Student Enrollment	Location
Dr. Nelson	Ed.D.	4	8	17	9-12	100-200	City
Mr. Smith	Multiple Masters	3	4	16	9-14	100-200	Rural
Mr. Brown	Masters	8	12	21	9-12	1500-1600	Suburban
Ms. Clark	Masters	1	19	25	9-12	100-200	Rural
Mr. Scott	Masters + CAS	5	5	15	9-14	0-100	Rural

Note: Participant names are pseudonyms.

Data were collected from the MLQ-5X survey, as well as phone interviews that were conducted over a time span of 1 month. Each of the phone interviews were scheduled at the principal's discretion. Some interviews were conducted during the school day while the principal was in their building, while some were completed on the evening or weekend, away from work. The size of the schools ranged from less than 100 students, to more than 1,500 students, as noted in Table 4.1. The principals had served in their STEM-focused schools from 1-8 years and had been principals in total from 5 to 19 years. Their years in the education field ranged from 15-25 years and included a variety of other positions within education, including elementary and high school teachers, data coordinators, assistant principals, director of technology, STEM mentor, and coordinator of student activities. One principal had completed a doctoral degree (in education), while the other four held master's degrees. All principals served in high schools, with two schools extending to Grade 14 using the PTECH model. Four of the principals were male, and one principal participant was female.

Data Analysis

Using the benchmark of 2.0/4.0 for Transformational Leadership, each of the eight participants that successfully completed the MLQ-5X met the criteria for leadership. Scores from all principals ranged from 2.8 to 4.0. From these principals, five scheduled follow-up phone interviews. Responses from these phone interviews were transcribed using an external service and then were coded individually. Initially, codes were generated based on the aspects of Transformational Leadership including charisma, motivation, individualism, rewards, and corrective actions. Next, open coding was used to continue to create codes from the transcripts. In looking at all codes in their totality,

supercodes began to emerge and led to the development of themes within the research. Despite the varying backgrounds of the STEM-focused school principals and the various types of STEM-focused schools, there were many similarities discovered within the data collected.

Research Question 1

Do principals of STEM-focused high schools demonstrate transformational leadership? In exploring the question of whether STEM-focused high school principals demonstrate transformational leadership, the MLQ-5X served as a tool to determine if the leaders are functioning as transformational leaders. As previously noted, all eight of the principals who completed the MLQ-5X scored at least a 2.0 on the MLQ-5X scale in transformational leadership.

Several questions in the principal interviews were closely aligned to highlight ways in which principals demonstrate transformational leadership, or not. These questions included: What, if any, challenges do you have in supporting teachers in a STEM-focused school? From your experiences, what has allowed you to support teachers in a STEM-focused school? How often do you utilize outside consultants or professional development? How do you convey your vision to your teachers and staff? Have you observed changes in the school culture since you've started? These questions helped to frame a picture of the leadership styles of the principals in their STEM-focused schools.

In the analysis of the responses to the above questions, two themes of transformational leadership emerged. The first theme noted was motivation, as many leaders shared ways in which they motivate their staff to reach their professional potential. From this main theme, two subthemes emerged: *vision* and *support*. The other

major theme to emerge is individualism. Many of the principals shared ways in which they work with their teachers on an individual level to help foster growth. Within the theme of individualism, two subthemes emerged: *mentors* and *risk-taking,* as noted in Table 4.2.

Table 4.2

Research Question 1 – Themes and Key Concepts

Theme	Key Concept	Subtheme
Motivation	Inspiring teachers to perform beyond expectations.	Vision
		Support
Individualism	Attending to the teacher's needs and guiding them.	Mentors
		Risk-Taking

Motivation. One of the major themes to emerge from the principals' discussions revolved around teacher motivation. All of the principals shared various ways in which they try to motivate their teachers to work and perform beyond the standard expectations. One of the ways in which these principals motivated their teachers is by conveying vision. In one such example, Dr. Nelson shared that "school leaders need to be invested in the 'why.' It's also important to know the job market. The employees need to know why we're doing this [model of schooling]." In another example, Mr. Scott shared his method to convey vision to his teachers:

> We are in the same office space every day, so it allows me to have both formal and informal conversations with them [teachers] that really, one, purposely verbalize and model what my vision is, but it also allows it to be a much more organic process as well so I don't always have to be saying something, more than

> just general conversations I can have with people that really had that philosophy embedded in it. Then that conversation, because we're all in the same room, I could be having a conversation with one staff member, but the other five are listening to the conversation as well.

Mr. Scott's ongoing dialogue about the school's mission, as well as his ability to model it in himself helps to motivate the school's teachers in following his lead. Mr. Brown extended his method for sharing his vision beyond just teachers, where he's able to engage the community as well. Mr. Brown has practiced his ability to engage the staff beyond memorizing a mission statement, but to extend their work:

> I think largely through conversations, through writing, I do a quarterly newsletter to the whole community. We have faculty meetings. Last year we did a series of three faculty meetings on values and beliefs and aligning on that. It's not about some of the stultifying missing writing exercises. It is more about just talking to people about what it is we do what we do, and checking-in and explaining rationales and philosophies behind that, getting people on-board.

Another aspect of motivation, according to the school principals, was support. Many of the principals highlighted their ability to show support to their teachers, as a way to further motivate the teachers to improve. Mr. Brown highlighted not only his school, but his district's ability to show support to their teaching staff. While he may not always understand the work they do, he recognizes the teachers' passion and supports them in their journey:

> [I like] Working in a community that is very supportive of education both in terms of resources, and in terms of the commonly shared belief in the public-school

> system here. I think being flexible as a leader, in allowing time out of the classroom to do the traveling, to meet with consultants. Having an infrastructure that supports innovation with grants that come from central office. Again, being fortunate to have the people in place who have the experience and the initiative to take us to the next level. It's so specific to their talents that the only thing I can really take credit for is throwing money at them and getting the hell out of the way. Because, that is not my wheelhouse. I am a social studies teacher by background. And so, they would just talk a mile a minute. I would go, "Oh, that sounds great. How much do you need? How many days do you need? And where do I sign?"

