THE IMPACT ON TEACHER EFFICACY DURING A STEM PROGRAM IMPLEMENTATION AT A MAGNET SCHOOL: A CASE STUDY

A Dissertation

Presented to

The Faculty of the Education Department

Carson-Newman University

In Partial Fulfillment

Of the

Requirements for the Degree

Doctor of Education

By

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May 2019
Dissertation Approval

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Abstract

Minimal research is available for high-achieving students within a STEM program or the educators who teach those students. The purpose of this study is to gain a better understanding of how high school teachers at a high-achieving magnet school respond during a STEM-program implementation. This specific study utilized a qualitative research approach to obtain teachers’ perspectives as they began working collaboratively for the first time in an interdisciplinary professional learning community (PLC) to develop cross-curricular projects. This study also sought to identify any shifts in teachers’ instructional strategies due to the interdisciplinary PLC and STEM-program implementation. Through questionnaires, interviews, and a focus group, participants offered their perspectives toward the STEM-program implementation, as well as, shifts in instructional strategies. Classroom observations were also conducted to help triangulate the data. Through open, axial, and selective coding this study showed that teachers acknowledge that students benefit from interdisciplinary collaboration, but there are obstacles in making a successful transition to a STEM focus. Teacher attitudes toward interdisciplinary projects are affected during a STEM program implementation and teachers were able to discover new instructional strategies. The information gained from this study will help school districts determine effective strategies to implement STEM-programs.
Acknowledgements

God is good. Twenty years ago, when I received the phone call from my first principal offering me my first teaching job, I had no idea how blessed I would be because of teaching. The great blessing is being in the classroom and working with children; however, there have been many unexpected blessings. These acknowledgements are pale thank-yous to those who have supported me through my journey so far.

I would like to thank Dr. Price for all the words of encouragement she has offered me. Her patience, wisdom, and guidance helped me over the various and many road bumps I hit. She truly encapsulates what it means to be a teacher.

Additionally, I would like to thank my committee members, Dr. Taylor and Dr. Hollingshead. I appreciate the time spent offering suggestions and words of encouragement.

To Dr. Connie Smith – from being a mentor and confidant to being a cherished member of my family, thank you is truly inadequate for how much you have helped me grow both professionally and personally.

To the Roland clan: when I prayed for a spouse to help me through life, I never imagined the support system that would come with that answered prayer. Your calls, texts, and willingness to listen have helped anchor me during this process.

To my siblings: I can never remember a time that you haven’t supported and loved me. You’ve always been there for me. I love you.

To Beth, Melissa, Jennifer, Brenda, and Melanie: I couldn’t have asked for better cheerleaders. When I had moments of despair, you offered words of encouragement. When I had moments of frustration, you offered words of reason. When I had moments to celebrate, you offered whoops of joy. This process was just another reminder of how deeply I cherish our friendships.

To my children – Avery, Alex, and Dorrie: I love the new season of life that we are in. As adults, each of you helped me through this process. From encouragement to tutoring in statistics, you helped me stay sane. Love you always and forever.

To my husband Todd: You have always been my rock. Your whole-hearted support during this journey is but a reflection of how you have always supported me. When I doubted and questioned what I was doing, you never did. Rather, you always managed to find the words that spurred me on. You reaffirmed your belief in me daily. Thank you for believing in me. I had no idea, as I prayed for a spouse who would love me unconditionally and support me in my spiritual walk, God would so completely and perfectly answer that prayer. I am beyond blessed, and I thank Him every day that you are in my life.
Dedication

I would like to dedicate this study to my mom, Bonnie Safley. Your support and your unconditional love have always been a constant in my life.
# Table of Contents

## Chapter 1: Introduction

- STEM Background ............................................................................................................. 1
- Magnet Schools Background .......................................................................................... 2
- Research Problem .......................................................................................................... 3
- Purpose of the Study ...................................................................................................... 3
- Research Questions ....................................................................................................... 3
- Rationale for the Study ................................................................................................. 4
- Researcher Positionality Statement ............................................................................. 4
- Frameworks .................................................................................................................. 4
- Limitations and Delimitations ..................................................................................... 5
- Definition of Terms ...................................................................................................... 6
- Organization of the Document ..................................................................................... 6
- Summary ....................................................................................................................... 7

## Chapter 2: Review of Literature

- Traditional Education .................................................................................................. 8
- Calls for Change at the Federal Level ......................................................................... 11
- Schools of Choice: Magnet Schools .......................................................................... 15
  - *Magnet School Staff* .............................................................................................. 18
- Gifted and Talented Students .................................................................................... 19
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Challenges of Gifted and Talented Students</td>
<td>21</td>
</tr>
<tr>
<td>Teachers of Gifted and Talented Students</td>
<td>22</td>
</tr>
<tr>
<td>Promoting Student Learning</td>
<td>24</td>
</tr>
<tr>
<td>Self-Efficacy</td>
<td>24</td>
</tr>
<tr>
<td>Active Learning</td>
<td>24</td>
</tr>
<tr>
<td>Inquiry-Based Learning</td>
<td>26</td>
</tr>
<tr>
<td>Product-Based Learning</td>
<td>27</td>
</tr>
<tr>
<td>Problem-Based Learning</td>
<td>28</td>
</tr>
<tr>
<td>Science, Technology, Engineering, and Mathematics (STEM)</td>
<td>28</td>
</tr>
<tr>
<td>History of STEM Schools</td>
<td>28</td>
</tr>
<tr>
<td>Obama and STEM</td>
<td>29</td>
</tr>
<tr>
<td>Characteristics of STEM</td>
<td>30</td>
</tr>
<tr>
<td>STEM Educators</td>
<td>31</td>
</tr>
<tr>
<td>Teacher Efficacy</td>
<td>32</td>
</tr>
<tr>
<td>STEM Professional Development</td>
<td>33</td>
</tr>
<tr>
<td>STEM Students</td>
<td>34</td>
</tr>
<tr>
<td>STEM Communities</td>
<td>36</td>
</tr>
<tr>
<td>High School STEM Education</td>
<td>36</td>
</tr>
<tr>
<td>Inclusive STEM High Schools (ISHS)</td>
<td>37</td>
</tr>
<tr>
<td>Post-Secondary STEM Education</td>
<td>38</td>
</tr>
<tr>
<td>Section</td>
<td>Page</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>STEM Accreditation</td>
<td>41</td>
</tr>
<tr>
<td>Educators Shifting the Paradigm: Professional Learning Communities</td>
<td>42</td>
</tr>
<tr>
<td>Interdisciplinary Collaboration</td>
<td>44</td>
</tr>
<tr>
<td><em>Keys for Success in Interdisciplinary Collaboration</em></td>
<td>45</td>
</tr>
<tr>
<td><em>Challenges to Interdisciplinary Collaboration</em></td>
<td>46</td>
</tr>
<tr>
<td><em>Student Benefits from Interdisciplinary Collaboration</em></td>
<td>46</td>
</tr>
<tr>
<td><em>Interdisciplinary Projects</em></td>
<td>47</td>
</tr>
<tr>
<td><strong>Chapter 3: Methodology</strong></td>
<td>48</td>
</tr>
<tr>
<td>Introduction</td>
<td>48</td>
</tr>
<tr>
<td>Research Questions</td>
<td>48</td>
</tr>
<tr>
<td>Descriptions of Specific Research Approach</td>
<td>48</td>
</tr>
<tr>
<td>Description of Study Participants and Setting</td>
<td>50</td>
</tr>
<tr>
<td>Data Collection Procedures</td>
<td>51</td>
</tr>
<tr>
<td>Ethical Considerations</td>
<td>52</td>
</tr>
<tr>
<td>Data Analysis Procedures</td>
<td>53</td>
</tr>
<tr>
<td>Summary</td>
<td>54</td>
</tr>
<tr>
<td><strong>Chapter 4: Findings</strong></td>
<td>56</td>
</tr>
<tr>
<td>Introduction</td>
<td>56</td>
</tr>
<tr>
<td>Pre-Implementation Questionnaire</td>
<td>60</td>
</tr>
<tr>
<td>Post-Implementation Questionnaire</td>
<td>61</td>
</tr>
</tbody>
</table>
Interview Data ........................................................................................................... 63

Interview Findings .................................................................................................... 64

Interview Question 1 ............................................................................................... 64

Interview Questions 2-4 ......................................................................................... 66

Interview Question 5 ............................................................................................... 68

Interview Question 6 ............................................................................................... 70

Interview Question 7 ............................................................................................... 73

Interview Question 8 ............................................................................................... 75

Interview Questions 9-10 ...................................................................................... 76

Interview Question 11 ............................................................................................ 78

Interview Question 12 ............................................................................................ 81

Sidebar Conversations ............................................................................................ 84

Focus Group ............................................................................................................. 85

Question 1 ................................................................................................................. 86

Question 2 ................................................................................................................. 86

Question 3 ................................................................................................................. 87

Question 4 ................................................................................................................. 88

Question 5 ................................................................................................................. 89

Classroom Observations ......................................................................................... 89

Chapter 5: Findings, Conclusions, Implications, and Recommendations .................. 91
List of Figures and Tables

Figure 4.1........................................................................................................................................58

Figure 4.2........................................................................................................................................59

Table 4.1 ..........................................................................................................................................60

Table 4.2 ..........................................................................................................................................60

Table 4.3 ..........................................................................................................................................61

Table 4.4 ..........................................................................................................................................62

Table 4.5 ..........................................................................................................................................62

Table 4.6 ..........................................................................................................................................63

Table 4.7 ..........................................................................................................................................63
Chapter 1: INTRODUCTION

STEM Background

President Barack Obama, in his 2011 State of the Union address, challenged America to answer the call to meet the demands of the changing world dynamic. Obama argued that Americans must reinvent themselves in a world where innovation and creativity go hand-in-hand with technology, math, and science to achieve this generation’s “Sputnik moment” (Obama, 2011). His speech encouraged more mainstream conversations among educators. While STEM was conceptually introduced in the 1990s by the National Science Foundation (Vasquez, 2014), there was a renewed push for an increased STEM focus that incorporated more math, engineering, technology, and science-focused curriculum in Pre-K-12 schools (Gunn, 2017).

Scrutiny of statistical data elucidates the reasons that educators began embracing a STEM-instructional focus. The number of individuals expected to be employed in STEM related-careers will increase to more than 9 million by 2022 (Vilario, 2014). The problem that must be resolved, however, is that only 26% of the nation’s 12th grade students scored at or above the proficient level on the NAEP math assessment. In science, only 21% of America’s students scored at or above the proficient level (National Science Foundation, 2009). When compared to other nations, American students ranked 38th of the 71 countries who participate in the Program for International Student Assessment (PISA) (Desilver, 2017).

The Pew Research Center (Desilver, 2017) released a report outlining how Americans viewed K-12 STEM education. Only 29% rated the STEM programs as above average. Pew also surveyed scientists who were members of the American Association for the Advancement of Science. Only 16% scored STEM education as above average, while 46% stated K-12 STEM education was below average. Student achievement data in the areas of math, science,
engineering, and technology prompted AdvancED, a school accrediting agency, to develop STEM standards, which offered schools a well-defined set of expectations when adopting a STEM curriculum (Denmark, 2014).

**Magnet Schools Background**

Magnet schools began during the 1960s and offered students a nontraditional educational option. Because of the flexibility of instructional structure, magnet schools provide an ideal environment for implementing a STEM program. In the 50 years since the first magnet schools opened their doors, there are now over 4,300 magnet schools in 46 states serving approximately 3.5 million students (Magnet Schools of America, 2017). Initially, magnet schools were a way to aid in desegregation. The concept of drawing white students to schools that were predominately black and offer specialized educational opportunities (i.e. performing arts, math, science), proved to be an unusual yet successful approach to desegregation (Rossell, 2005).

Over the years, the definition of what a magnet school means has been expanded (Blazer, 2012). Today, while magnet schools are still an avenue of promoting racial diversity, magnet schools also seek ways to create social and economic diversity, narrow student achievement gaps, and provide innovative curriculum for their students (Pack, 2017).

To assist magnet schools in their mission of providing alternative educational choices, Magnet Schools of America (MSA), a non-profit organization, offers a national certification for schools meeting five specific criterion diversity, innovative curriculum, academic excellence, high-quality instructional systems, and family and community partnerships. These guidelines, like the AdvancED STEM indicators, provide clear, delineated standards for magnet schools wishing to offer high-quality programs (Magnet Schools of America, 2017).
Research Problem

There is a large body of research that focuses on lower-achieving students engaged in a STEM program and the benefits of a STEM education. There are also studies that have specifically centered on specialized STEM schools and teacher beliefs about student ability (Tofel-Grehl & Callahan, 2017). However, minimal research is available for either high-achieving students or the educators who teach those students (National Science Foundation, 2012).

Purpose of the Study

The purpose of this qualitative study was to determine how high school teachers at a high-achieving magnet school, who have not traditionally worked on interdisciplinary projects, respond when a STEM program is implemented. Data for this study was gathered via teacher surveys, classroom observations, a focus group, and teacher interviews and surveys. This study seeks to determine educators’ perceptions of a STEM program within a high-achieving school and to identify any shifts in teachers’ instructional strategies.

Research Questions

1. How are magnet school teacher attitudes toward interdisciplinary projects affected during a STEM program implementation?

2. What are the nature and extent of changes in magnet school teachers’ use of interdisciplinary collaboration during a STEM program implementation?

Rationale for the Study

Magnet schools afford students the opportunity to increase their academic achievement by offering specialized curriculum. Research focusing on the impact of magnet schools, however, offers mixed results. Some studies argued that magnet schools have a positive effect
for student academic achievement; other studies suggested comparable levels of academic
achievement for students who attended magnet and non-magnet schools (Blazer, 2012). Multiple
studies have been conducted for low-achieving students involved in a STEM program; however,
the National Science Foundation (2012) noted that minimal research has been conducted
involving high-achieving students.

**Researcher Positionality Statement**

The researcher worked collaboratively with teachers who are beginning to implement a
STEM program. Additionally, the researcher worked with AdvancED and is a STEM-certified
evaluator, conversant in the STEM indicators. The researcher’s position within the school
affords the opportunity to work with various teachers and students who will be involved in the
STEM program.

**Frameworks**

The constructivist theory was used as the theoretical framework for this study because
teachers must construct knowledge instead of simply acquiring knowledge. Constructivist theory
highlights the idea that learning is an active process. With all things new, there is a learning
curve for both students and teachers. The constructivist theory drives STEM. Because students
must engage in inquiry and reasoning, apply content, and learn to collaborate and communicate,
teachers must also engage in the same processes to help facilitate a successful and seamless
transition to a STEM program.

PLCs and the AdvancED STEM indicators were used as the conceptual framework for
this study. PLCs revolve around three key principles. First, teachers must be concerned with
emphasizing student learning. To help achieve this, there several questions PLCs must ask
themselves continuously: What do educators want students to learn? How will educators know
students have learned it? How will educators respond with struggling students? (DuFour, 2004).

The second principle is to develop a collaborative culture. Are teachers continuously seeking ways to improve classroom practices that deepen student learning? The third principle, focusing on results, requires teachers to acquire and act upon data concerning student success or failure.

The AdvancED STEM indicators aid in determining whether teachers were incorporating problem-based curriculum (a core component of STEM education) in the classroom. These indicators highlight what qualities and components are necessary for schools to both create and sustain a STEM program (AdvancED, n.d.)