While Mr. Brown did not have the background from a STEM field, he was aware of his teachers' needs for improvement and supported their desire to grow. He additionally highlighted his staff and their growth over the past years, including his founding teacher's years of growth:

> I'm proud to say that we have four teachers involved with the program now, but the founding teacher has really been a leader herself in providing and designing curriculum, designing the program, connecting with other schools, independent schools as well as college and universities to find what they're doing. Bringing this home in a way that is congruent with our students' interests and needs. She has been taking the initiative to create that which is not in place. It's a lot of hard work, but supporting her with travel expenditures, and just bringing in people as consultants all that is money. So, it's been a lot of the ancillary support to allow this to happen.

The above examples from the principals highlight ways in which they work to motivate their teaching staff in pursuit of excellence. All of the principals discussed a desire to see their teachers grow in their practice and improve as educators. Their ability to successfully motivate their teachers varied from principal to principal and school to school, however they all shared the same transformational trait of motivation as a leader.

Individualism. In transformational leadership, the area of individualized consideration allows the leader to connect more personally with the followers and adapt their leadership approach and support based on that person's needs. Within the study, the principals interviewed highlighted ways in which they would connect with their teachers on an individualized basis. The ability to connect on a more personal level with the teachers fostered a connection between the principal and teacher, and established pathways for more unique improvement strategies to be shared, that are more tailored to the teacher. Ms. Clark shared her success working individually with new teachers in assisting with general classroom procedures, as well as a method to convey the overall vision and mission for the school:

> So now with the new staff, with them being fresh and new, it's great because I was able to mold them right from the beginning and say this is how we're going to do this, this is going to be a welcoming atmosphere….For my new teachers, I'm doing a lot of professional development, a lot of individual time with my teachers to guide them through what it's like to be a new teacher, how to establish routine, how to establish your team, how to establish discipline in the classroom. I'm able to guide my teachers in how to work with students who may be a challenge socially, emotionally, or academically.

All of the principals highlighted that outside mentors or professional developers assisted their teachers in growth. As the individual teachers needs vary, professional development, or outside mentors are able to help foster growth for the teachers as they continue to craft their practice. All five STEM-focused school principals mentioned various professional development or consultant support that suited the needs of the classroom teachers. These connections did not always come from the top. In one such example, Mr. Brown discusses how teachers can often make a connection to build a bridge from outside experts, professionals in the field, or other resources to their school:

> Often when a teacher makes a connection to someone at the university level, or who's doing interesting work at another school, we are eager to bring them in and to expand our knowledge base in that way. We're also fortunate to have the resources to do that with pretty incredible frequency.

Risk taking also emerged as a common response among principals in the interviews. Two of the principals shared specific ways in which they would encourage their teachers to take risks and try something out of the ordinary. This encouragement enabled the teachers to try new things for the betterment of their class and school. Mr. Smith shared his mentality in regard to risk:

> I'm the one that any teacher has an idea, I'm willing to try it. Obviously, of course, unless it breaks the law or anything like that. But I think just having that openness to listen to them [teachers] to see what they'd like to do, and just support them along the way. Just open-minded listening has been really helpful for me…. What we do is so non-traditional, that a lot of the teachers come from a traditional teaching background of teaching through their schooling and through

> other experiences. I want the teachers to have a mindset to try something new, try something out of the ordinary, and really going out of their comfort zone.

Similarly, Mr. Scott shared that he pushes for teachers to connect outside of their typical networks:

> I really try to encourage my teachers to reach outside of their standard network and be able to kind of generate some ideas. And so, I'll give you a good example from a physical education setting. Our health and physical education teacher has developed a partnership with SUNY-Brockport that really kind of helped build a project-based setting. . . . So, she is able to leverage that network to build some other creative ideas on how to bring project-based learning into a physical education setting. I am trying to work with my teachers to really stretch outside of their normal network to engage in discussions and brainstorming around what kind of projects we could develop that would be STEM-focused.

The ability to encourage teachers to take risks is another example of how these principals function as transformational leaders within their schools.

As noted in the above examples, the two major themes of transformational leadership highlighted from the interviews were motivation and individualized consideration. These are the two areas of transformational leadership that were distinctly noted within the research. In the next section, themes from the data about research question two will be shared.

Research Question 2

How do principals in STEM-focused schools who utilize transformational leadership support their teachers' academic instruction? The principal survey included a

variety of questions that addressed how they support their teachers' instruction. These questions include: How do you determine who you're hiring at your STEM-focused school? Do you see your leadership style different for your STEM versus non-STEM faculty? Have there been any changes in the academic success of the students since you've begun? Have you noticed changes in student attendance since you've started? Have you observed changes in the school culture since you've started? Can you share with me how often you utilize an outside consultant or outside professional development? From your experiences, what has allowed you to support teachers in a STEM-focused school? What, if any, challenges do you have in supporting your teachers in a STEM-focused school?

In reviewing the data collected from the STEM-focused principal interviews, several themes emerged. These themes include human resources, collaboration, culture, and instructional strategies. There were also some areas of overlap with Research Question 1. Further subthemes emerged including flexibility and mindset through human resources, as well as attendance and achievement from culture. Additionally, professional development also emerged as a subset of instructional strategies, as noted in Table 4.3.

Table 4.3

Research Question 2 – Themes and Key Concepts

Theme	Key Concept	Subtheme
Human Resources	Hire right to get the desired team.	Flexibility
		Mindset
Collaboration	Together, we can make great things happen.	
Culture	Beliefs, assumptions and practices shared among the school.	Attendance
		Achievement
Instructional Strategies		Professional Development

Human resources. One of the major themes to emerge from the research was in human resources. The principals all shared the same view: that if you are able to hire well, it makes the job of principal much easier. As Mr. Brown noted, "If you're not nice and you're not flexible, it's not going to work." The importance of hiring the right people for the STEM-focused school was an important aspect to ensuring the success of the program.

A subtheme of the human resources frame was flexibility. In a STEM-focused school, it is imperative for teachers to be flexible in their work. The daily operations of a STEM-focused school can vary greatly depending on the program implemented, including inquiry-based learning, project-based learning, or interdisciplinary teaching

practices. Four of the five principals noted flexibility as an important trait for their staff. As Mr. Smith noted about who he looks to hire:

> The biggest thing, obviously, we look at the teachers who can be flexible, same thing we looked at with our students. It's definitely a flexible educator that is needed. I think anybody can learn, anybody can develop, anybody can have that area, but as long as they're willing to be flexible, and they want to learn and challenge themselves, that's what I look for.

Additionally, another subtheme of human resources was in mindset. The ability for the new staff members to be able to see the "why" of the STEM-focused school and share the same beliefs about student success and growth. Mr. Brown shared his criteria when hiring as follows:

> Smart and likes kids. That's the criteria I use for every subject. Then, it's specific to the area. Some experience with design thinking, or engineering, or Project Lead the Way….It's really some baseline knowledge of the field, some baseline knowledge of pedagogy. We hire by committee here, so the department does the screen, then my screen, all kidding aside, really is "Do you have a disposition that's favorable to students connecting with you? And are you flexible and, frankly, smart enough to do what it takes to get the job done in the right way?" If those two are present, we usually can work on everything else.

Truly, what Mr. Brown looks for in a staff member boils down to their personality and mindset in education. Ms. Clark shares a similar viewpoint in the hiring at her school. As she shared, she is careful to hire someone that will work well with her already-established team:

> If I'm looking for a particular type of personality, I think about how they are going to fit in with my staff. Are they going to be able to, especially an instructional coach in particular, get the teachers to do what they need to do? Or is it a type of person who is going to be abrasive and not be able to gel with those teachers?

When it comes to hiring in a STEM-focused school, careful consideration must be made to any potential candidate, as the STEM-focused schools often require much collaboration among the staff and students, as well as a flexible mindset that enables the students to meet the unique structure some of these schools offer.

Collaboration. Building principals focused a lot of their attention on the ability for the school to collaborate. This theme was apparent within all five STEM-focused schools, as an important aspect of the program. Dr. Nelson noted, "The staff collaborate in all areas, STEM and the humanities." Four of the schools shared the interdisciplinary approach to instruction as a need for collaboration among the classes. The collaboration was not just reserved for the school buildings themselves, but often collaboration took place between schools too. As Mr. Smith noted, collaboration is key within his school and between schools:

> The model we have here with hands-on learning, trying new things, and the collaborations. I've been in schools where you're just teaching what your subject area is, and now I'm seeing how much you can do as a while with all of the cross-curricular activities and lessons. . . I think collaboration is really critical for this, not only within our staff, but also others in the area. In our PTECH, I've connected [our teachers] with a lot of other STEM-focused schools that are in

> similar situations. We go to professional development with them. We, as leadership, meet together. The ability to connect with others has been helpful, and to know others are in similar situations, that's good to hear too.

The desire for collaboration was heard within all of the principal interviews. As described above, principals were able to reach out to foster connections between buildings and within their own walls to ensure that teachers and students were collaborating. This practice was highlighted among the STEM-focused school principals as a key component to their school.

Culture. Another aspect of the STEM-focused school buildings that emerged as a key theme in the research was culture. Laying the groundwork for a healthy school culture further enabled the school's success going forward. As Mr. Scott highlighted his journey building culture within his STEM-focused school:

> The first cohort of kids we brought in collectively had the mindset that they were owed everything and that there wasn't a whole lot of expectation that they needed to give anything in return. We've gotten more to a point now, I think, where the students that are there are academically more successful than they had been in their previous schools. In large part, it has to do with the culture and climate we've built in our building more than anything else. . . We've started to refer to our program as the land of misfit toys, because we get a lot of kids that socially did not feel like they were accepted in their home schools. And we've been able to build a culture where those kids feel at home, and so now they're more successful academically because they're less concerned about the social dynamics when they're on our campus.

While Mr. Scott highlighted his school's growth in building a successful school culture, Mr. Brown likewise noted that much of his ability to be successful in the school starts with the students' homes. Mr. Brown shared the benefits of the school's greater community as follows:

> I'm very fortunate to work in a community that prioritizes education, kids coming from very affluent homes that have a number of resources, where the discourse at the dinner table is often about the current events of the day. The kids are well-traveled internationally and nationally. And so, a lot of those families' realities translate into the way education feels in the classrooms. I feel it's our job to make the most of those excellent raw ingredients and just take this to the next level. And I think we've been able to do that, without stressing everybody out all of the time.

A subcategory that emerged from the discussions about school culture revolved around attendance. Notably, three of the school principals noted that attendance was not a category that they monitor closely, as the student attendance rates are excellent. This was attributed to the school's programming and the motivation for students to attend. While these three principals were not able to comment directly on attendance rates, they did attribute high interest in school and motivation to attend, as a reason they have not been concerned with their school's attendance rates. It is important to mention that not all of the schools are similar in enrollment processes. Two of the schools in the study are local PTECH schools in where students must apply and interview to attend. Two other schools are STEM-magnet schools and one school is a local high school that all students in the area attend.

As Mr. Smith shared with his school's attendance rates, he has seen a steady jump in regard to the students' attendance. Mr. Smith shared:

> Many of the students that came in struggled with attendance and they definitely have improved since they got here. I think a lot of them realize a couple of things: One, they like to be here. Two, they realize if you miss a day, it's hard to bounce back so quickly.