**Limitations and Delimitations**

There have been STEM studies conducted for public schools. However, there is a lack of research which examines how a high-achieving, academically focused magnet school, seeking to receive a STEM certification, is impacted during the STEM certification process.

The data gathered was limited because there is only one magnet school in the Middle Tennessee school district where the study was conducted. Additionally, the data was limited to only those teachers who are directly involved in the STEM program. This minimizes interview responses and focus groups where participants may or may not be comfortable expressing their true opinions concerning the STEM program and the required PLC and interdisciplinary projects.

**Definition of Terms**

- Constructivist theory: A method that encourages active learning and supports the idea that learners should not simply acquire new knowledge but construct new knowledge (Bodner, 1986).

- AdvancED: AdvancED is a non-profit, non-partisan organization which provides accreditation for educational institutions across the world. AdvancED has over 100 years
of school accrediting expertise and partners with over 36,000 educational institutions (AdvancED, n.d.).

- STEM Program: Offers students the opportunity to develop as innovative, creative, and systematic problem-solvers (AdvancED, n.d.).

- Professional Learning Communities (PLC): Educators who focus on learning rather than teaching. These teachers collaborate and hold one another accountable for achieving results for continuous improvement (Dufour, 2004).

- STEM Indicators: A set of 11 criterion which provide a framework for schools to assess the rigor and viability of STEM programs (AdvancED, n.d.).

- Interdisciplinary Projects: An approach to curriculum that applies the language and methodology from at least two disciplines, which allows students to focus on common themes, topics and problems (Jacobs, 2004).

- Interdisciplinary Collaboration: An interpersonal partnership approach that develops communication and coordination (Bronstein, 2003).

**Organization of the Document**

This study was organized into five chapters. The background of the study, problem statement, and relevance of the research were detailed in chapter one. Additionally, the research questions, theoretical, and conceptual frameworks were described. Limitations and delimitations of the study were outlined, and a definition of terms were included. The second chapter consisted of a comprehensive literature review related to the topic. The third chapter focused solely on the methodology that detailed the proposed research. The fourth chapter reported the results of the data, and the fifth chapter specified conclusions, implications, and recommendations of the study.
Summary

The purpose of this qualitative study is to determine whether teachers’ attitudes shift when asked to collaborate in cross-curricular projects during a STEM program implementation, and whether that collaboration led to a shift in instructional policies. While there are numerous studies revolving around STEM and the impact of STEM programs on low-performing students, little research is available for those schools that are already high-performing and offer rigorous curriculum.
Chapter 2: REVIEW OF LITERATURE

Traditional Education

The history of public education in America began with Massachusetts, who initiated providing free education to children. Within seven decades, all states in the Union offered a basic education to its citizens (Rose, 2012). This segment of history of American schooling marked the first of three major educational transformations, periods defined as where the majority of children completed a certain level of education. The first transformation witnessed publicly-funded primary schools becoming more commonplace, where students had the opportunity to receive some formalized education (Goldin, 1999). Rury (2005) noted the evolution of modern American schools had its roots in the 19th century as the United States expanded and embraced the Industrial Revolution. Basic education in the areas of reading and arithmetic helped prepare children to acquire the work skills needed as the world became more mechanized (Facing History and Ourselves, 2017).

Horace Mann, perhaps the most famous of public school proponents, is credited for the creation of the school model that would be used nationwide in the mid-1800s (Groen, 2008). In his quest for education reform, Mann introduced what is known as the Prussian model of education. This model became analogous to the factory lines, where many Americans worked. Schools became more standardized, centralized, and reflected the factory model of an industrialized nation. Students were considered the “raw material,” and teachers were the factory workers, implementing the bureaucratic mandates handed down by upper management (i.e. principals/superintendents) (Christiansen & Robey, 2015). Students were grouped by age, seated in rows while the information was delivered in a fixed manner, and taught with an “inflexible view of time” (Khan & Noer, 2012; Christiansen & Robey, 2015). Subjects were
taught via rote memorization and repetition; success was dictated by the amount of information students retained when taking exams (Guisepi, n.d.).

In 1892, the National Education Association (NEA) commissioned the Committee of Ten to assess and then make recommendations concerning the standardization of high school subjects. Primarily concerned with the overall quality of education in American schools, the committee argued that of the 3,000 public high schools in the nation, only 30 high schools adequately prepared students to enter college. In its final report, the committee, composed primarily of college presidents, reflected this belief by suggesting that all students, regardless of whether they would attend college or not, should be educated the same, arguing that no differentiation in instruction or coursework should be implemented (Mackenzie, 1894).

However, the Committee of Ten report was problematic because it was short-sighted in terms of a nation committed to educating all its citizens. The four-year programs of study suggested by the committee – Classical, Latin-Scientific, Modern Languages, and English – were completely academic, not allowing room for vocational courses (Kliebard, 1995).

Almost 25 years later, the NEA commissioned another report. This report, known also as the Seven Cardinal Principles, provided a counterpoint to the Committee of Ten’s suggestions. Part of this shift was due to the social changes occurring in the country at the time. For example, the report argued that the workplace itself had changed (i.e. automation of industry versus manual labor) and perceived a growing specialization of labor as the old apprenticeship system dissolved (Commission on the Reorganization of Secondary Education, 1918, p. 7).

At the heart of the NEA’s 1918 report was the underlying doctrine of social efficiency. Unlike the Committee of Ten, which argued schools focus solely on academic and intellectual development, the NEA detailed seven crucial guidelines schools should adhere to: health;
command of fundamental processes; worthy home-membership; vocation, citizenship, worthy use of leisure, and ethical character. These principles became schools’ manifestos as education shifted curriculum to be more comprehensive in nature, including vocational courses to better meet the needs of students. As society changed, schools had to change as well; therefore, courses in clerical training, home economics, and agricultural were specifically mentioned in the 1918 report (Kliebard, 1995).

Part of the shift from a purely academic curriculum to one that embraced vocational education was spurred by the 18.2 million immigrants who came to America during this time. Schools were seen as a place to inspire a sense of citizenship for new immigrant children (Johanek & Puckett, 2017), as well as a place to provide a “democratic education” that guided students to discover not only their “niche” in society to empower these students to help society. The end result, the report argued, was to make both student and society more noble (Commission on the Reorganization, 1918, p. 9).

This period in the early 20th century marked the beginning of the second and most rapid educational transformation (Goldin, 1999). In 1900, only 630,000 students were enrolled in high school. By 1930, the number had reached 4.8 million (Puckett & Johanek, 2018). By 1940, more than half of American high school students were graduating versus the less than 10% just 30 years earlier (Goldin, 1999).

However, there was minimal change for over a century regarding school structure since Mann first introduced the Prussian Model. This lack of evolution was highlighted in 1983 when A Nation at Risk used the term “mediocrity” to describe the American educational system. One problem was a continued embrace of traditional teaching techniques: the teaching methodology remained stagnant for years. Traditional teaching, often referred to as the lecture or “sage on the
stage” method, is a teacher-centric approach that typically does not invite students to participate in constructing their knowledge base or expand their learning (Khalid & Azeem, 2012). Cuban (1984) conducted a quantitative study on classroom practices which noted the tendency to favor more traditional teaching methods. One trend indicated that as students shifted from elementary to high school, courses were more teacher-centric, where lectures predominated up to 50% of class time, and nearly 75% of the time was dedicated group instruction (Cuban, 1984, pp. 237-240).

Calls for Change at the Federal Level

When Ronald Reagan campaigned prior to his election in 1980, he promised to abolish the Department of Education, established by the Carter administration. Once entering office, Reagan appointed Terrell Bell as Secretary of Education and tasked him to fulfill his campaign promise. Bell, however, felt that instead of reducing the Department of Education, a “Sputnik-like occurrence” was actually needed. Bell’s Sputnik moment resulted in *A Nation at Risk*, a report he commissioned and one that has defined American education for the past 35 years (Borek, 2008). Within that report, the commissioners stated that a primary goal of education was to develop students’ talents to their fullest as well as allowing students to work within their capabilities. Part of achieving this goal was an expectation that schools held students to high standards (Nation at Risk, p. 13).

Since that report, every president, with varying degrees of success, has sought ways to ensure that the nation’s schools achieved the excellence urged in *A Nation at Risk*. In George H. Bush’s 1991 *Address to the Nation on the National Education Strategy*, he offered six goals. One of those goals urged Americans to ensure that the nation’s students would be first in the world in both math and science by the year 2000. According to Bush (1991), America’s
educational challenge was a revolution culminating in “a battle for our future.” Bush believed in a more active federal government participation and created America 2000, an agenda which President Clinton renamed Goals 2000 (Diorio, 2013).

Part of President Clinton’s emphasis was helping students become more college-ready (Clinton, n.d.). His focus attempted to prompt the third American transformation: higher education. Following the World War II, in conjunction with higher graduation rates and the implementation of the G.I. Bill, more Americans have continued to seek a high level of education (Goldin, 1999). Goals 2000 produced the National Educational Goals, which established higher standards in core subjects to better prepare students for colleges. (Clinton, 1994). The Improvement Council, which had authority over state content standards, also derived from Goals 2000 (Diorio, 2013).

The most extensive educational reform, however, came in 2001 when George W. Bush signed No Child Left Behind (NCLB), which was a redevelopment of the Elementary and Secondary Education Act of 1965 (ESSA). Under NCLB, states designed and implemented educational goals (Ametepee, Tchinsala & Agbeh, 2014) to achieve one of the primary purposes of NCLB: 100% proficiency in math and reading for all American students by 2013-2014 (Jill & Ginsberg, 2013). Four key components defined NCLB: stronger accountability, more flexibility of use for federal funding at all levels of education, increased educational choices for disadvantaged families, and research-proven teaching methods (Husband & Hunt, 2015).

While NCLB had bipartisan support, it was not without its controversy. To ensure that states complied with the mandates of NCLB, a mixture of incentives and sanctions were instituted. NCLB became the largest source of federal funding for the nation’s schools, and by 2008, was sending $13 billion dollars annually to Title I schools. But states chaffed at the
federal government’s “incursion on their historical turf” (Chubb, 2009, p. 4). NCLB dramatically reduced the autonomy at both the state and district levels. To receive federal funding, states had to meet outcome-based benchmarks measured by annual standardized testing (Heiss, 2017), and states were allowed to define and establish student proficiency benchmarks. Peterson and Hess (2007) discovered, however, a gradual decline in those standards when comparing the National Assessment of Educational Progress (NAEP) and 2007 test score information to assess the rigor of state proficiency standards.

But perhaps one of the largest controversies was how NCLB highlighted a major conflict in educational philosophy: traditional education versus progressive education. Proponents of progressive education argued against centrally-developed curricula and stipulated that educators should act as facilitators of learning, providing meaningful, classroom experiences. However, within the confines of NCLB, educators struggled to create those experiences because of high-stakes testing (Hayes, 2008, pp. 33-34). Richard DuFour, in an interview with Thiers (2016), noted that NCLB ultimately harmed educators, creating an “embattled profession” as teachers were evaluated on test scores and felt increasing pressure to “teach to the test.”

When President Obama entered office in 2009, he addressed the issues surrounding NCLB. In his first major speech concerning education delivered to the Hispanic Chamber of Commerce, Obama called for higher standards and higher accountability. Essentially, Obama argued for making NCLB live up to its name (Obama, 2009). Obama’s speech was delivered several weeks after he signed the American Recovery and Reinvestment Act (ARRA) into law; $4.35 billion was earmarked for a competitive grant program known as Race To The Top (RTTT) to help spur innovations in education (Howell, 2015).
The framework of RTTT centered on four key areas: developing both standards and assessments that prepared students for success, constructing comprehensive data systems that measured student growth, retaining and rewarding effective educators, and turning around failing schools (Aguilar & Richerme, 2014). Within five years of the program’s implementation, 43 states and the District of Columbia had developed higher standards which focused specifically on college and career readiness (Weiss & Hess, 2015). Peterson and Ackerman (2015) found that many states were beginning to adopt stricter proficiency standards; the authors posited that because state compliance with NCLB requirements concerning meeting proficiency targets had been waived, states felt less pressure to keep lower-level proficiency standards.

In 2015, President Obama signed the Every Student Succeeds Act (ESSA) into law. ESSA, in essence, replaced NCLB. One notable difference between NCLB and ESSA, articulated by Senator Lamar Alexander, was a “devolution of power” of the federal government. Under ESSA, states must have challenging academic standards, are still empowered to develop those standards, but more importantly may establish how students are tested. Another notable difference between NCLB and ESSA is the focus on accountability. Under NCLB, states faced penalties from the federal government if they did not adequately achieve the specified benchmarks; ESSA grants states more control over the consequences if they fail to meet the state-defined benchmarks. While ESSA can still impose sanctions on schools, these are limited to schools whose performance puts them at the bottom 5% of the state or who have a 67% or lower graduation rate (Heiss, 2017).

In the Department of Education’s most recent congressional mandated The Condition of Education report, there were some interesting highlights to note when evaluating the impact of NCLB and RTTT. While it was clear that NCLB’s goal of having 100% of American students
be proficient in both math and reading was not achieved by the 2013-2014 deadline (Jill & Ginsberg, 2013), some progress has been made. Reading and mathematics scores have improved since 1992 for 4th graders and 8th graders. However, since 2015, the average scores have not been measurably different, other than the 2017 score for 8th graders, which was higher than the 2015 score. When scrutinizing NAEP data from 2009 and 2015, there was a 4% increase for both 4th grade and 8th grade students scoring at or above the Proficient level (34%); there was not a measurable difference of 12th grade student scores (22%) (McFarland, et al, 2018).

When President Trump released his first full education budget, the administration revealed plans to cut $10.6 billion from previous administration’s education initiatives; however, the Trump administration reinforced its goal of supporting school choice. This budget allotted $1.4 billion or various elements of school choice. President Trump has repeatedly argued the need to reduce role the federal government plays in education, empowering schools at the local level to have more control. It has been suggested that the cuts to long-term programs with the monies being allocated for school choice reflect the current administration’s belief that the effort by the federal government to improve the current state of education in America has failed (Brown, Strauss, & Douglas-Gabriel, 2017).

Schools of Choice: Magnet Schools

One unexpected effect of NCLB’s requirement that academic performance become more easily available and accessible is that a growing number of parents began demanding more school options. By 2014, approximately 10% of students chose to attend a school of choice: charter or magnet (Heise, 2017). Magnet schools, the largest school of choice option (Siegel-Hawley, Frankenberg, & University of California, L. C. 2012), differ from charter schools. Considered public schools, charter schools often are exempt from many state regulations with the
expectation of an increased accountability (Edchoice, 2018). Charter schools may be operated by a state or local school board, private cooperation, or a university, and while charter schools are free, they can be for profit (Magnet Schools of America, 2017). Magnet schools are part of public school districts and must adhere to all state standards and regulations. These schools offer specialized curriculum not available in traditional schools, whose goal is to attract students interested in the specialized focus of the school (Edchoice, 2018). These specialized areas can include the following themes: fine and performing arts; science, technology, engineering, and mathematics (STEM); International Baccalaureate or Advanced Placement; and career and technical education (Magnet Schools of America, 2017).