Mr. Smith noted what the other principals had seen: that their STEM-focused school is enjoyable and they need to be present. Ms. Clark shared her own personal connections with students as a method for attendance monitoring. With her smaller school, she is able to greet and welcome students daily. As Ms. Clark shared:

> I have a small number of students, so I'm at the door every day and I greet the students as they're coming off the bus and I know every one of them by name. And because it is so small, I know from day to day who was there, and who was not. I've seen a big difference when I say, "Hey, you know what Johnny? You weren't here yesterday. Where were you? We missed you. It's really important for you to be here. I really want you to be here." We have seen an increase in attendance, and I think that helps a lot. There was a young lady I spoke to today who I know purposely chose not to come to school yesterday, and I pulled her aside and said "Now you know that I was going to talk to you today, right? . . . You need to get here. I really want you here. I was worried about you, and you can't do that again." I make a lot of statements to the students like that, and you see a big difference.

Another subcategory of culture was in student achievement. The STEM-focused principals were aware of their students' achievements and were able to highlight the efforts made among the staff in increasing student achievement. Being well versed in highlighting student growth helped foster a strong culture within the building with a focus on academics. As Mr. Smith notes:

> Our students were considered at-risk students, and we're dropped the number down. I mean, in our first year, we were at 70% at-risk students, now that group is down to about 23%. Every year we've had great growth with students that are considered at-risk. That percentage has dropped every single group of students that we've had.

Mr. Smith highlighted his school's ability to lower the number of students considered at-risk by great numbers. Likewise, Mr. Brown's school did not struggle with at-risk students, but has been able to highlight the academic growth and achievement of their students at the STEM-focused school. Mr. Brown emphasized the number of students taking college-level courses and honor society membership as points of pride within his building:

> We don't have AP classes here; we have AT classes which are college-level courses. We have more than 70% of our students taking at least one college level course. The top two thirds of our students go to the top-tier colleges in the country. So those metrics have remained strong. The percentage of students graduating who have been admitted to the Honor Society has gone up a bit over time, so things have remained at a high level or gotten better.

While student success and achievement are important goals to work towards within the schools, Mr. Brown noted that sometimes, it can become too much. Mr. Brown shared his strategy on improving school culture surrounding achievement as follows:

> The teachers and parents here feel this obligation to provide a very rigorous college preparatory high school experience, and it comes from a very good place. When that becomes too extreme, it can cause a level of stress that's unmanageable for many students. And so just thinking about finding the right balance between rigor and wellness. Thinking about structures around testing, and homework over breaks, and things of that nature. As well as how the use of technology during and outside of the school day, impacts student mental health and cognition, and their ability to engage in long-form reading and really talking about those things.

A STEM-focused school's culture was an important part of the data collected. As noted above, attendance and student achievement played into the overall view of a school's culture. The school principals interviewed spend time, carefully working to improve their own school's culture, as it is presented in the community and to the staff and students.

Instructional strategies. Another area of support provided by the STEM-focused school principals comes in the area of instructional strategies. The principals are able to support the academic instruction of students through the work with teachers on instructional strategies. As Dr. Nelson shared, "One way we have been able to grow is to create benchmarks to understand where students are starting from." This work with teachers and creating benchmarks helped the teachers better plan for instruction, and

monitor student growth. One area that Dr. Nelson has been focused upon is growth in mastery and college-level courses. As Dr. Nelson shares:

> We've been focusing on mastery in our Regents exams. I have seen marked improvements in lots of different areas. College credits attained is another area we look at. We had 130 kids last year and they earned 748 college credits, and all of our seniors graduated with college credits, an average of 19 apiece.

While Dr. Nelson's instructional focus was in mastery, Mr. Scott has been working on good practices with his staff. His approach is a bit varied from the traditional, as he is utilizing videos to support instructional coaching:

> We're working on utilizing videos from an instructional coaching perspective. So, we're really trying to look a little bit deeper at our instructional practice, and then using that information coupled with an internal focus, if you will, on talking about what good instruction is more than content. I think coming into this program, one of the philosophies I really tried to reinforce with my teachers is their content delivery is secondary in my mind to their effectiveness of just utilizing good sound instructional practice. And so we really have focused heavily on trying to identify what are some key areas of instruction that we want to touch on, and then utilizing video as a tool to reflect on whether or not we're doing it to the degree that we should be or are.

Similar to Mr. Scott, Ms. Clark also describes the work that her instructional coach has been able to do with her staff that enables them to improve in their practice. Ms. Clark explains:

> I'm blessed in this school, as we have what's called an instructional coach and that person does individual work on top of what I do with my teachers in helping them develop professionally. Sometimes that person will plan a professional development day….Because so many of my teachers are still at the basics of how to establish a routine, how to establish order and discipline in the classroom, and how to navigate Next Generation standards, which are brand new to them as well, I'm going to stick with the basics this year of establishing routines and learning the standards as well as using the project based learning model.

Closely related to instructional practices, all of the STEM-focused principals shared a focus on professional development. This emerged as a subtheme of instructional practices. The principals discussed various professional development opportunities they've helped to facilitate in their schools. Mr. Smith shared how he goes about selecting opportunities for his staff, and getting the staff motivated to participate. Mr. Smith shared:

> Having the openness to listen to the teachers to see what they'd like to do, and just support them along with providing professional development opportunities. Any place they want to go that really fits our mold here, I let them go. . . We've had someone come from PBL Ohio to visit us just a couple of weeks ago, and we like to go places too. But, both of these also offer so many great things, we have a unique opportunity with that too. Any (program) that comes here, we can sign up and go there.

Mr. Smith's openness to listen to his staff's interest in professional development encourages and motivates his staff as they work to improve their craft. Similarly, Mr.

Scott shared that professional development continues to push teachers in their practice, beyond the traditional approaches to instruction. Additionally, he brought in professional development to help support a change in culture. Mr. Scott shares:

> We strive to be a project-based learning school, and from a teacher preparation perspective, they are still kind of prepared to deliver content in the traditional stand-and-deliver mode. So, trying to find opportunities where they can engage in thinking more on a project-based level is a challenge. . . . I've brought in a consultant to work with us on team culture. We're an incredibly small program. When you look at us staff-wise, we're a combined total of maybe eight people. And we're essentially housed in the same office, so our teachers push into classrooms….I brought in a consultant to help us have an outside discussion around culture and so he was instrumental as we went through personality assessments, so we better understand who we are, one as individuals, but also how do our personalities and styles integrate to make ourselves either a strong or weak team.