Magnet schools, originally intended to aid efforts to integrate schools while offering innovative curriculum, continue to evolve (Siegel-Hawley, Frankenberg, & University of California, L. C. 2012). In the early 1990s, magnet schools were defined by several common characteristics. First, the curriculum is both distinct and specialized in some way, whether by instructional method or theme. Second, students and parents choose to be a part of the school community. Additionally, enrollment extends beyond “the regular attendance zone” (Dentler as cited by Parillo, 2015; Magnet Schools of America, 2017). This final component presumes that magnet schools will provide educational equity for students from both economically advantaged and disadvantaged backgrounds and varied ethnic groups (Kitmitto, Levin, Betts, Bos, Eaton, & Society for Research on Educational Effectiveness, 2016). Pack (2017) expounded on what is known as the “five pillars” as defined by Magnet Schools of America: diversity, innovative curriculum, academic excellence, high quality instructional systems, and family/community partnerships. These pillars reflect the continued evolution of magnet schools.
Diversity remains a consistent focus for magnet schools. Research suggests that there are positive benefits with schools that have racial diversity (Angioloni & Ames, 2015). Siegel-Hawley, Frankenberg, & the National Coalition on School (2011) noted some key social benefits that magnet school students experience. Perhaps the most important finding was that minority students reported “feeling significantly closer” to white students, having multiple white friends versus their experiences in non-magnet schools. Conversely, white students felt more connected to their minority peers and reported having multiple minority friends. The study also noted that magnet school students were more likely than non-magnet students to use their diverse school experience in helping them understand multicultural differences.

Part of the success and popularity of magnet schools is that in addition to offering equitable learning environments, magnet schools offer challenging and innovative courses, encouraging student to meet a higher level of standard (Hundley, 2017). Weiss and Baker-Smith (2010) found that students attending magnet schools during middle school reflected a “significant positive factor” in a student’s academic success in high school. Gifted and talented students attending magnet schools with targeted curriculum outperformed gifted and talented students in non-magnet school classrooms (Young & Balli, 2014).

Many students who attend traditional schools report not feeling challenged in their courses. Yazzie-Mintz (cited by Gubbins et al, 2013) noted that in a recent survey of high school students, less than half felt academically challenged in most of their classes. Sixty-three percent indicated that in most of their classes, they were not required to work hard. These findings were validated by Boser and Rosenthal (2012), who analyzed student survey data and data from National Assessment of Educational Progress (NAEP). The study determined that most schools did not challenge students, leaving students with a sense that school was easy. Over 30% of 8th
grade students reported reading less than five pages a day, whether at school or as homework; the same number reported that writing lengthy responses occurred, at best, two times a year. This trend was consistent through 12th grade.

In contrast to their traditional counterparts, magnet schools, by their very design, can offer a cross-curricular learning experience that is challenging (Hundley, 2017). The Department of Education (2008) suggested that as magnet schools develop both a rigorous and relevant curriculum, the schools also create a curriculum that demands students master and apply 21st century skill sets, including critical thinking and communication. Studies detailed mixed results concerning an improved academic performance for students attending magnet schools versus those students who attend other types of schools; however, these studies suggest that there are possible benefits for magnet school students. These benefits include the uniqueness of the courses offered, innovative teaching methods, and students either maintain or improve “achievement levels in core areas” (Blazer, 2012).

Magnet School Staff

Crucial to the success of magnet schools are the leaders who create an environment of collaboration and share a commitment to the mission of the school with the faculty (Department of Education, 2008). Recent studies suggest some common characteristics of successful magnet school principals. First, the administrators empower the faculty by allowing autonomy in decision-making. Secondly, the administrators lead by example: working hard and being passionate about the school’s mission. Most importantly, however, the school leaders demonstrate how to be creative problem-solvers, listening to both students and faculty to best determine how to meet the needs of the students and address any challenges (Hundley, 2017). Pack (2017) noted that magnet school principals, in order to ensure a viable themed focus for the
school, will ensure that professional development (PD) and professional learning communities (PLC) will provide support for teachers. Specifically mentioned were STEM/STEAM school staff, who must work collaboratively integrating science, technology, engineering, and mathematics throughout the entire curriculum.

Teachers, whether in a magnet school or not, have a responsibility to ensure that they are a cornerstone for learning. To illustrate that point, George (2002) cited Virgil, who said of students “They are able because they think they are able”; George also argued that teachers must rise to the challenge of meeting the individual needs – intellectual, social, and emotional – of the students taught. According to Clark & Callow (2002), this is particularly true of magnet school students; these students best relate to teachers who are experts in their content area, develop meaningful relationships with their students, teach creatively while encouraging creativity from their students, embrace challenge themselves, and are both enthusiastic and confident.

**Gifted and Talented Students**

There are varying definitions of what gifted and talented means; however, Neihart and Betts (as cited in Karuntzas, 2017) offer six distinct profiles of these students. The Successful Learner is identified as the individual who achieves good grades, needing approval and challenges. The Creative Learner is highly creative but can also challenge teachers and rules. The Underground Learner desires to belong to a social group and tends to feel unsure of self, often rejecting challenges. The At-Risk Learner can demonstrate anger, depression, or resentment, causing disruptions and choosing not to come to school. The Twice or Multi-exceptional Learner (i.e. autism, Asbergers, ADHD) may experience frustration and anger, not see him/herself as successful, but can think conceptually. The Autonomous Learner is self-confident, resilient, socially aware, and self-directed. Eyre and Lowe (2015) noted that because
gifted and talented students are not homogenous, individual needs must be considered to fully support student learning.

Part of that support is recognizing characteristics that are shared by gifted and talented students. The first of these characteristics is that these students demonstrate a high ability by thinking abstractly and retrieving relevant information quickly. Task commitment, the second characteristic, is when students exhibit a “refined…motivation” toward a specific project or subject. The third characteristic is that gifted students are creative problem solvers, often thinking outside of the box to develop solutions in a “complex world” (Young & Balli, 2014).

Ozgur and Yilmaz (2017) noted that creative problem thinking is especially evident in science courses. Inquiry-based classrooms tend to be today’s norm, where students are challenged to actively learn and creatively think versus the traditional model of memorization of concepts. The authors also reported that in the context of an inquiry-based classroom, this method provides multiple benefits for gifted and talented students because they are developing their learning in meaningful and conceptual ways.

Olszewski-Kubilius (2010) suggested that specialized schools, such as STEM-focused schools, offer one of the best options for gifted and talented students in these areas. The author identified several characteristics of STEM schools which directly benefit gifted and talented students: advanced and rigorous curriculum: faculty higher levels of content expertise; beyond the school day opportunities, working with professionals in related fields; and a like-minded group of students whose focus is on areas of STEM. In conjunction with the characteristics, there were some notable advantages to a STEM-focused school for gifted and talented students: students were surrounded by intellectual peers consistently; students became motivated by being involved in real-world STEM activities; students developed study habits and learned to manage
stress due to the workloads; and students were provided better benchmarking because they were in an environment of “true peers.”

Challenges for Gifted Learners

Sometimes learning can be stymied because of life’s risks and challenges: family dynamics, racial, cultural, or ethnic backgrounds. Additionally, students, whether gifted or non-gifted, face depression, loss, pain, and anxiety. However, gifted and talented students are sometimes overlooked because of their academic performance and often experience challenges their peers do not. Some students, because they spend their time intensely-focused, develop into perfectionists. While not unique to gifted learners, perfectionism can become dysfunctional. A consequence of dysfunctional perfectionism is that it can spawn emotional turmoil and lead to underachievement. A gifted student who has dysfunctional perfectionism may choose not to submit work because it does not meet his/her expectations, which in turn leads to feelings of “worthlessness” and “depression” (Kennedy & Farley, 2017).

There are other risks and challenges that gifted and talented students face. Self-handicapping can be defined as creating an obstacle which allows individuals to deflect poor performance. Procrastination, lack of sleep, and spending time with friends are all behaviors where the student intentionally creates a distraction, which may be due to a fear of failure or an avoidance of “negative implications about their ability” (Harun, Engin, & Ucak, 2017). Gifted students may also face the challenge of asynchronous development. Gifted students may be advanced in some areas (academic) but not all (social and emotional). Sometimes when these students recognize a difference between themselves and their peers, they may engage in social coping behaviors (i.e. hiding their talents to steer attention away from that talent). Another challenge is that if a gifted student’s asynchronous development makes his/her behavior difficult
to predict, peers will most likely reject the individual. The danger for a gifted and talented student who misses social learning opportunities is the long-term impact it can have on his/her ability to relate to others (Cross & Cross, 2015).

**Teachers of Gifted and Talented Students**

Classroom teachers learn how to quickly identify students who struggle. These students regularly require additional support. Karantaz (2017) suggested that too often teachers fail to consider that gifted and talented students need aid because of the assumption these students will already be successful. The author argued that gifted and talented students desire a challenging learning experience. Consequences of schools not providing an effective learning environment for gifted and talented students can lead to boredom, underachievement, and possible disillusionment. In fact, some research indicated that gifted and talented students do not necessarily “get it on their own” without intentional intervention (Buchanan, Fox, & Martin, 2006).

When teaching gifted and talented students, teachers must consider student learning styles when constructing both instruction and assessment. The strength of many schools of choice is that the curriculum differentiates instruction. Suggested types of instructional strategies for gifted and talented students include the following: project-based learning, independent studies, and collaborative projects (Buchanan, Fox, & Martin, 2006).

Learning environments have been a topic of study since the mid-1930s. Much of the research conducted examined the association of student learning outcomes – both cognitive and affective – in conjunction with how they perceived the classroom psychosocial characteristics. However, researchers did not avidly explore the interactive relationship between teachers and students and how student outcomes until the Quek et al (2005) study. This study specifically
focused on learning environments within the context of gifted and talented science classrooms to
gain a better understanding of how to cultivate student abilities. The researchers found that
framing the learning environment in an open-ended context directly correlated with student
perceptions and attitudes. In fact, one major implication of the study suggested that learning
instruction should be customized by incorporating lively and practical approaches to the material
and encouraging both creative and critical thinking skills. Rita and Martin-Dunlop (2011)
argued that teachers should provide students with the opportunity to design projects or
experiments based on classroom discussion.

Olthouse (2014) argued that talent and gifted is a multidimensional concept and offered
an opera metaphor to illustrate her argument that students need multiple resources to be
successful. An opera singer cannot showcase talent without additional support such as the
physical support (orchestra and staging) and the collaboration of others (stage hands, chorus, and
director). This metaphor is analogous to the teacher’s role in supporting the gifted and talented
learner. Teachers must provide a context for success, creating an environment conducive for
successful learning and a place where talent can emerge.

One study suggested that gifted students, when exposed to an advanced instruction
curriculum, do demonstrate “significant academic achievement” (Swanson, 2006). Effective
classroom practices that lends itself to supporting this academic achievement includes the
following: defining learning objectives, setting effective classroom tasks, differentiation,
effective questioning, and effective explanations (Eyre & Lowe, 2013).
Promoting Student Learning

Self-Efficacy

Bandura (1993) defined self-efficacy as how an individual perceived his/her own skills in terms of being able to complete complex tasks. Self-efficacy influences several key processes, including cognitive and motivational processes. Additionally, self-efficacy contributes to academic development. How students believe in their efficacy, in terms of regulating their learning and then mastering subjects, assists in solidifying their aspirations, motivations, and ultimately their academic achievements. How teachers believe in their efficacy in relation to motivating and promoting learning influences both the classroom environment and what level of academic success their students achieve.

Because self-efficacy factors into an individual’s belief of self, it impacts what approaches the individual chooses to achieve specific goals. In fact, studies have noted self-efficacy enhances an individual’s achievement. One’s self-efficacy beliefs directly correlates to one’s motivation and behavior (Ergün & Avci, 2018). When considering students’ self-efficacy, motivation is one factor, and motivation is critical when students are engaged in active learning. Student motivation is a combination of goals and needs, and as teachers construct active learning opportunities, keeping student goals and needs in mind is important given how it impacts self-efficacy (Myeong-Hee, 2018).

Active Learning

Lachat and Williams (1996) analyzed the structure of traditional classrooms. The study identified how teachers within the traditional context accepted that multiple students might fail; in fact, minimal monitoring of student success was conducted. Assessments tended to require lower-order thinking, and teachers taught in ways that required students to rote memorize the
material (Guisepi, n.d.). Often seen as autocratic, traditional teaching methods failed to consider how students learned. Teachers created environments where students simply sat, listening passively (Gordon, Jones & Bailey, 2018).

Bonwell & Eison (1991) first defined active learning as students both doing activities and then thinking about those activities. Active learning calls for students to become engaged in the classroom and to engage in the higher order thinking that was not always evident in traditional teaching methods. Classrooms that promote active learning are dynamic in nature: teacher and students are mobile, students collaborate, and the instructor supports student-learning (Phillipson, Riel, & Leger, 2018).

Unlike the traditional classrooms where students sat in rows, an active learning space is one that promotes collaborative learning. Some research seems to suggest there is a correlation between how a learning space design influences the way teaching occurs (Ramsay, Guo, & Pursel, 2017). Sawyers et al. (2017) found that teachers who shifted to more active learning strategies tended to increase the use of the classroom space and felt students were more engaged in the lesson. The study noted that instructors who practiced a more constructivist approach seemed to experience a smoother transition and were better prepared when incorporating active learning into the classroom.

In order to engage students, two factors come into play: student choice (what time and energy are they devoting?) and school facilitation (how does the school encourage student engagement?). While teachers have limited control over the first factor, educators can purposefully create an environment that fosters an active learning environment (Wawrzynski & Baldwin, 2014).
However, there are students who do resist in classrooms that are engaged in active learning. Student resistance may occur (i.e. not engaging in in-class activities, causing distractions, working with minimal effort). Several reasons have been offered as to why students may offer resistance to an active learning environment: active learning demands students to work more, students may experience anxiety about performing well in an active learning environment, or students are given expectations when they are poorly prepared to meet those expectations. (Finelli, et al, 2018).

**Inquiry-Based Learning**

Inquiry-based learning (IBL), a method of active learning, provides students a sequence of tasks, which have been scaffolded, and then students are asked to solve the task – whether as an individual or within a group (Academy of Inquiry-Based Learning, n.d.). IBL seeks to offer opportunities for all stakeholders – teachers and students – to work toward building knowledge and seeking interrelated connections (Repinc & Južnič, 2015) IBL is not a new movement in the education field; in fact, the National Science Foundation recommended that inquiry-based learning be used as an instructional method in 1996 (National Science Foundation, 1996), and when implemented successfully, students excel. Scott et al. (2018) noted that in the 2015 Program for International Student Assessment (PISA) results, the top three countries leading the world in education have various approaches to education but do have one common denominator: a commitment to inquiry-based learning.

Repinc & Južnič (2015) expanded on the benefits of IBL, especially for gifted students. Project work that is multi-tiered and interdisciplinary allows students to make connections to different subjects, think critically, and work collaboratively. Because of the approaches used in IBL, it is a recommended method especially in conjunction with STEM subjects (Silm et al,
Typically, IBL incorporates a constructivist approach in that students learn by doing, in essence fulfilling what Dewey argued students should be able to do: learn how to learn. IBL, by its very nature, often involves both problem and project-based learning, which is why it is an effective strategy for STEM classrooms (Carfora, & Blessinger, 2015).

Product-Based Learning

Educators must learn how to best facilitate learning for the 21st century student. Lachat (2001) cited the National Association of Secondary School Principals (NASSP) policy on how educators can best achieve this. The school environment must be intellectually stimulating, rigorous, personalized and differentiated, and connects to authentic learning. While various assessments are needed within the classroom, STEM classrooms revolve around product-based learning (PBL). Well-structured PBLs provide students with both authentic and meaningful learning opportunities. Students work to answer real-world questions that are complex in nature over an extended period of time. Because of how PBLs are structured, students must critically think, collaborate and communicate with their peers, problem-solve, and self-direct their learning (Caparo & Slough, 2013).

Caine and Caine (2010) noted that challenges enhance complex learning, a necessary component for effective PBLs. Additionally, some research seems to indicate that students whose classrooms incorporate PBLs tend to retain more information than their peers who do not have PBLs (Daniel-Gittens, Chen, & Thompson, 2014). Bruce et al (2014) reported that as teachers reflected on PBLs within the classroom, students began to become more independent in conducting their investigations. What teachers noted was that students had to draw on their background knowledge and then transfer that knowledge to solve the problem at hand.
Problem-Based Learning

Problem-based learning is a hybrid of inquiry instruction and product-based learning. Vanhala (2018) noted that previous researchers had described problem-based learning as a framework where students solve authentic, complex problems. Teachers facilitate learning as students, working at their own pace, learn what is needed in order to apply their new knowledge to answer the question. The emphasis of problem-based learning includes problem-solving skills and collaboration, which encourages students to become lifelong learners.

Magnussen, Ishida, & Itano (2000) argued that problem-based learning, at its most fundamental level, allows students to demonstrate knowledge (or gaps in knowledge), which reflects less superficial learning and more substantial learning. Students who have been exposed to problem-based learning tend show a greater capacity to conceptualize concepts and content and do not rely on memorization alone. The researchers contend that problem-based learning stimulates cognitive processes

Science, Technology, Engineering and Mathematics (STEM)

History of STEM Schools

The Science, Technology, Engineering and Mathematics (STEM) movement is an instructional shift that advocates a more holistic classroom approach. Introduced by the National Science Foundation (NSF) in the 1990s, STEM learning removes the barriers between subjects, integrating them into “real-world, rigorous, relevant” student learning (Vasquez, 2014). Schools are encouraged to shift away from a segmented-content approach to one that stresses an interdisciplinary connection and relating classroom lessons to the world at large. STEM focuses on teaching students 21st century skills – collaborating, questions, problem-solving, and critical thinking – to be competitive in future jobs (Gunn, 2017).
Gubbins et al (2013) reported on the findings of a national STEM school search conducted by The University of Connecticut and the University of Virginia. As of 2012, there were 916 STEM-specific focused schools. These schools – including magnet, charter and governor schools – were not all originally founded as STEM schools. The study noted that STEM high schools began to proliferate during the Second Industrial Revolution as the nation required a skilled workforce in a more modern economy, but the greatest growth of STEM-based schools occurred during George W. Bush’s administration. While there has been some form of STEM schools since 1844, these schools did not look like those of today – both in curriculum approach and instruction.

Obama and STEM

In the years following President Obama’s call for a “Sputnik” moment, much was done at the federal level to ensure that the goals outlined during the Obama administration were achieved. In 2009, Obama asked the President’s Council of Advisors on Science and Technology (PCAST) to develop a series of recommendations to help the United States became a leader in STEM education. To achieve excellence in STEM, two goals were developed: all students, including all genders and races, should be both prepared and proficient in STEM subjects, and all students must be inspired to not only learn STEM but be motivated enough to pursue STEM careers (President’s Council of Advisors on Science and Technology, 2010). The study concluded that, at the federal level, no coherent strategy to achieve a high-performing level of STEM education had emerged for various reasons. To resolve the lack of “clear vision,” several recommendations were offered, including the following: 100,000 “great” STEM teachers would be recruited and trained over the next 10 years; the nation’s top 5% of STEM teachers would be recognized and rewarded through the creation of a STEM Master Teachers Corps;
innovations will be driven by technology use, playing a transformative educational role; students will have STEM opportunities for outside-of-the-classroom experiences; and 1,000 newly created STEM-focused schools would open over the next decade. To reach the recommendations of PCAST, President Obama allocated $4 billion to spend toward improving STEM education in the 2017 budget. Of note within the budget were the following: $125 million improving STEM teaching; $10 million designated for the STEM Master Teacher Corps; and $109 million ensuring undergraduate students had “the most effective learning experiences” (Office of Science and Technology Policy, 2016).

Characteristics of STEM Schools and Programs

Peters-Burton, Lynch, Behrend, and Means (2014) outlined 10 defining characteristics of STEM schools: the curriculum is STEM-focused; instructional practices are research informed and are immersive; technology use is both integrated and innovative; learning occurs outside of the classroom and school day; students experience and participate in real-world STEM opportunities with community stakeholders; higher education opportunities are provided; staff are well-prepared in STEM content; the school’s mission is STEM-inclusive; the administrative structure supports the STEM environment; and underrepresented students are supported through various programs.

Gess (2017) explored the nuances between a STEM and STEAM (science, technology, engineering, arts, and mathematics) education and offered several conclusions. Regardless of whether the approach is STEM or STEAM, educators must provide an integrative curriculum, meaning that the process is continuous. The classroom instructional approach must also be one that is an intentional construction for authentic, real-world learning that is problem-based.
STEM schools share common beliefs concerning the climate and culture of the school. Administrators, teachers and students feel that motivated students supported by capable faculty facilitate an inclusive and welcoming community. The sense of belonging to the community impacts student learning and their overall satisfaction with their learning experiences. STEM schools value real-world learning experiences and seek ways to incorporate those learning experiences – something which the STEM schools believe differentiate them from non-STEM schools (Tofel-Grehl & Callahan, 2014).

**STEM Educators**

Olszewski-Kubilius (2010) noted that often STEM educators have an exceptionally high expertise in content level which directly benefits students who are challenged in a unique environment. It is because of this expertise that Allen, Webb, & Matthews (2016) argued effective STEM educators must engage in adaptive teaching. They defined the process as one where teachers adapt instruction as they “recognize and gauge” the students’ STEM development, whether it is through conceptual development via inquiry or making real-world connections.

STEM educators serve as catalysts of learning who use an inquiry-based model. By empowering students to question and investigate while providing a safe environment to take risks and experience failures, they ensure that meaning is at the core of student learning (Mezirow, as cited in Carfora & Blessinger, 2015). Mezirow argued that students accept new knowledge when it consistently aligns with their current knowledge base. STEM educators who embrace inquiry-based learning recognize that learning should be an active process driven by real-world, problem-based questions. STEM educators facilitate learning during the process, providing structure as needed, which includes assessing student work (Carfora & Blessinger,
2015). One study noted that a great number of students, based on their high school experiences and teachers, tend to choose to pursue a STEM career following graduation (Pedersen & West, 2017).

One of the concerns for STEM is attracting women and minorities into the field. The US Department of Commerce (2017) noted that STEM-educated women are more likely to work in education. There are multiple reasons why this is the case – from feeling that teaching field is more family-centered to regular schedules. However, despite the number of STEM-educated women who do turn to education as careers, there is still seems to be a disparity in the percentages of women teaching some STEM subjects (Pedersen & West, 2017).

Teacher Efficacy

Researchers agree on a broad sweeping definition of teacher efficacy, rooted in Bandura’s social cognitive theory, which explores behavioral changes and human agency. Teacher efficacy can be defined as the educator’s view on his or her capability of influencing both student learning and achievement. Teacher efficacy is also the belief that teaching is a significant factor in student learning and a teacher’s belief that he/she an be effective in educating his/her students (Seals, Mehta, Berzina-Pitcher, & Graves-Wolf, 2017). Teachers who feel satisfied in their school environment report higher levels of professional efficacy. Increased teacher efficacy is aided by a combination of several components: supportive leaders who are both strong and visionary; supportive peers; positive relationships with students; and purposeful professional development (PD). An additional factor into a teacher’s sense of efficacy is directly related to how willing he/she is to adopt new teaching methods. Teachers who have a higher sense of efficacy tend to be more open to experiment with new methods in an effort to better address student learning needs (Silm et al, 2017).
Prior to the technology boom experienced in the 20th century, mankind’s knowledge doubled, on average, once a century. The Sputnik era witnessed the knowledge rate increase every two decades. However, as technology has advanced, our current knowledge doubles every 13 months, and predictions indicate that soon our knowledge will double every 12 hours (Schilling, 2013). Hughes & Kritsonis (2007) recognized that growth does not happen if individuals do not continually learn. Teachers must have specific, high-quality PD. Stewart (2014) noted the correlation between the quality of PD and the quality of teaching. Educators are expected to be cognizant of that knowledge is continually evolving (Muhammad, 2006). Today’s educators must prepare students for degrees and careers in the STEM field, however, educators, especially at the elementary level, too often have not been exposed to using inquiry-based instruction when teaching STEM content. Because inquiry-based learning exposure at an early age may impact career choices later, teachers must be provided with the requisite skills and knowledge. As STEM becomes a staple in the classroom, teachers must be instructed about the multi-faceted nature of inquiry instruction – both in its complexity and significance in educating today’s students (Nadelson et al., 2013).

STEM professional development (PD) can provide an effective opportunity for teachers to discover the value of inquiry-based learning and interdisciplinary collaboration. For STEM PD to be effective, schools must provide supportive environments, offer organized PD that meets the needs of teachers, and increase teachers’ sense of efficacy with STEM and inquiry-based learning (Avery & Reeve, 2013). Increasing efficacy is important, since research suggests that when teachers feel uncomfortable with topics that are challenging both conceptually and content-wise, especially in terms of STEM, they either avoid teaching the topic or teach it superficially.
There is a direct correlation between teacher efficacy and comfort-level with content and student learning. If a teacher is uncomfortable with STEM content, there can be negative consequences regarding how a student perceives STEM subjects (Nadelson, Seifert, Moll, & Coats, 2012).

Caparo et al. (2016) cited numerous studies that underscore the value of PD when it is both sustained and high-quality: statistical data demonstrate positive effects for teachers and students. While the data points to the power of sustained PD, research also indicates that many educators are not exposed to high-quality PD. To ensure that PD is sustained and high-quality, Avery and Reeve (2013) offered several recommendations as administrators developed STEM PD: PD should train educators in how to develop inquiry-based challenges and products; PD should include how to integrate STEM content appropriately; and PD training must provide exemplars as references once the PD is completed.

One way educators can continue their own PD is to seek support outside of the school building. With the accessibility of PD online, teachers can expand their knowledge base using available digital tools. In addition to online PD, the internet affords teachers with the opportunity to work with in virtual professional learning communities (PLC), a unique way to sustain PD. An online STEM PLC, allows teachers to share lessons (via live streaming or recorded), conferencing (either through discussion groups or platforms like Skype or Zoom), and analyze student work (Fulton and Britton, 2011).

**STEM Students**

Traditionally, males have tended to make up the majority of the STEM students. Mau (2016) stipulated that women and minorities are still underrepresented populations in STEM. However, Stoeger et al. (2017) noted that the homogenous relationship between gender and STEM participation is changing at the high school level. While there is still an
underrepresentation of female STEM participation at the collegiate and professional levels, more girls are choosing STEM options as part of their school courses. However, females are not pursuing extra-curricular opportunities that require high-commitment. The Stoeger et al. (2017) study suggested that while it is important to spark girls’ curiosity and interest about STEM extra-curricular opportunities, care must be taken. Teachers must understand students’ internal and external motivations and influences, and why pursuing STEM extra-curricular activities may be different than taking STEM subjects during the school day.

There has been an ongoing conversation of how best to increase minority participation in STEM. Numerous factors have been suggested for underrepresentation, which includes the following: cultural norms, secondary school preparation, organizational structures, and discrimination. One critical factor is that an individual’s sense of belonging may directly impact STEM participation (Rainey, et al. 2018). Much of the African American student literature suggests that African American student peer culture directly impacts success, tragically in an adverse way (Morris, 2001). Hanson (2013) noted that research indicates that youth minorities are aware of negative stereotypes which impact both self-perception and achievement; she also noted a positive in that some ethnic groups (i.e. Latino culture) place a high value on education and work success, which can be used as a resource to encourage that group’s youth.

Gottfried, Estrada, and Sublett (2015) examined the participation rates of sexual minority students (gay, lesbian, and bi-sexual) in STEM programs. The study, the first of its kind, scrutinized STEM course choices made by sexual minority students and compared them to their heterosexual peers. The researchers discovered that there was not a significant difference in advanced math and science courses chosen by either group. A conclusion of the study was the sexual minority students at the high school level had comparable rigorous STEM academic
foundations compared to their peers and that these students did not experience significant
discrimination that might adversely impact their pursuit of a STEM career or degree at the
college level.

**STEM and Community**

The final two AdvancED STEM indicators specifically focus on the importance of
community for successful STEM programs. Community members are encouraged to actively
support and engage with teachers and students, and through these community interactions,
students experience real-world learning, both within and without the school’s boundaries
projects. They found that as both students and community members became fully invested in
STEM projects, evidence of STEM principles emerged during the process. Exploring an
authentic problem, students and community members worked together toward solving a problem,
and community members modeled interdisciplinary collaboration.

**High School STEM Education**

The National Science Board (NSB), in its Science and Engineering Indicators (2018),
noted that 89% of students who had attended four years of high school (2009-2013) completed at
least Algebra 2 or a higher level of mathematics, with 19% taking calculus or higher; and 98%
had completed biology, with 76% taking chemistry and 42% taking physics. The report also
indicated a rise of students taking Advanced Placement (AP) mathematics and science exams.
AP Computer Science A reflected a quadruple increase in students taking the exam. While these
were positive gains, the NSB concluded that the progression being made to improve STEM
education in the United States has produced mixed results (National Science Board, 2018).
While STEM education may be producing mixed results, Ernst, Glennie, and Li (2017), reported some research suggesting STEM schools, especially those using a constructivist approach, do cultivate students’ critical thinking skills through the use of active learning. Bruce et al. (2014) noted that STEM-focused high schools provide a setting for students to be a part of a challenging environment which incorporates instructional strategies that promote real-world learning skills. The importance of relationships between the school community members, the curriculum, instructional strategies, and the overall learning environment is significant. When the relationships were strong, students willingly took risks and attempted to meet the rigorous academic expectations of the school.

**Inclusive STEM High School (ISHS)**

One of PCASTs (2010) initial recommendations was to create 1,000 STEM schools over the next decade – 200 high schools and 800 elementary and middle schools, and a new type of STEM school has begun to emerge as a result: inclusive STEM high schools (ISHS). ISHSs actively seek out STEM students from underrepresented groups who are both interested in STEM and willing to challenge themselves in a college preparatory setting (Spillane, Lynch, & Ford, 2016). ISHSs focus on preparing students to succeed in STEM studies (Peters-Burton, Lynch, Behrend, & Means, 2014) and offer open enrollment, seeking students based on their STEM interests rather than abilities or prior achievements (Spillane, Lynch, & Ford, 2016).

ISHSs are emerging in rural areas. Many rural schools face the following challenges: size, typically smaller than their urban and suburban counterparts, and limited resources. Educators often teach in multiple content areas and professional development tends to be limited. However, an advantage that rural schools have over their counterparts is a strong connection with community stakeholders. Rural ISHSs can use this advantage to develop partnerships
within the community – local government, business, and colleges – to improve STEM education (Peters-Burton, et al., 2014).