Mr. Scott's experience in determining professional development needs, and locating the right resources echoes the sentiments of the other STEM-focused principal's desire to find opportunities to help their school's growth. Ms. Clark shared a similar opinion, as she works on professional development opportunities for her staff. While looking at her staff, she is quick to locate resources that may support some of her teachers or looking at the big picture to determine professional development needs for the whole staff. Ms. Clark shared:

> I'm always on the hunt for various things that I think will help my teachers. Such as today, I got a flyer in the mail about working with students who may be challenging behaviorally. And how teachers can work with students who may be resistant to learning. So, I think this would be really good for my teachers. . . We're also going to put our teachers through with an outside expert on project-based learning next summer, which is going to be a little bit more intense. So right now, it's kind of like project-based learning lite and we're just getting through the basics.

The STEM-focused principals centered on improving instructional strategies, as well as locating professional development opportunities for their staff are more examples of ways in which these principals work to support their teachers.

Summary of Results

This chapter presented the data collected from the five STEM-focused principal interviews and the results of the MLQ-5X survey tool. For Research Question 1, the data were explored to learn whether STEM-focused school principals demonstrate transformational leadership. Two themes that emerged from this inquiry. The first, motivation, was a transformational leadership practice that was evident in all STEM-focused school principals. This theme was further broken down into the subthemes of vision and support. Secondly, individualized consideration was another transformational leadership practice that was emphasized. Mentorship and risk taking were subthemes of the individualized consideration theme.

This question centered around the idea of transformational leadership practices as an effective strategy within STEM-focused schools. While the MLQ-5X showed that all

STEM-focused school principal respondents met the transformational leadership threshold for the research, including the STEM-focused school principals who did not complete the phone interview, the follow-up interviews further developed and highlighted ways in which these principals demonstrated their transformational practices.

For Research Question 2, the support provided by the STEM-focused school principals were probed and four themes emerged. First, human resources surfaced a priority among the principals. Hiring the right people was imperative for the school's success, and this included the right mindset and candidate flexibility. Collaboration was another key idea from the data analysis, where the principals highlighted the ways in which they work throughout the building and across schools. Culture was the third theme, and this was further broken down into the subthemes of attendance and achievement. The STEM-focused school principals discussed ways in which they help support and strengthen their school culture. Finally, instructional strategies, and relatedly, professional development, were investigated and emerged as subtheme. The STEM-focused principals shared ways in which they help support teachers' growth in practice and help support teachers through professional development opportunities.

Chapter 5: Discussion

STEM, as an instructional focus, has been an area of attention for many years in education. The emergence of STEM-focused schools has been one way in which our educational system turned attention to instruction on science, technology, engineering and mathematics. While there are many studies that have been conducted on STEM-focused schools, their students, and teachers, there are limited studies conducted on principal leadership in these schools. The purpose of the study was to determine the transformational leadership practices of STEM-focused school principals.

Participants were selected utilizing purposeful sampling of STEM-focused high school principals from across New York State. This chapter will present the research findings, implications, and limitations of the study, and recommendations for continued research. To help understand the leadership practices of STEM-focused school principals, questions were devised to frame the research. This study had two guiding questions:

1. Do principals of STEM-focused high schools demonstrate transformational leadership?
2. How do principals in STEM-focused schools who utilize transformational leadership support their teachers' academic instruction?

Implications of Findings

This study looked at principal leaders through a transformational lens. Here, we look to the leader, the principal, for ways in which they invest and connect with the teachers, or followers. The leadership practices explored ways in which the principal

created intrinsic motivation for teachers. There are four areas of focus for transformational leadership including charismatic leadership, the ability to inspire motivation, the leader being intellectually stimulating to followers, and individualized attention to followers. The goal of transformational leadership is to develop followers who are able to reach their greatest potential (Northouse, 2016). In this study, leadership practices that enable the teachers to work to their best are explored.

Three findings stemmed from the completed research. First, principals in STEM-focused schools work as transformational leaders and demonstrate these qualities as well. Second, principals of STEM-focused high schools work carefully to craft the environment and culture of their building to operate at its best. Third, principals of STEM-focused high schools work to support their teachers.

Finding 1: Principals of STEM-focused high schools demonstrate transformational leadership. Principals often wear many hats in their role at their school. Often the principal handles multiple priorities and items at any given time. Principals are seen to be the agents of change and are expected to foster growth and "push out" new initiatives in their building. Liu et al. (2013) described that in a school building, the principal is often expected to build and grow the school's success and culture while still completing the managerial tasks of the position simultaneously.

Attention on leadership styles was also a part of this study. The targeted leadership style for this study was transformational leadership. This style of leadership can be broken down into categories known as the "Four I's." (Northouse, 2016). These categories include idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration. For this study, STEM-focused school principals across

New York State were invited to take a part in the study and complete an assessment that would determine if he or she demonstrated transformational leadership qualities. In this study, all of the principals who completed the entire MLQ-5X (n=8) scored at least a 2.0 on the MLQ-5X scale in the area of transformational leadership, which was the minimum criterion for participation in the interview process. During the principal interviews, two of the areas of transformational leadership were highlighted. These areas were inspiring motivation and individualized consideration. The other areas, idealized influence and intellectual stimulation, may be present in the STEM-focused principals, but were not evident in the interviews conducted for this study. This will further be discussed in the limitations and further research sections.