Students attending an ISHS tend to perform better than their peers at traditional schools when comparing mathematics high-stake test scores for their first two years in high school. ISHS 9th grade students were 1.8 times and ISHS 10th graders were 1.5 times more likely to meet reading and mathematics benchmarks. The numbers were similar for 10th grade ISHS students, who were 1.5 times more likely to meet the benchmarks (Erdogan & Stuessy, 2015). While the numbers seem initially promising, one study denoted the findings of a three-year comparative longitudinal and ethnographic study of STEM and ISHS schools in Denver and Buffalo that offer a cautionary tale. The study concluded that the intention to implement reform in the guise of STEM-focused schools, did not result in meaningful improvement. As the programs lost momentum, due to various reasons, upper-level courses were not offered. When the ISHS shifted from their original purpose, student opportunities became “limited” rather than “expanded” (Weis et al., 2015).

Post-Secondary STEM Education

Two years following their initial report, PCAST (2012) argued that based on the economic forecasts for the coming years, one million STEM college graduates would need to be produced. The study found that less than 40% of college students majoring in STEM fields completed the degree (President’s Council of Advisors on Science and Technology, 2012). A later study by The National Science Foundation (NSF) (2016) suggested that students pursuing STEM careers make the decision during high school. During the 2011-12 academic year, NSF noted that two additional factors for students pursuing STEM degrees were the mathematics
courses (e.g. calculus) taken during high school and their cumulative grade point average (e.g. 3.5 or higher).

In a study analyzing data collected by ACT, there appeared to be a discrepancy between ACT-tested high school students who expressed interest in a STEM major (roughly 50%) and those who declared a STEM major (less than 30%) (Radunzci, Mattern, & Westrick, 2017). To help encourage students to pursue STEM post-secondary degrees, PCAST (2012) offered several recommendations, which included: encouraging a widespread use of validated and researched teaching practices; offering support to replace traditional and standardized courses with “discovery-based” courses; and conducting a nation-wide experiment in postsecondary math education, specifically addressing preparation gaps.

When scrutinizing the first two PCAST recommendations, Freeman et al. (2014) completed a meta-analysis of 225 studies comparing the data on examination scores or failure rates for those students in STEM courses who were traditionally taught (i.e. lecture-based) or incorporated active learning (i.e. discovery-based). A specific finding of the study underscored the positive benefits of active learning – average grades raised by half a letter – while highlighting the negatives of traditional lecturing – failure rates increased 55% when compared to those rates of active learning. The study concluded if the nation’s post-secondary schools were to answer the call of increasing the number of STEM-degree seeking students, abandoning traditional lecturing was part of the answer. However, it is problematic that too many post-secondary professors have had little, if any, training as teachers. Given that an active-learning approach differs at a fundamental level than the traditional approach, many post-secondary instructors are challenged to effectively incorporate an active-learning environment (Auerbach, Higgins, Brickman, & Andrews, 2018).
To elaborate on the PCAST recommendation of addressing preparation gaps, one study analyzed the transitional educational points from middle school to college. One finding, supporting that of Freeman et al. (2014), suggested that instructional gaps, especially the transition from high school to college, could simply be addressed by promoting active learning as students take introductory STEM courses at the undergraduate level (Akiha et al, 2018).

Mau (2016) identified specific characteristics of students choosing to pursue a STEM-career and those who did not. The study validated previous studies that found minority and female students, other than Asian-American students, were not as likely to pursue a STEM-related major than male or white students. Within the science and engineering workforce, about 25% of employed scientists are women, and minority women are still underrepresented (representing only 11% of that total). Fields like computer science are also seeing a decrease in female participation, and at the university level, there is a low percentage of STEM female faculty (Committee on Underrepresented Groups, 2011).

Veterans are beginning to enter STEM-related careers. World War II and the implementation of the G.I. Bill witnessed the beginning, and still ongoing, third major educational transformation: students seeking postsecondary degrees (Goldin, 1999). During the 2016 fiscal year, over one million beneficiaries received monies totaling $12.6 billion from the G.I. Bill (the number, however, may include individuals who used the benefit more than once) (U.S. Department of Veteran Affairs, 2017). Cate and Davis (2016) analyzed the results from the 2015 Student Veterans of America Survey, which found that nearly one-third of students were seeking STEM degrees, a trend that indicated more student veterans were pursing science and engineering degrees. This trend could be, in part, due to the training veterans received while serving in the armed forces. STEM students’ belief in self-efficacy and self-learning are directly
linked both academic commitment and achievement (Jenson, et al., 2011), which are skills that veterans developed while serving.

These skills are also applicable to disabled veterans. Groah et al., (2017) studied whether STEM offered viable career options for those individuals, specifically with disabilities, participating in the GI Bill. Lee (2011) determined that students with disabilities are more likely to pursue STEM majors in two- and four-year institutes than students without disabilities.

**STEM Accreditation**

AdvancED is an international accrediting agency, serving a network of over 27,000 schools. AdvancED provides tools, resources, and support as educational institutions pursue continual improvement. One element of school improvement that AdvancED supports is that of STEM education. One of just a few institutions that offer STEM accreditation for schools, the AdvancED STEM certification is only 4 years old. First launched in August 2014, AdvancED piloted its program to ensure the validity of the standard and its accompanying indicators. Nine schools went through the certification to test the validity and reliability of the process. Since its implementation, the total number of STEM certified schools at the end of the 2016-2017 school year rose to 104. Currently, schools in 19 states, Puerto Rico and Saudi Arabia have received certification. The Oak Ridge school district in Tennessee was the first district in the country to receive certification (AdvancED, 2017).

The AdvancED STEM certification is grounded in a research-based framework and provides the criterion needed to develop, assess, and certify the quality and rigor of STEM programs. AdvancED requires schools to increase expectations of students and faculty and reflect a commitment to both a rigorous and high caliber education. In order to receive STEM
certification, schools must demonstrate that students experienced success as in the STEM courses as innovators, creators, and problem-solvers (AdvancED, n.d.).

**Educators Shifting the Paradigm: Professional Learning Communities**

As the federal government attempted to improve education, educators sought ways to implement reform. It has been suggested by some that school improvement is most successfully achieved when educators actively, continuously, and frequently engage in conversations about the practice of teaching (Joyce, 2004). This collaborative practice, known as professional learning communities (PLC), is defined as a group of professional educators, including both teachers and administrators, seeking ways to improve their own learning, sharing their discoveries so that students benefit (Hord, 1997). DuFour and Eaker (1998) further elaborated on the individual educator’s role, stating that the individual not only sought to increase knowledge, but also remained current in that knowledge base.

The impact on educational reform of an effective, collaborative PLC can be powerful; so powerful that Shomaker (2004) suggested PLCs could realize the “most productive shift” in the history of educational practice. To achieve this shift, DuFour and Eaker (1998) outlined characteristics of a successful PLC: an organization must develop and share the same mission, vision, and values; the group members collaborate while making collective inquiries; the PLC seeks to continually improve by being action oriented and experimenting; and data is used to drive decision-making.

Bullough (2007) analyzed the findings of The Eight-Year Study, where PLCs and their effectiveness were examined; the study’s findings and those characteristics offered by DuFour and Eaker (1998) aligned. Several other important elements, specifically concerning teachers, were identified. First, and perhaps the most important lesson, at the heart of school reform is
teacher education and “capacity building.” Additionally, teachers, while working collaboratively, must be allowed to explore and experiment (Bullough, 2007).

Teachers are an essential part of school reform. One component of success lies in the trust that is developed within the team. When analyzing a STEM PLC, Fulton and Britton (2011) found that when trust was established within the group, an environment encouraging conversations about classroom practices and content emerged. Teachers, following PLC meetings, implemented more research-based instructional strategies, encouraged students to use more diverse problem-solving strategies, and empowered students by listening and valuing their reasoning.

The role of administrators is dependent on whether a school has an existing PLC. An effective shift from the traditional paradigm to a PLC takes time. For elementary schools, the process takes three years, and secondary schools need six years (Fullan, 2000). As a school’s paradigm shifts, administrators must navigate faculty through the change, using the existing structure (i.e. academic departments) as the vehicle of change (Marx, 1997). Administrators must also encourage teachers to be a part of both the changing culture and collaborative teams (Jessie, 2007). Most importantly, though, administrators must communicate that the PLC and its essential component of collaboration is not an optional choice, but an expectation (Many, 2009).

The challenge with any type of effective reform is ensuring that the process can be sustained. Part of sustaining a viable PLC mandates numerous expectations from leaders of the school: administrators who provide consistent and frequent time for faculty to meet; administrators who empower faculty to participate in decision-making; and administrators who offer opportunities for feedback (Louis as cited in Blankstein, 2008). Sustainability also implies schools have created PLCs that have both depth and breadth. The depth of a PLC suggests the
team and the school have focused on what is truly driving the reform: all students learning. The breadth of a PLC indicates that administrators and teachers analyze the data and then use the data to drive instructional choices (Hargreaves as cited in Stoll, 2007).

**Interdisciplinary Collaboration**

To enter into a conversation concerning interdisciplinary collaboration, one must first define the term “academic discipline.” There are many components that go into defining the term. The term suggests an organizational system of learning which systematically produces new knowledge. In education, discipline is often synonymous with subject; however, not every subject can be seen as a discipline (i.e. driver’s education courses) (Krishnan, 2009). Groskey et al. (2010) noted that discipline, as defined by the Oxford English Dictionary, is a specialized area of academic scholarship. Understanding this definition is important given the growth of human knowledge, specifically within the last two decades and especially as the call for more interdisciplinary collaboration becomes more vocal. Because discipline typically offers a specific perspective about any given topic or problem, interdisciplinary collaborations ask professionals to bring in their unique insights and integrate them with other disciplines in to develop a fuller understanding of the question or problem at hand (Greef, 2017).

There is current discussion concerning whether K-12 teachers are truly members of a discipline or whether these teachers simply are engaged in the practice of teaching. Noddings (2003, as cited in Fordham, 2016) argued that K-12 teachers are not members of academic disciplines because they are not adding to the existing body of knowledge. Using mathematics as an example, she observed that elementary teachers do not contribute to content areas but conceded that the some high school teachers may meet the criteria of part of the discipline. Fordham (2016) argued if one understands that a discipline can be defined as a pursuit of
knowledge than those who are participants (i.e. teachers) who are in seek knowledge are indeed a part of the discipline they teach. He further suggested that being actively engaged is a necessity for teachers for students to best learn that discipline.

The conversation concerning the need for interdisciplinary collaboration is not a new one, with increased discussions beginning the late 1980s. In 1989, both The National Council of Teachers of Mathematics (NCTM) and the American Association for the Advancement of Science (AAAS) both recognized the role of language, literacy, and communication in their content areas (Kaufman & Brooks, 1996).

**Keys for Success in Interdisciplinary Groups**

For success with interdisciplinary collaboration, Nameth & Wheeler (2017) offered three key insights from their personal journey in creating an interdisciplinary curriculum project. Teachers must be ready to learn, willing to collaborate, and respect each other’s expertise, seeing one another as peers. Youngwerth & Twaddle (2011) argued that effective collaboration is comprised of multiple factors. Communication, relationships, and organizational structure all contribute to the success of the collaboration. However, communication is the linchpin for group’s efficacy. Good communication, whether occurring in a formal or informal manner, helps create higher levels of innovation, encourages productive collaboration, promotes healthy partnerships, and resolves conflict.

Administrators are an integral part of whether interdisciplinary collaboration is successful. Leaders must communicate that the interdisciplinary approach is one which is both valued and supported. To demonstrate this, leaders should develop a structure which supports faculty to pursue interdisciplinary projects. This could be in the form of common planning time,
professional development, or creating environments for co-teaching opportunities (Crabtree, 2014).

Challenges to Interdisciplinary Collaboration

Strober (2011) acknowledged that interdisciplinary collaboration can be both difficult and productive. She noted that due to the complex and ever-burgeoning vault of knowledge, academia finds itself in a paradox. The amount of knowledge demands specialization; a consequence of this specialization is that transcending academic boundaries becomes difficult in terms of creating a healthy interdisciplinary collaborative environment. Similar to the idea within PLCs that group norms should be established (DuFour and Eaker, 1994), for interdisciplinary collaboration to work well, participants must construct a method for negotiating goals. This becomes incredibly important given that individuals do not always immediately understand what other group members perceive as important. Failing to create group norms can impede the productivity of the collaboration (Gooch, 2005).

Youngwerth & Twaddle (2011) noted that many obstacles exist which prevent successful interdisciplinary collaboration. Communication breakdowns, real or perceived hierarchies, and undefined or poorly defined roles can all create barriers. The study noted that at communication is at the core of collaboration; if communication breaks down, the collaboration becomes ineffective and ultimately impacts others.

Student Benefits from Interdisciplinary Collaboration

There are distinct advantages for students when teachers collaborate. Perhaps the biggest gain for students is the opportunity to expand traditional “discipline-defined” boundaries by making cross-disciplinary connections. By creating interdisciplinary lessons or units, teachers provide students with the opportunity to take information from one field of study and make
applications to another field of study. An added benefit is for students to see science teachers reading and discussing literature and English teachers reading and discussing a recent scientific finding. When this happens, students discover that learning is multi-faceted and multi-disciplined (Saunders & Ingalls, 2013).

In terms of interdisciplinary learning, students begin taking the connections made between the disciplines and applying those lessons to real-world problems. This approach to learning aids in creating an opportunity for a global awareness which encourages students and teachers alike to be more civically engaged. Because of the diversity of opinions and experiences, interdisciplinary learning opportunities may be more innovative and engaging than those that are non-interdisciplinary (Crabtree, 2014).

Interdisciplinary Projects

Interdisciplinary projects, by their very nature, demand that educators find ways to demonstrate to students that different content areas are connected to one another (Kwon, Warship, Gomez, 2014). The process, unlike traditional activities that can be considered “non-additive” (Blunden, 2014), requires students and teachers alike to investigate real-world issues using a variety of multidisciplinary strategies. Cross-curricular projects demand that teachers coordinate and plan at a more intensive level (Kwon, Warship, Gomez, 2014).

Nicolson et al. (2002) identified several elements that should be remembered when implementing an interdisciplinary project. First, be aware of the various skills members within the group bring and use those skills accordingly. Second, clearly delineate the problem early on; this will aid the communication of the group, especially as different perspectives are being offered for the solution. Caenpeel and Wyrick (2001) elaborated that member skills should be complementary in nature in order to successfully complete the project.
CHAPTER 3: METHODOLOGY

Introduction

The purpose of this study was to gain a better understanding in how high school teachers at a high-achieving magnet school responded during a STEM-program implementation. This specific study utilized a qualitative research approach to obtain teachers’ perspectives as they began working collaboratively for the first time in an interdisciplinary professional learning community (PLC) to develop cross-curricular projects. This study also identified any shifts in teachers’ instructional strategies due to the interdisciplinary PLC and STEM-program implementation. This chapter presents the entire research approach, data methods, how data were analyzed, and the population used for the data.

Research Questions

In this study, the researcher gathered data to analyze and answer the following research questions:

1. How are magnet school teacher attitudes toward interdisciplinary projects affected during a STEM program implementation?
2. What are the nature and extent of changes in magnet school teachers' use of interdisciplinary collaboration during a STEM program implementation?

Description of Specific Research Approach

To gather the perceptions of the participants, the researcher utilized a qualitative research design. This was accomplished through focus groups and individual interviews. While both the focus group and interviews provided the primary sources of data, triangulation was achieved by examining questionnaires and artifacts. Artifacts included the interdisciplinary PLC notes, teacher lesson plans prior to STEM-program implementation and during STEM-program...
implementation, interdisciplinary project rubrics, and additional artifacts found to aid the analysis.

Qualitative research methods were developed in the social sciences, allowing researchers to understand phenomena within society as it experiences changes and creates new contexts and perspectives (Flick, 2014, p. 12). Qualitative research provided the researcher with the means of examining how teacher perceptions and behaviors were impacted as the school experienced changes through the STEM-program implementation. Since teacher perceptions were a crucial component of the study, the study necessitated a qualitative approach using focus group and individual interviews as data.

Individual interviews that are in-depth and semi-structured allow the researcher to explore the experiences and what those experiences meant for the participants. Using open-ended questions, the researcher can pursue topics discussed by the respondents and ask for clarification on question responses. The in-depth interviews provide an opportunity for respondents to discuss sensitive topics that might not otherwise be addressed (Tong, Sainsbury, & Craig, 2007). In this study, interviews were conducted with each of the 35 teachers involved in the STEM-program implementation. Open-ended questions were asked, allowing each respondent to explore his/her own perceptions about the STEM-implementation and the interdisciplinary collaboration.

A focus group provides an avenue of examining participant knowledge, opinions, and how the knowledge and opinions were developed. A researcher utilizes the data collected in a focus group by observing communication, interactions, and behaviors between the participants. The researcher encourages participants to interact with each other by asking questions, exchanging experiences, and making connections on one another’s points of view (Kitzinger,
In this study, a focus group of five teachers was formed. These teachers had been involved in establishing various elements of the STEM-program prior to the 2018-2019 school year. The group, meeting over a period of several months, was interviewed to understand participants’ insights on the successes and challenges faced during the implementation.

**Description of the Study Participants and Setting**

The researcher studied a magnet school located in Middle Tennessee, which began operation in 2010. The school was a 6-12th school composed of approximately 1,200 students. Academics are the primary focus of the school, and students are admitted based on their academic record and test scores. Of the 1,000 students applying to the school each year, roughly 37% are admitted. The courses offered are rigorous in nature: 74 Honors/Advanced Honors classes and 29 Advanced Placement classes. To receive the school’s specialized diploma, students must take at least four AP courses during their high school career, complete 25 hours of community service each year, and present a senior thesis. Ninety-nine percent of the school’s graduates attend a 4-year college, and last year’s average ACT score was 29.6.

The study participants were the faculty members directly involved in the STEM-program implementation. Of the 35 participants, 20 were female and 15 were male; 7 held Bachelor degrees (one individual held two Bachelor degrees); 20 held Master’s degree; 2 held Master’s degrees plus 30 hours; 4 held Educational Specialist degrees; 1 held Ph.D. in Mathematics Education; and 1 held a Doctor of Jurisprudence. 17 of the participants taught at least one Advanced Placement course. The gender breakdown of subjects taught were as follows: Math – 3 females and 2 males; Science – 2 females and 3 males; Career and Technology – 5 females and 2 males; English – 2 females; Social Studies – 1 female and 4 males; World Languages – 6
females and 2 males; Fine Arts – 2 females and 4 males. Given the diversity of content areas, courses taught, and level of experience, a variety of participants’ opinions were offered.

**Data Collection Procedures**

Prior to beginning the study and the data collection process, the researcher received permission from the Carson-Newman University Institutional Review Board. The researcher also followed the research district’s policy prior to receiving study consent: identification of the researcher as a student of Carson-Newman University; purpose(s) of the research study; procedures of the research in chronological order; individuals who will have access to the data gathered; what will happen to that data when the study is terminated; how confidentiality will be maintained; methods to minimize risk to subjects must be explained; sampling techniques and purposes must be explained; all instruments to be used in the study; informational document to be given to subject; and draft of consent forms. Once the research district provided approval, the school administrator granted final approval.

Once approval was granted, the researcher created two questionnaires participants would answer regarding their experiences and opinions: a pre and during-implementation questionnaire. The Likert scale, a widely used scale, allows participants to provide responses ranging from strongly disagree to strongly agree with a middle neutral response (Maurer and Pierce, 1998). By using a Likert-scale questionnaire, the researcher could assess participant attitudes. The teachers participating in the STEM-program implementation were asked to answer a series of close-ended questions using 5-point Likert scale questionnaire. The first questionnaire was used to gauge teacher perceptions prior to the implementation of the STEM-program. The questionnaire responses were used as a foundation for questions asked during the individual interviews. While there were predetermined questions, the researcher allowed for
transition if the participant chose to discuss other experiences within the STEM program. Each interview was audio recorded and then transcribed by the researcher. The interviews occurred during the participants’ planning period and lasted between 30-45 minutes. The researcher audio recorded and transcribed the individual interviews and took notes to record observations during the focus group’s meeting.

Participants were asked to complete a second Likert-scale questionnaire at the conclusion of the first semester. The researcher developed a series of questions based on the second questionnaire responses and used these to begin discussions with the focus group. While the questions were predetermined, the researcher allowed the five focus group members to discuss the study. The researcher audio recorded and transcribed the focus group’s meeting and took notes to record observations during the focus group’s meeting.

Classroom observations were also conducted as teachers began their interdisciplinary collaborations and projects. Observations were completed in order to note and record teacher practices and student behavior while lessons were being presented. The researcher engaged in a “time and event sampling” classroom observation approach, which is used when multiple observations are being made in order to find patterns within the classroom (Montgomery, 2013).

**Ethical Considerations**

Harnett and Cooper (2010) defined privacy and confidentiality with a research context. Privacy concerns individuals’ sense of other’s access to their personal lives. A researcher must keep in mind that participants are allowing the researcher into their lives. Confidentiality is an extension of privacy in that any identifiable data of the participants is excluded from the research, and that participants are aware of how access to the data will be handled.
Before the study began, the researcher received authorization from the Carson-Newman University Institutional Review Board. Following the University’s authorization, the researcher obtained permission from the school district, school administrator, and study participants. The researcher confirmed that the participants understood that the study was voluntary and were willing to participate. The researcher also informed the participants that pseudonyms would be used to identify them throughout the study. Informed consent forms were signed prior to the interviews and focus group. Participants were also reminded that the study was voluntary, and all responses were confidential. The researcher received permission to audio record the interviews and focus group and to use direct quotes in the report.

**Data Analysis Procedures**

After the interviews and focus group, data analysis occurred. Transcripts were made of both the notes and audio recordings taken during the interviews and focus groups. Participants had access to the transcriptions to verify their responses were interpreted and decoded correctly. The researcher continuously discussed the findings with a peer throughout the data collection and analysis processes. The peer debriefer role was to challenge the researcher to reduce bias by limiting themes and conclusions to only those which could be fully supported by data. Member checks were also conducted to confirm the accuracy and validity of findings that emerged from the analysis. Member checks also served as a data collection point for clarifying details related to those findings.

Data analysis then occurred. The researcher identified emergent patterns and themes from the transcriptions that correlated to the research questions. Clark and Veale (2018) noted that a thematic analysis is common in qualitative research because data are presented as words. These words are obtained via interviews, documents, and field notes. Coding is defined as “the
transitional process” the researcher employees after the data has been collected and as the data is analyzed. Codes, found in the words of the subjects, represent various elements of the data.

The researcher first used open coding. Bôhm (2004) noted that by using an analytical approach, open coding breaks down data that allows the researcher to identify core concepts, develop categories, and identify patterns. Patterns are defined as words that regularly or repetitively occur within the transcripts. Patterns are characterized by their similarity, difference, frequency, sequence, correspondence, and/or causation (Clark and Veale, 2018). Once open coding was completed, the researcher used axial coding to “refine” and “differentiate” the identified concepts and patterns to identify any relationships within the codes (Bôhm 2004, p. 271). Once coding and transcriptions were completed, peer debriefing was used. To ensure the research was valid and credible, an impartial peer review was conducted in which the data and methods used for analysis were evaluated. Member checks were also conducted to confirm the accuracy and validity of the participant interview transcripts.

Summary

To answer the research questions, a qualitative research study was conducted. Data were analyzed from questionnaires, interviews, classroom observations, and a focus group. Questionnaires were given to the teachers participating in the STEM program to gain a foundation for the interview and focus group questions. A focus group comprised of the five teachers who had been involved in establishing various elements of the STEM-program was held where the researcher asked questions developed from the questionnaires. Individual interviews were held with those teachers not involved with the initial STEM program development using questions developed from the questionnaires. Classroom observations were also conducted.
From the results of the classroom observations, interviews, focus group, and questionnaires, data were coded, using open, axial and selective coding, to determine patterns in relation to the research questions. The benefits of this research will aid teachers who are a part of implementing interdisciplinary projects and professional learning communities.
CHAPTER 4: FINDINGS

Introduction

This qualitative study sought to determine how high school teachers at a high-achieving magnet school, who have not traditionally or formally worked on interdisciplinary projects, responded when a STEM program is implemented. This study scrutinized educators’ perceptions of a STEM program within a high-achieving school were either reinforced or changed.

This study collected data through two surveys, 24 individual teacher interviews, one semi-structured interview with a focus group of five teachers, and classroom observations. The researcher studied a magnet school located in Middle Tennessee. The research school population is approximately 1,200 students in grades 6-12. Academics are the primary focus of the school, and students are admitted based on their academic records and test scores. The courses offered are rigorous in nature: 74 Honors/Advanced Honors classes and 29 Advanced Placement classes. Participants were teachers who taught senior-level courses.

The following research methods were used to answer the research questions that comprised the basis of this study:

1. How are teacher attitudes toward interdisciplinary projects affected during a STEM program implementation?

2. What are the nature and extent of changes in teachers' use of interdisciplinary collaboration during a STEM program implementation?

Both surveys utilized a 5-point Likert scale, with general questions regarding educators’ STEM knowledge and their attitudes and perceptions toward a STEM program implementation. The surveys were sent via email; all teachers were asked to complete these surveys. The 24
teacher interviews were conducted with teachers who were not directly involved in overseeing the senior thesis. The focus group consisted of five teachers who were directly involved in overseeing the senior thesis. Ten classroom observations were completed and were a mix of teachers of who were and were not directly involved in overseeing the senior thesis.

Data were sorted through open, axial, and selective coding. Common themes emerged from the data which were then narrowed into categories. Figures 4.1 and 4.2 illustrate the level of coding for the study.
Figure 4.1: Data Sorted in Levels of Coding for Research Question One

Data Sorted in Levels of Coding for Research Question One: How are teacher attitudes toward interdisciplinary projects affected during a STEM program implementation?

<table>
<thead>
<tr>
<th>Raw Data</th>
<th>Open Coding</th>
<th>Axial Coding</th>
<th>Selective Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;But it's just not knowing how to do it [lack of training]. . . These ideas sound great, but how do you implement them and where do you find resources to show you how to implement them?&quot;</td>
<td>How to implement interdisciplinary projects</td>
<td>Professional development and specific training</td>
<td></td>
</tr>
<tr>
<td>&quot;If we could get the training on how to get kids through interdisciplinary projects... fantastic.&quot;</td>
<td>Need for affective resources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;How do you implement them and where do you find resources to show you how to implement them?&quot;</td>
<td>Understanding and incorporating active learning (inquiry, product, problem-based learning)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Students work collaboratively, they ask questions... so that they can explore a problem in depth and come up with a best solution.&quot;</td>
<td>Students exposed to multiple facets of learning</td>
<td>Students synthesize information from multiple disciplines</td>
<td>Educators understand the benefits of interdisciplinary learning for students; however, teachers must have adequate training in order to make effective change to the status quo.</td>
</tr>
<tr>
<td>&quot;Students have an opportunity to be curious about things.&quot;</td>
<td>Power of transfer</td>
<td>Take of learning/higher order thinking</td>
<td></td>
</tr>
<tr>
<td>&quot;Giving students a problem after having already scaffolded the general knowledge they need so that they can go look at a problem and determine an effective answer to it.&quot;</td>
<td>Comradery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Go[ing] the students to think at a higher order&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;I don't want to do anything new, but I think that's the nature of change.&quot;</td>
<td>Direct instruction</td>
<td>Change challenges status quo</td>
<td></td>
</tr>
<tr>
<td>&quot;I definitely think there are pockets of resistance, as there are with any change.&quot;</td>
<td>Comfort Zone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;And, that's why I don't understand is why we're still teaching that way, I'll be honest with you, but that's the system, and yeah, I get that. But, myself, as a teacher can change that in my own classroom.&quot;</td>
<td>One more expectation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 4.2: Data Sorted in Levels of Coding for Research Question Two

Data Sorted in Levels of Coding for Research Question Two: What are the nature and extent of changes in teachers’ use of interdisciplinary collaboration during a STEM program implementation?

<table>
<thead>
<tr>
<th>Raw Data</th>
<th>Open Coding</th>
<th>Axial Coding</th>
<th>Selective Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;I could get excited about everything... but it's just the reality of the time constraints.&quot;</td>
<td>Being intentional and consistency</td>
<td>Challenge to overcome time and course constraints</td>
<td></td>
</tr>
<tr>
<td>&quot;The biggest barrier I would say is time. To intentionally sit down and find those connections I was talking about.&quot;</td>
<td>Timing interruptions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Lack of dedicated time is a big issue.&quot;</td>
<td>AP course restraints</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;The time makes us all nervous because we are pressed for time automatically.&quot;</td>
<td>Ability to meet with other teachers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;I'm not sure how much crossover there would be.&quot;</td>
<td>Failure to see how disciplines can crossover</td>
<td>Mixed reactions to change</td>
<td></td>
</tr>
<tr>
<td>&quot;I've even had teachers come to me and say, a student said that what I'm teaching relates to something they've learned.&quot;</td>
<td>Other perspectives beneficial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;I believe that the teachers here wish to collaborate more and speak more with other teachers, just to get other perspectives.&quot;</td>
<td>Lack of understanding other teachers' curriculum and objectives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;I think it just helps to talk to other teachers about instructional strategies in general.&quot;</td>
<td>Instructional strategies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Just being in the same room and sharing the conviviality and knowing what's going on in the other classrooms, it's like we get in these little bubbles.&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;So it seems like we could benefit from mentoring type of teaching.&quot;</td>
<td>Shift from direct instruction to facilitation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;I think direct instruction has been laid-basted way too much.&quot;</td>
<td>Unwillingness to sacrifice AP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;I try to always lead from a facilitating place because it gives them more ownership.&quot;</td>
<td>Territorial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;With AP it is not about the joy of discovery or anything like that, it's just they need to have the skills they need to pass the exam.&quot;</td>
<td>Rut/Bubble/Isoation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;And in the AP Curriculum I teach to the test because I know that if they can pass the test, then they know the information.&quot;</td>
<td>Pressure to shift to unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Teachers by nature are somewhat territorial and collaboration with other teachers in certain areas are difficult.&quot;</td>
<td>Confusion</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overloaded</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Pre-Implementation Survey

This survey sought to obtain a baseline for participants’ STEM knowledge, incorporation of teaching strategies related to STEM, and general attitudes toward STEM. The responses were based on a 5-point Likert scale. The survey was distributed to the 29 senior teachers, and 20 of these teachers responded. The first question asked respondents to identify the level of their STEM knowledge prior to the 2018-2019 school year. The responses are detailed in Table 4.1.