Motivating teachers was one area that STEM-focused principals pursued to ensure that their teachers were working to their greatest potential. All five of the study participants cited motivating their teachers as a priority in their role. Motivation was accomplished in two ways with the study participants: creating vision and providing support. Principal participants often shared that vision was an ongoing dialogue in their building. This occurred formally in presentations and meetings, or informally as "water cooler" talk. One principal noted that the teachers need to know the "why." If they do not understand why the STEM-focused school model works well, it is an uphill battle for growth. Likewise, he noted that his more informal conversations about the school's vision and direction in the faculty room allowed for more discussion and questions to ensure that all teachers are on the same page. Another principal shared that his method to spread the school's vision was through writing. He would often send newsletters out to the staff and the greater school community. In the newsletter, he was able to capture the

attention and share the school's successes as well as highlight areas of growth for the future.

Providing support to the teachers also helped to motivate the staff to grow to their professional best. The principals in the study shared examples of ways they would provide support to their teachers. One principal noted that while his background was not in STEM, he would often provide support as best as possible, and "get out of the way." This included support for grant-writing, professional development, and working with outside resources. Similarly, another STEM-focused school principal noted that one of his earliest STEM teachers spent much time designing the overall curriculum and program development for the school. This principal acknowledged and supported a blossoming teacher-leader. While he was not specifically designing the curriculum, he was supporting and providing resources to this lead teacher.

The STEM-focused transformational leaders also demonstrated ways in which they would provide individualized support to their teachers. One principal shared how she would spend a lot of time with her new staff members and help mold these teachers into the professionals she would expect for her building. Often, they would spend time discussing how to create routines, handle behavior, and how to conduct the learning in the room. With much of her time spent with teachers meeting their individual needs, this is another way that she is able to demonstrate her transformational leadership. The five principals also utilized professional development opportunities for their staff as ways in which they would provide individualized support for the teachers in their building. Similarly, higher education and industry connections were also highlighted as ways in which principals support their teachers with outside resources for growth.

Transformational leaders must instill a sense of purpose and validation for their followers (Burns, 2003). In the above examples, the principals at STEM-focused schools demonstrate transformational leadership as evident from the MLQ-5X survey results, and the interview data that highlights both individualized consideration, and inspiring motivation.

Finding 2: Principals of STEM-focused high schools craft the desired environment. The school culture plays a large role in the success of the building. The principal is largely responsible for crafting this school culture. In other research, STEM-focused schools project a positive school culture (Almarode et al., 2014; Burton et al., 2014; Tofel-Grehl & Callahan, 2014). The STEM-focused school principals construct the school culture through a variety of ways. The principals in this study worked to build their culture by changing the mindset of the students that attend their building. While one principal shared that initially, his students felt very entitled to a lot in the building, without a lot in return. After working closely with the staff and students, the feeling in the building highlights that students are expected to work hard, and work toward success. Much of this can be attributed to creating a feeling of trust among the students and staff.

Attendance, as a part of the overall school culture, was also explored in the STEM-focused schools. Three of the school principals were not concerned with their school attendance, as their attendance numbers do not raise any red flags and are comparable to other schools in good standing. The other principals shared that motivation is an area that encourages attendance. Students enjoy coming to their STEM-focused school and the attendance at this school is better for the students than it was when they were enrolled in traditional schools. Another principal noted that students are aware it is

harder to bounce-back after an absence. Students in these schools spend a lot of time collaborating in project-based learning opportunities and need to be present to get work done. The principal feels that this team-expectation keeps students motivated to attend.

Greeting students on their way into the building was one way a STEM-focused school principal noted that she works to increase attendance. While many students had attendance concerns, her informal greeting of students in the morning helps to motivate students as they go through their day and lets students know that the adults in the building care about them. If she were to see a student that had been out for some time, she takes the time to talk to the student, noting that they were missed and it's good to see them in school.

Crafting the school culture is one way in which the STEM-focused principals help to craft the desired environment in their school. Another way that the principals work for the environment is through their hiring process. All of the principals noted that it is important to hire well in their buildings. As STEM-focused schools are not the same as a traditional high school, the importance to interview well, and hire carefully becomes more important, as many applicants may not have the full picture of what the schools experience will be.

According to the principals looking for the right candidates for the STEM-focused school meant finding teachers who were flexible. The demands of a STEM-focus school vary, and the day-to-day operations may be different than that of a traditional high school. Four principals highlighted flexibility as an important trait in any new staff member. One principal went further, saying that if he could find a teacher who enjoyed collaboration and was flexible, that was more important than posted credentials. The

teacher-candidate mindset was another important area of consideration. Teachers here must have an outgoing personality that students will work hard for. Another principal noted that she thinks carefully about any new member of her staff, as they collaborate so often, it is important that their personality will mesh with the rest of the staff. As noted by the STEM-focused principals, if you have the right staff, the job of principal becomes easier.

Another aspect of the environment is producing a collaborative atmosphere for the school. This is important for both the staff and students. One principal highlighted that staff in all instructional areas need to collaborate. Noteworthy, collaboration in STEM-focused schools not only exists within the school walls, but also between schools. One STEM-focused school principal noted that his PTECH model school staff collaborated often with other PTECH school staff. This happened with students, staff, and principals. These meetings are valuable as the educators from these schools can learn from each other. The STEM-focused school principals all expressed the importance of collaboration within their buildings.

Finding 3: Principals of STEM-focused high schools support their teachers. STEM-focused high school principals support their teachers in their daily work. As Terosky (2016) found, there are greater expectations for principals to serve as instructional leaders for their teachers. As principals often have many tasks going on at one time, this expectation of instructional leadership can be difficult (Katterfeld, 2013; Terosky, 2016). However, when the principal shifts his/her attention on classroom instruction, the level of student success and teacher confidence increases (Liu et al., 2013; Terosky, 2016).

The study participants noted that understanding the students' foundational knowledge is critical to ensure students are making progress. One principal noted that his school has been working to create benchmarks to measure students' academic progress. The work to create benchmarks allows teachers to collaborate and discuss what is essential for students to know at any given level of their program. This STEM-focused school principal specifically mentioned that their school is focused on increasing the number of students that pass their Regents exams at the mastery level and increasing the number of college-level offerings.