Table 4.1

Results for Pre-Implementation Survey Question 1

<table>
<thead>
<tr>
<th>Extremely Knowledgeable</th>
<th>Very Knowledgeable</th>
<th>Knowledgeable</th>
<th>Somewhat Knowledgeable</th>
<th>Not Knowledgeable</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td>15%</td>
<td>30%</td>
<td>35%</td>
<td>15%</td>
</tr>
</tbody>
</table>

The next series of questions asked respondents how often they utilized various STEM elements. All questions asked teachers to consider practices prior to the current school year (2018-2019) and how often those practices occurred. A 5-point Likert scale was used. The responses are categorized in Table 4.2.

Table 4.2

Results for Pre-Implementation Survey Questions 2-6

<table>
<thead>
<tr>
<th></th>
<th>Weekly</th>
<th>Monthly</th>
<th>Twice a Semester</th>
<th>Two/Three Times a Year</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inquiry-Based Learning</td>
<td>45%</td>
<td>25%</td>
<td>25%</td>
<td>0</td>
<td>5%</td>
</tr>
<tr>
<td>Problem-Based Learning</td>
<td>35%</td>
<td>25%</td>
<td>15%</td>
<td>20%</td>
<td>5%</td>
</tr>
<tr>
<td>Product-Based Learning</td>
<td>50%</td>
<td>25%</td>
<td>10%</td>
<td>5%</td>
<td>10%</td>
</tr>
<tr>
<td>Interdisciplinary Projects</td>
<td>0</td>
<td>15%</td>
<td>20%</td>
<td>35%</td>
<td>30%</td>
</tr>
<tr>
<td>Interdisciplinary PLCs</td>
<td>0</td>
<td>5%</td>
<td>15%</td>
<td>20%</td>
<td>60%</td>
</tr>
</tbody>
</table>
The third series of questions assessed teacher attitudes toward STEM and the elements associated with STEM (i.e. interdisciplinary projects). The first two questions asked teachers to identify their current attitude; the last three questions asked teachers to identify their attitude prior to the 2018-2019 school year. A 5-point Likert scale was used. The responses are detailed in Table 4.3.

**Table 4.3**

*Results for Pre-Implementation Survey Questions 7-11*

<table>
<thead>
<tr>
<th></th>
<th>Very Positive</th>
<th>Positive</th>
<th>Neutral</th>
<th>Negative</th>
<th>Very Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implementing STEM process into curriculum</td>
<td>30%</td>
<td>50%</td>
<td>20%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Interdisciplinary projects</td>
<td>40%</td>
<td>35%</td>
<td>20%</td>
<td>5%</td>
<td>0</td>
</tr>
<tr>
<td>Engineering process</td>
<td>35%</td>
<td>20%</td>
<td>40%</td>
<td>5%</td>
<td>0</td>
</tr>
<tr>
<td>Cross-curricular learning</td>
<td>45%</td>
<td>35%</td>
<td>10%</td>
<td>10%</td>
<td>0</td>
</tr>
<tr>
<td>Active Learning</td>
<td>65%</td>
<td>20%</td>
<td>15%</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The final question asked teachers if they had acted as mentors for the school’s senior thesis. This question was important because of the interdisciplinary nature of the thesis. At its core, the thesis is intended to give seniors a chance to synthesize what they have learned through the years, demonstrate college level scholarship, and develop and complete an original process or product that contributes to the greater field of academic study. Seniors are asked to find mentors (individuals considered experts in the field); 60% of the respondents indicated that they had served as mentors.

**Post-Implementation Survey**

This survey sought to gauge the extent to which participants’ STEM knowledge increased during the STEM-program implementation; whether participants incorporated active learning teaching strategies; and how participant attitudes were impacted concerning STEM and its
required elements. The survey was distributed to the 28 senior teachers (one teacher who had completed the first survey was no longer teaching at the school) with 22 responding. The first question asked participants to identify their current level of their STEM knowledge. The responses are provided in Table 4.4.

**Table 4.4**

*Results for Post-Implementation Survey Question 1*

<table>
<thead>
<tr>
<th>Knowledgeable Level</th>
<th>Extremely Knowledgeable</th>
<th>Very Knowledgeable</th>
<th>Knowledgeable</th>
<th>Somewhat Knowledgeable</th>
<th>Not Knowledgeable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.5%</td>
<td>31.8%</td>
<td>54.5%</td>
<td>9.1%</td>
<td>0%</td>
</tr>
</tbody>
</table>

The next series of questions asked respondents how often they utilized various STEM elements. All questions asked teachers to consider practices specific to the current school year (2018-2019) and how often those practices occurred. No question concerning interdisciplinary PLCs was asked because it was a mandatory requirement. The responses are categorized in Table 4.5.

**Table 4.5**

*Results for Post-Implementation Survey Questions 2-5*

<table>
<thead>
<tr>
<th>Learning Type</th>
<th>Daily</th>
<th>Weekly</th>
<th>Monthly</th>
<th>Once a nine weeks</th>
<th>Once a semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inquiry-Based Learning</td>
<td>22.7%</td>
<td>40.9%</td>
<td>27.3%</td>
<td>9.1%</td>
<td>0%</td>
</tr>
<tr>
<td>Problem-Based Learning</td>
<td>13.6%</td>
<td>27.3%</td>
<td>31.8%</td>
<td>13.6%</td>
<td>13.6%</td>
</tr>
<tr>
<td>Product-Based Learning</td>
<td>22.7%</td>
<td>54.5%</td>
<td>13.6%</td>
<td>4.5%</td>
<td>4.5%</td>
</tr>
<tr>
<td>Interdisciplinary Projects</td>
<td>0</td>
<td>13.6%</td>
<td>18.2%</td>
<td>22.7%</td>
<td>45.5%</td>
</tr>
</tbody>
</table>

The third series of questions assessed teacher attitudes toward teacher efficacy and knowledge. A 5-point Likert scale was used. The responses are detailed in Table 4.6.
Table 4.6

*Results for Post-Implementation Survey Questions 6-7*

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interdisciplinary PLCs enhanced/reinforced STEM knowledge and its components</td>
<td>13.6%</td>
<td>63.6%</td>
<td>22.7%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Collaboration with other teachers has improved teacher efficacy</td>
<td>40.9%</td>
<td>50%</td>
<td>4.5%</td>
<td>4.5%</td>
<td>0</td>
</tr>
</tbody>
</table>

The fourth series of questions assessed current teacher attitudes toward STEM and the elements associated with STEM (i.e. interdisciplinary projects). The responses are categorized in Table 4.7.

Table 4.7

*Results for Post-Implementation Survey Questions 8-12*

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implementing STEM process into curriculum</td>
<td>36.4%</td>
<td>50%</td>
<td>9.1%</td>
<td>4.5%</td>
<td>0</td>
</tr>
<tr>
<td>Interdisciplinary projects</td>
<td>40.9%</td>
<td>40.9%</td>
<td>13.6%</td>
<td>4.5%</td>
<td>0</td>
</tr>
<tr>
<td>Engineering process</td>
<td>27.3%</td>
<td>54.5%</td>
<td>13.6%</td>
<td>4.5%</td>
<td>0</td>
</tr>
<tr>
<td>Cross-curricular learning</td>
<td>59.1%</td>
<td>22.7%</td>
<td>13.6%</td>
<td>4.5%</td>
<td>0</td>
</tr>
<tr>
<td>Active Learning</td>
<td>63.6%</td>
<td>27.3%</td>
<td>9.1%</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Interview Data**

The interview process consisted of 24 individual teacher interviews with a total of 12 interview questions; the interviews were open-ended and based on the pre-implementation survey and aforementioned research questions. In order to ensure that interview responses were interpreted accurately, an audio recording and journal were used. Interview times varied
between 20 to 40 minutes in length. Peer debriefing was used after the coding, and transcriptions were completed to ensure the process was conducted with fidelity. An impartial peer reviewer evaluated the methods and data to confirm the research was both valid and credible. Member checks enabled participants to review and confirm both notes and transcripts in order to ensure that responses had been interpreted correctly. Following member checks, one teacher requested that the interview not be included in the survey, so 23 interviews were then included in the research.

Interviews served as the primary source of data; however, triangulation was achieved by also examining the surveys, focus group responses, and classroom observation data. Interviews were conducted in November 2018 and December 2018. All subject areas, with the exception of English, were represented in the teacher interviews.

Teachers T and U interviewed at the same time. The subject matter of that interview focused on these teachers concerns regarding STEM.

**Interview Findings**

Data from the study was coded into various subcategories. Pre-set coding (i.e. Teacher A) was used to both identify the participant while protecting his/her identity.

*Interview Question 1: What is STEM?*

Vasquez (2014) suggested that STEM-learning provided an outlet for the barriers between subjects to be removed, allowing teachers to offer “real-world, rigorous, relevant” student learning. Gunn (2017) argued that STEM should focus on instructing students on necessary 21st Century skills – collaborating, questions, problem-solving, and critical thinking. Despite the STEM movement being a part of education for nearly 30 years, there seemed to still be some misconceptions among the staff at the beginning of the school year. Accordingly, to
begin each interview, teachers were asked to define STEM after having been engaged in the
STEM program implementation for four months.

Of the 23 responses, seven teachers simply answered using the acronym – Science, Technology, Engineering, and Mathematics; 5 of those teachers were within the STEM fields. However, the rest of the participants elaborated on STEM and its role within education.

From these interviews, several themes emerged: problem-solving, collaboration among students, and collaboration among disciplines (interdisciplinary). In terms of problem-solving, teachers recognized the role STEM played in helping students. This belief was highlighted best by two teachers. Teacher L believed STEM offered “a common ground in terms of the process we go through to problem-solve, and to develop the best strategy for solving whatever problem that we have in front of us.” Teacher R argued that STEM is also “about the process of collaboration and problem solving. So, it can be applied to, not just the sciences, but also more to the humanities and the literature.”

When discussing the interdisciplinary component, teachers expressed an evolving understanding of what STEM implies for educator collaboration. Teacher H noted that before the initial STEM meeting at the beginning of the school year that STEM did not “apply” to her subject; as the year progressed, so did her understanding, including the importance of collaboration. She concluded that teachers must use all the “elements that you can possibly exhaust in your classroom, and then as a collaboration between you and another department to bring up the students’ education to a higher level for them to be like ‘Oh, hey, I can use this in this class and this one, and not just in this class alone.’”
Interview Questions 2-4: What are inquiry, problem, and product-based learning?

Inquiry, problem and product-based learning are all facets of active learning, which is a form of learning that engages higher order thinking. Active learning within the classroom provides a dynamic atmosphere where teacher and students are mobile, students collaborate, and the instructor supports student-learning (Phillipson, Riel, & Leger, 2018). Teacher responses in defining the facets of active learning reflected various levels of understanding.

As teachers defined the three terms (inquiry, problem, and product), nearly half offered analogies, extended definitions, or specific examples of those types of learning implemented within their classrooms. These teachers reflected an understanding of how these types of active learning functioned within the classroom. Teacher B stated that the structure of his course has changed this year and noted that “more inquiry that has gone on in this semester, and I found out I'm able to do it more effectively by using excerpts as opposed to a larger document.” Teacher B then furthered his explanation by offering some of the specific strategies he used within the class. Teacher H, in defining the terms, detailed that because of the nature of her courses, all three types of learning played an integral part to the classroom setting. She noted that while she teaches the “basics,” students take that knowledge “and run with it”; her specific philosophy is to “guide [the students]…to advance…and get a better understanding based” on their investment and work on the assignment. Of the 11 teachers who offered detailed definitions, Teacher P was the only teacher who used the word “scaffold” to describe active learning: “This [learning] is based around giving students a concept or a problem after having already scaffolded the general knowledge they need so that they can go look at a problem and determine an effective answer to it.”
While the term “active learning” has been a part of educational jargon since the early 1990s, the interviews revealed that not all teachers were able to confidently define the terms. Four teachers fell into this category and used qualifying or negative language prior to offering an explanation. Specifically pertaining to product-based learning, Teacher K responded, “Product-based, that one I'm not quite as sound on. Maybe, in my opinion, if I want to do more research on it, it would be maybe …we're trying to figure out how do we fix those problems.” Both Teachers F and Q, while offering solid definitions for both problem and inquiry-based learning, were not confident in their answers: “Okay. So, an inquiry based learning, and this is not perfect, but you have a question that you want to solve or explore in greater depth…I guess” (Teacher F); “I guess that's what I would say” (Teacher Q). Teacher E, when defining inquiry-based learning, offered “Using one's knowledge in order to, oh gosh, yeah sorry, the knowledge that one attains I guess from a specific topic.” One teacher simple responded, “Product based, I haven't heard of” but went on to say concerning the specifics of her classroom curriculum that “it is not about the joy of [content area] or discovery or anything like that. It's just they need to have the skills they need to pass that exam. Well, I guess that would be product based, wouldn't it?” (Teacher A).

One theme that emerged from these three questions was that a quarter of the teachers viewed inquiry and problem-based learning to be synonymous. Teacher S noted that active learning is what “every scientist, a good scientist does. They have a question and they're trying to answer the question. It is an approach to learning. It is an approach to problem solving, which is why problem solving and inquiry are synonymous for me.” Teacher G suggested that “inquiry-based learning is essentially an exploratory style of learning where you ask a lot of questions. I think that's pretty closely tied to problem solving. I think those two are pretty linked, because problem usually result in inquiry.”
**Question 5: What role do you see active learning playing in a classroom curriculum? Are they an important component to any classroom?**

Repinc & Južnič (2015) suggested specific benefits when active learning is an integral part of a classroom; when active learning is both multi-tiered and interdisciplinary, students make connections to different subjects, think critically, and work collaboratively. All teachers responding to these questions saw the value of active learning within both their classrooms and others. Teacher C remarked that in her classroom “we're constantly creating a product and figuring out what works and what doesn't work. Asking ourselves specific questions, what we have to do in order to create the product that we envision and that we imagine…so that has a lot of layers of revision and all that kinda stuff. And letting them try to figure that out too, instead of just telling them. But giving them tools to help them figure out how.”

Several teachers specifically mentioned the value of active learning both for the teacher and the students. Teacher E offered a personal insight into why active learning was so important within the classroom: “I'm hands on. If I don't do it, I don't get it.” Teacher S noted that as a whole “We don't learn by hearing. We learn by doing.” Teacher R commented that his opinion concerning active learning was not simply based on research but also personal experiences which has “only strengthen that idea that that is how we learn. We have to be active, and we have to be reflective in what we do, so that we have that true understanding.”