Another way STEM-focused school principals have worked to support their teachers is in professional development and instructional coaching. One principal shared that they have been using best practices videos and discussing them as a staff to determine areas of success and potential instructional strategies to include in their own school. Another principal highlighted the incorporation of an instructional coach as a great resource to promote instructional growth within her staff. This person helps to ensure that all of the staff are well prepared to deliver instruction to the students in the building. The areas of attention can vary based on the needs of the teacher and trending practices in education.

Similarly, professional development opportunities afford these STEM-focused teachers the ability to get some training from someone specifically trained in their areas. All of the principals noted that they would support any teacher who would want to further their growth in their practice. As a part of the professional development, one principal highlighted the follow-up opportunities, to bring an expert into the school to work with teachers in their classrooms to ensure that the learning is being implemented in the

classroom and answer any questions. As a building leader, the principals will find professional development opportunities that echo the building's goals for growth that would work for all teachers, such as in project-based learning, or individualized professional development for a content-area teacher within their area of expertise. Another principal highlighted the same idea, that she is always looking for opportunities to help her staff grow, either in managing behavior, working with special needs populations, or in instructional delivery.

Limitations of the Study

This study was centered on STEM-focused high school principals at public schools in New York State. After a canvass of 52 public, STEM-focused schools in New York State, five completed the entire study. As a result, the findings cannot be suggested to represent all STEM-focused principals.

This study centered upon public schools in New York that self-identified as a STEM school or were on a list of recognized STEM schools. There are also many private schools that focus on STEM instruction. These schools were not included in this study.

This study required the self-evaluation of principals as they completed the MLQ-5X and interview. The perspective of the teachers was not included in this study either on the MLQ-5X rating scale or as a part of phone interviews, which limits some of the findings in terms of transformational leadership, as assessments of leadership style and quality are, in part, made by those with whom the leaders interact, in this case, teachers.. Some areas of transformational leadership were not highlighted among the principal participants, as they could not easily be determined with a phone interview without

talking with teachers. The areas of charisma, for example, did not emerge as a code, as the principals did not talk about themselves as charismatic.

Recommendations for Further Research

There are several areas in which further research would be useful. First, this study only explored the perspective of the STEM-focused school principals. The administration of the MLQ-5X survey can be broaden to include faculty and the results triangulated to gain a better picture as to the leadership styles of the principals involved. Likewise, teachers, as a part of the interview process, may highlight other areas of strength from their principal as well as other areas for growth. The teachers may also note areas that were not revealed through the self-assessments of the principals, but which align with notions of transformational leadership, such as charisma.

Opening this study to additional STEM-focused schools may increase the pool of principals in the group. By surveying STEM-focused school principals nationally, more isolated numbers of principals would not sway as much of the discussion. There could also be a better balance between rural, suburban, and urban schools, as well as principals with a variety of backgrounds in STEM and leadership.

The differences between schools that function as a local school, compared to those that require applications and an admissions process may also be another area for further research. The differences between leadership and pedagogical practices in these schools may vary based on how students are enrolled.

Recommendations for STEM-Focused School Principals

The purpose of this study was to explore the leadership qualities of principals serving in STEM-focused schools. As shown from this study, STEM-focused school

principals serve in a variety of roles within their building. Ways in which they directed their attention can change the outcome for the school. Principals serving in STEM-focused schools will need to ensure they hire the right staff. As noted from the principals within the study, this is a critical area that has lasting effects on the school. Principals should look to hire teachers who have a collaborative mindset and are flexible in their instructional approach. By meeting these needs, the teachers will be better equipped to serve in a STEM-focused school.

STEM-focused school principals should also work to create the right culture for their school. This can be accomplished in a variety of ways. Tofel-Grehl and Callahan's (2014) study found that STEM-focused schools held a unique culture compared to other local high schools including a particular value on academic achievement. One way to work on culture is to simply start by greeting students in the morning. Keep an eye on attendance and make sure that the students feel welcome. Have frequent conversations with staff and students that help push the school vision to everyone.

The school staff must be motivated to work to their best. In transformational leadership, inspirational motivation encourages the followers to the shared vision (Northouse, 2016). It is important to ensure that all staff know their purpose. Why does this school exist? What is special about this STEM model? Why are we doing it? Be sure that the teachers know risk-taking is encouraged. Staff should feel challenged to try new things and work to improve their instruction. Supporting and motivating the teachers in the building is a critical area for sustained growth.

Professional development and instructional support are vital to the school program. In Nadelson et al.'s (2013) study, teachers who received professional

development in STEM subjects reported higher confidence in their ability to teach STEM content, as well as their effectiveness in STEM. STEM-focused school principals should listen to the needs of their teachers as they look for professional development opportunities. Likewise, as the leader of the school's vision, the principal should be on the lookout for school-wide professional development that would help to foster growth towards school goals.

Chapter Summary

The attention on STEM instruction in the United States has continued to grow over the past years. Today, STEM-focused programs are viewed as a way to keep United States students globally competitive (Hansen, 2014). While there is a plethora of articles about STEM education in the United States in general, there is little research into the practices of the principal at STEM-focused schools.

The expectations of a school principal have evolved over the years. Previously, this role was largely managerial and was burdened with bureaucratic work. Today, the attention has shifted to the principal serving as the instructional leader of the building. As such, the principal should be much of their time working to improve the staff's teaching practices (Liu et al., 2013).

The purpose of this study was to explore the leadership qualities of principals serving in STEM-focused schools. There are several findings from the study that highlight ways in which STEM-focused high school principals lead in their buildings. Five principals at STEM-focused schools completed the transformational leadership assessment, the MLQ-5X, and completed the follow-up phone interview. These interviews highlighted several themes of leadership from these principals. These included

motivating staff with a compelling vision and individualized support through mentorship and risk-taking, as well as hiring staff with flexibility and a growth mindset, valuing collaboration, crafting the culture for the school, and leading instructional growth.

In leadership, the principal must take the helm of the school and guide the building to its goals. As such, these STEM-focused schools are like early explorers, as they need to find their course in a relatively new field. STEM-focused school principals can help foster growth in their building by following the recommendations for STEM-focused principals implicated by the study's findings. Recommendations for further research were also crafted from the study's results and data.

As the focus on STEM education continues to surge and the position of principal continues to evolve into the instructional leader, the findings of this study will be useful to STEM-focused school principals as they work to grow success in their buildings. The transformational leaders of our schools will help to motivate and support the teachers as they work to their greatest potential.

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Appendix A

Demographic Survey Tool

Principal Name:

Level of Education:

Number of years as principal in current school:

Number of years as principal (total, all schools):

Number of years in education (total, all related jobs):

Past experiences in education prior to principal (Please include subject areas):

School Name:

Grades Served:

Total Enrollment:

Location (Urban, Suburban, Rural):

Appendix B

INFORMED CONSENT FORM

Title of study: STEM Leadership

Name of researcher: Mr. Steven L. Denaker

Faculty Supervisor: Dr. Susan Schultz

Phone for further information: 585-690-4936

Purpose of study: The purpose of this study is to explore the leadership qualities of principals serving in STEM-focused schools.

Place of study: The demographic tool and MLQ-5X survey will be completed online. Selected participants will be invited to complete a 30-minute phone interview.

Length of participation: Approximately 30-45 minutes for the MLQ-5X and Demographics. An additional 30 minutes for a phone interview for selected participants.

Method of data collection: Online Demographic Survey Tool & MLQ-5X, a semi-structured phone interview for select participants.

Risks and benefits: The expected risks and benefits of participation in this study are explained below:

Risks for participation in this study are minimal. There are no anticipated physical or emotional risks inherent in participation. Participants may opt-out at any time. By choosing to participate in this study, participants will be provided an electronic copy of their MLQ-5X Leadership Profile.

Method for protecting confidentiality/privacy of subjects: Pseudonyms will be utilized for all school principals and schools. Participant names and all identifiable information will remain confidential. All online MLQ-5X and demographic survey data will be stored on MindGarden's secure server and is password-protected. Information downloaded from MindGarden will be stored on the researcher's personal, password protected laptop stored at his residence. Notes and paper materials related to data analysis will be stored at the researcher's residence in a locking file cabinet. After a period of 12 months, all paper data will be securely destroyed, and all electronic files erased. Data stored on MindGarden's servers will also be erased after a period of 3 years. Your information may be shared with appropriate governmental authorities ONLY if you or someone else is in danger, or if we are required to do so by law.

Your rights: As a research participant, you have the right to:

1. Have the purpose of the study, and the expected risks and benefits fully explained to you before you choose to participate.
2. Withdraw from participation at any time without penalty.
3. Refuse to answer a particular question without penalty.
4. Be informed of the results of the study.

I have read the above, received a copy of this form, and I agree to participate in the above-named study. (Digital Signature)

If you have any further questions regarding this study, please contact the researcher listed above. If you experience emotional or physical discomfort due to participation in this study, please contact your personal health care provider or an appropriate crisis service provider.

The Institutional Review Board of St. John Fisher College has reviewed this project. For any concerns regarding this study/or if you feel that your rights as a participant (or the

rights of another participant) have been violated or caused you undue distress (physical or emotional distress), please contact Jill Rathbun by phone during normal business hours at (585) 385-8012 or irb@sjfc.edu. She will contact a supervisory IRB official to assist you.

Appendix C

Email Invitation to Participate

Subject Line: STEM Leadership Research

Dear Principal _____,

My name is Steven Denaker. I am a high school principal in Avoca, NY. Additionally, I am a doctoral candidate in the Executive Leadership program at St. John Fisher College in Rochester, NY. As a requirement of my Ed.D. degree, I am conducting a research study involving principals at STEM-focused high schools. I would like to invite you to participate in this study. My research has been approved by the Institutional Review Board.

The topic of my study is transformational leadership of STEM-focused school principals in regard to teacher leadership. To further my study, I would appreciate it if you would complete my online survey, and MLQ-5X tool. The study is completely online, and should take approximately 30 minutes. There is no preparation needed to complete the online tool. Participation in this survey is confidential.

Based on the results from the MLQ-5X, some principals will be contacted for a 30-minute phone interview to discuss ways in which you support teachers in the school.

Your participation in the study in voluntary, and the results are confidential. You may opt-out of the study at any time. In appreciation of your participation, you will receive a complimentary Leadership Report, generated from your MLQ survey.

Thank you for your consideration. If you would like to participate, please complete the MLQ-5X survey at this link: *(Link Removed)* This link is designed just for this study. Please do not share this link with others.

Sincerely,

Steven L. Denaker

Appendix D

Phone Interview Protocol

Date & Time of Call: _____

Name: _____

Pseudonym: _____

School Pseudonym: _____

Thank you for your time and participation in this study. I would like to first remind you of the signed consent for participation, the study outline, risks and benefits, and your rights as a participant. As a reminder, your participation is completely voluntary, and you may withdraw at any point of this study. This interview should last approximately 30 minutes. I will be asking you about how you lead your teachers at your school. As a reminder, I will not be using your real name, or the name of your school in my research. I will be randomly assigning a pseudonym and one for the school. The information you share with me will be used in my dissertation and any follow up publications and presentations. Are you ready to begin with the questions?

Questions:

- What, if any, challenges do you have in supporting your teachers in a STEM-focused school? (Follow Up: How do you address these challenges?)
- From your experiences, what has allowed you to support teachers in a STEM-focused school?

- Do you see your leadership style different for STEM versus non-STEM faculty? (Follow Up: In what ways?)
- How often do you utilize outside consultants or Professional Development? For what areas?
- How do you determine who to hire in your STEM-focused school?
- How do you convey your vision to your teachers and staff?
- Have you observed changes in school culture since you've started?
- Have there been changes in academic success of students since you've started? (Follow up: In what ways?)
- Have there been changes in student attendance since you've started?

Thank you again for your time. If you need to contact me for any reason, please call or email me. Have a good day.