Two teachers specifically mentioned the role of direct instruction in tandem with active learning. Teacher X commented that “I think those are essential part of the learning. You didn't mention lecture, and reading, and some other things, so I don't want to exclude those, but if I had to put a percentage on it, 50% or more ought to be those kinds of things.” Teacher P communicated perhaps the strongest opinion concerning active learning offered by all the teachers:
I think direct instruction has been land blasted way too much, but I think it is crucial for building the base that students need so they actually can do inquiry-based and problem-based learning in the first place. I think kindergarten should be heavily inquiry and problem-based. I think students should be developing knowledge for themselves. I think direct teaching should be more limited in elementary school based on what students need to learn and then you should allow them to explore freely in order to gain a stronger knowledge base within something like science. Or for my son, when it comes to science, what he really is really interested in is zoology and paleontology. And so if there was science curriculum and he was allowed to really focus on those, he would excel because that's what he's really interested in. He can gain a lot more knowledge with that. Simply giving him a topic and filling his head with information I think is incredibly ineffective at that age. I think direct teaching has a better place as students get older and older but even so, it should not be the sole focus of any classroom.

While all teachers, as mentioned above, positively responded that active learning had a role within the classroom, there were teachers who noted the challenges of doing so, especially within the confines of an Advanced Placement course. Teacher D said, “I have tried to implement, well, I do try, to implement those in my room…It's really hard. It's really hard [in conjunction with preparing students for the AP exam].” Teacher F indicated that “In an ideal world our learning should be completely these things as we move to an age in which information is easily or readily available…It's important to have these things. However, when you have a[n] AP class, it is very typical not to [do these things] because these things take a greater amount of time…realistically in my classroom I'm not taking any of my class time. Not in AP.”

Another challenge teachers noted was using active learning as a bridge to create collaboration between departments. Teacher L suggested that because of the wide range of classes offered at the school “that we also have very specific courses that don't have somebody else to collaborate with…I think we, sometimes we get in our classroom and we shut the door.” Teacher M noted that having active learning occur on a grand scale is “hard to do.”
Question 6: Prior to the 2018-2019 school year, had you ever collaborated on an interdisciplinary project? 35% said either monthly or a couple of times a semester; 35% said twice a year, and 30% said never. Considering the school’s environment, what are your thoughts concerning those percentages?

Interdisciplinary collaborations ask professionals to incorporate their unique insights and integrate them with other disciplines in to develop a fuller understanding of the question or problem at hand (Greef, 2017). In response to this question, 65% of the teachers were not surprised by the results. Several themes emerged from participant answers: time constraints, AP constraints, and isolation. Teachers A, I, Q, R, and V all specifically mentioned how lack of time directly impacts teachers’ abilities to create effective interdisciplinary collaborations. Teacher A noted that both “time constraints” and “timing interruptions” directly correlate to the lack of interdisciplinary crossovers. Teacher I suggested that the issue of time is “tricky because when we try to fit more into a day without extending the hours of the day – and that's what happened when we switched from our former platform of six classes a day to seven a day – you're trying to rush through that curriculum and you have less time with the students between the beginning of the year and the end of the year.”

Teacher Q offered a very transparent reason to why he doesn’t participate in cross-curricular collaborations, that while he does want to collaborate, he “hardly has time” just for his classes. Teacher R noted he too would like to have more cross-curricular connections because it would enable him to “get other perspectives and ideas,” but “the barrier of time” even impacts his ability to sit down with other members inside his department: “Even during our planning time, or designated PLC time, we're limited. You know we have 10, 15 minutes to give, because we have to get back to our rooms to finish up with last minute planning, or finish with grading.”

For AP teachers, the limitation on interdisciplinary collaboration was due to a combination of both time and content. Teacher B noted that, in the context of AP classes,
because the content is “dense and heavy,” time becomes critical. Teacher B acknowledged the benefits of the interdisciplinary connections and “if I had my druthers, I would…but there is just not that time.” Teacher V did not note whether he had or had not ever collaborated; however, he shared that he would not collaborate because of the AP course he taught: “there’s just not time to do it.” Teachers A and F admitted that they fell into the “never collaborated category” because of the rigors and demands of preparing students for the AP test.

The third predominant theme which emerged from the 65% of teachers who were not surprised by the results was that of isolation. Two sub-themes emerged from this category: understanding what other teachers were doing (i.e. content, standards, objectives) and being in a rut or classroom bubble. Teachers A and I each noted how not being aware of other teachers’ constraints directly impacted interdisciplinary collaboration. Teacher A said, “nobody truly understands what the other teacher's going through with their time constraints and what their objectives, and then to try to mesh it [with someone else’s curriculum].” Teacher I noted that “it's hard to really get a good picture of what your colleagues are doing that might tie into [what I am doing].”

Regarding issues concerning being in a rut or bubble, Teacher J stated, “Teachers by nature, in my limited experience, are somewhat territorial, and collaboration with other teachers in certain areas are difficult.” Teacher S believed that some teachers “are very stuck in our paradigm of, I'm a great lecturer and I'm always going to lecture, and that's sort of the old school.” Teacher K asked how certain subjects could even crossover and expressed doubt of subjects being able to do so (i.e. how do subjects like P.E. and Personal Finance collaborate). Teacher W spoke of the excellence of each department within the school but felt that “sometimes
there's not as much of a push or a need, maybe from an internal perspective, to collaborate with others.”

Several teachers were surprised by the results. Only one teacher was surprised by the percentage and assumed more collaboration was occurring. When asked why, Teacher C responded, “Because I think that all of those things work together in order to help the kind of students that go here…top-notch students that's performing well in almost everything that they do.” One teacher was surprised because he thought the percentages were too high. Teacher G remarked, “I'm kind of surprised to hear that we do as much as at least a third frequently, and two-thirds at all. I think that's surprising to me. My understanding of teaching…there was quite a clear delineation between the subject areas.”

Almost half of the teachers specifically mentioned previous collaborations when discussing interdisciplinary projects. Two teachers, Teachers B and X, noted previous collaborations had been inconsistent. Teacher X said, “The fact that I did it eight years ago doesn't mean that I'm doing it every year, or multiple times a year, certainly. So as an example, I collaborated with [another teacher], but I haven't done anything with the new teacher….So that's one of the problems.” Teachers M, S, and W mentioned moments where the cross-curricular collaborations were happenstance and occurred when students made the connections between courses first. Teacher M commented, “I've heard of things that a lot of them [teachers] are doing. The kids are talking about what they're doing in class. There's connections being made as things come … I've even had teachers come to me and say a student said that what I'm teaching relates to something they've learned before…And so we then talk about the connection ourselves.” Teacher S noted that “The kids who will come in and say, "Oh, we did this in [this] class, in biomed or in engineering…that we ended up doing over here. We could probably do a
better job of aligning with those folks. Teacher W mentioned that when the collaboration develops from by chance into something intentional she loved, “seeing the reaction on the students’ faces ’cause they're like, whoa! we learned that in another class.”

**Question 7: What value do you see interdisciplinary projects playing in your curriculum?**

Perhaps the biggest gain for students is the opportunity to expand traditional “discipline-defined” boundaries by making cross-disciplinary connections. By creating interdisciplinary lessons or units, teachers provide students with the opportunity to take information from one field of study and make applications to another field of study, and when this happens, students discover that learning is multi-faceted and multi-disciplined (Saunders & Ingalls, 2013). All teachers responded positively to this question. Several themes emerged during the interviews: training, time, and benefits. One teacher specifically mentioned the need for training and resources in order to effectively incorporate interdisciplinary projects within the classrooms. Teacher A asked, “These ideas sound great, but how do you implement them and where do you find resources to show you how to implement them? But it's just not knowing how to do it.” Teacher I and K simply noted that training was needed.

Time continued to be a concern for five teachers, all of whom teach AP courses. Teacher I, while recognizing the value of interdisciplinary projects, believed that, “time constraints and the lack of familiarity maybe with other people's curriculum” is part of the hurdle in effectively incorporating interdisciplinary projects. She subsequently stated that as teachers we need to ask “am I doing it for the sake of learning?” Teacher M believed the time constraints with AP directly impacted instructional choices within the classroom. One AP class, because of the workload, “they don't even have snow days. They have to work on snow days.” Any interdisciplinary
connections are made outside of class, which she said is “So kind of sad, because there’s a lot of fun things to do with [this subject].”

When specifically mentioning the benefits of interdisciplinary projects, Teacher C noted that “just the comradery, and knowing what’s going on in the other classrooms” is a benefit of working with other teachers. Teacher D remarked that the benefit of interdisciplinary projects extends beyond the high school classroom: “Knowing computer science will make them a better doctor, and knowing computer science will make them a better whatever and that without knowing computer science, you will get left behind in whatever field you’re in.” Teacher J stated, “It completes the story because not everything happens in a vacuum.”

Teachers acknowledged they might make an effort to highlight interdisciplinary connections within their classroom but would not necessarily create interdisciplinary connections with a teacher in another department. Teacher M noted that “they’re getting connections big time in that. I feel like as we go through the AP curriculum, I actually like it. It has connections within it automatically… We’re making connections.” Teacher V echoed similar thoughts to Teacher M in terms of the curriculum already making interdisciplinary connections, but noted that finding the time “getting them ready for the test” and also trying to sit down with other teachers to see “would fit in to my curriculum” is the biggest challenge. Teacher G presented several interdisciplinary connections within his classroom because he “believe[s] in the power of transfer and making those connections.” When asked if he had collaborated with teachers in other departments to help aid his lessons, whether in English or Foreign Language, he responded in the negative.
**Question 8: Have you ever participated in an interdisciplinary PLC before this school year? If yes, was it valuable? Why or why not? If no, do you think they could be valuable? Why or why not?**

All teachers believed that interdisciplinary PLCs were valuable at some level with the exception of one teacher who chose not to answer. However, only a few had actually participated in an interdisciplinary PLC. Three teachers indicated they had participated in an interdisciplinary PLC at the school being studied. Of these teachers, one teacher defined interdisciplinary PLC as being the meetings held during in-service days; one teacher defined interdisciplinary as possibly being with the same department but different focuses. Five teachers said they had participated in interdisciplinary PLCs at previous schools. All other respondents indicated they had never participated in an interdisciplinary PLC.

Teacher E noted that “I think we always talk about it, but it just doesn't happen”; she believes that time is the biggest hurdle for interdisciplinary PLCs: “I think sometimes you get bogged down and you think, oh my god I don't have time to do this extra whatever it is. I think time really is the biggest issue. I think we all are willing to work together.” Teacher F believed that interdisciplinary PLCs are beneficial because “it just helps to talk to other teachers about instructional strategies… it's good to be reminded…of what to do, because there's so many things for us to do.”

Multiple teachers, while recognizing the value of interdisciplinary PLCs, voiced concerns. Teacher G offered an honest response of interdisciplinary PLCs feeling like “just one more thing to do”; while he sees the value of working with other colleagues, he does not want to take time away from opportunities that will help him in his subject area. Teacher J believed that the primary challenge of interdisciplinary PLCs, specifically at the school being studied, was because of the high level of classes offered and testing accountability. Teacher P argued that
interdisciplinary PLCs are “highly valuable” but qualified his statement that they must be well-coordinated: the danger of ill-constructed interdisciplinary PLCs is that collaboration disappears and “it becomes more of a faculty meeting.” Teacher W believed that interdisciplinary PLCs often did not apply to her content.

Questions 9 and 10: Prior to this school year, did you see yourself as a STEM teacher? Based off our meetings this year, has this perception shifted or been reinforced?

In response to the first question, the results were almost evenly split between teachers identifying themselves as STEM teacher and those who did not identify as STEM teachers. While most responded with one word, several expanded on their answers. Teacher A, whose content areas would fall under the STEM definition, believes she is just a teacher in her subject. She stated that “I am very much about content, not about expanding science, technology, engineering and mathematics.” Teacher R offered that he does his best to “integrate from other fields but definitely [is] not a STEM teacher.” Teacher I believed that she was a STEM teacher but only on a “superficial and limited basis.” Teacher O empathically stressed that “I do see myself as [a STEM teacher]” but did not believe that others within the school did.

The majority of teachers responding to the second question indicated that their perception has either been reinforced or shifted during the current school year. Part of this year’s in-service and interdisciplinary PLC meetings have been intentionally designed to help teachers better incorporate active learning within the classroom, examine the engineering process as teaching method (ask, research, imagine, plan, create, test, and improve), and effectively collaborate with other disciplines. Several teachers who had not seen themselves as STEM teachers elaborated on their shifts in perception. Teacher C stated, “I realize that it’s something that I think is important and that I want to do with my kids.” Teacher Q said that she sees herself “a little bit” of a STEM teacher and is beginning to make interdisciplinary connections more consistently. Teacher R
recognized that his content area is “not an individual endeavor. You need other people to communicate with and work with. So, I guess that falls into place pretty well with the ideas of STEM.”

One teacher who had previously believed he had not been a STEM teacher demonstrated how his perception has shifted during the current school year. During the interview, Teacher B stopped to aid a student who had walked in. While the teacher and student were conferencing, both modeled elements of the engineering process. After the student left, the teacher remarked that he now sees himself as a STEM teacher because he has become more aware and has “identified some things that I saw in class.”

Three teachers who have always considered themselves as STEM teachers offered insight as to why their perceptions have been reinforced. Teacher M noted that “I'm doing better [with interdisciplinary elements]... I can see in the next year or two even, really being able to do a lot better with that because I'm going to be purposefully thinking about it more.” Teacher W felt validated in what he has always been doing within the classroom, but like Teacher M, recognized the need for more interdisciplinary collaboration: “It's also encouraged me to be more intentional about seeking out those opportunities with other teachers, which is very fun too.” Teacher X stated: “The meetings we've had actually created me a sense of being more of an Evangelist for STEM and encouraging STEM among the other teachers.”

Four teachers responded that their perceptions have not shifted at all during the current school year. Teacher P qualified his answer and said in one class, because of content, he felt that he was a STEM teacher, but in his other classes, because of content, he did not feel he was a STEM teacher. Teacher G simply said, “I don’t.” Teacher O commented that “I feel like I'm doing the same thing. I mean, I see other people being more focused on it, which is good, but I
don't feel like I'm doing anything differently.” Teacher V, who considers himself as a STEM teacher, does not believe that his perception has shifted, especially when it comes to incorporating interdisciplinary projects: “I don't. I mean, we tend to be stuck in our own little groups. The people that I talk with, day in and day out, are mainly the science teachers. I think there's some that are actively trying to reach out and do some of that. There's others, like myself, that I'm trying to improve my AP scores”

Question 11: How do you think the staff as a whole feels about the STEM program implementation, interdisciplinary projects, and interdisciplinary collaboration?

Of all the questions asked during the interview, the final two questions (11 and 12) received the most response from all study participants. For question 11, teacher responses reflected predominately mixed responses (they offered both positive and negative reflections) with one teacher who was solely negative. For those teachers indicting mixed reactions, several key themes emerged which were negative in nature: stress, time, burden, and relevancy.

Part of the stress stems from the fact that STEM implementation equals change; something Teacher C specifically noticed that “some people are struggling with.” Teacher I believed that there is an added amount of pressure because the school is a magnet school: “I think the pressure that's there, of the expectation of what it looks like to hit the levels that are required by state testing to maintain your status, yeah, I think that's there. I think that's heavy on people, that they can't, because the students already come in at such a high level, it takes so little for that to go in the negative direction. I think there's a lot of pressure from that standpoint.”

Regarding burden, Teacher D remarked that when the STEM program was first implemented there was “Confusion and [then] pushback because it seemed like it was so much more that we would have to do.” Teacher F believed that “I think that it's just difficult for us to have a positive attitude in that we have so many other things on our plates that we have to excel
at, that this is just one more thing.” Teacher K believed that both stress and burden are factors: “I think they're [the staff] a little apprehensive, and I say that not because they don't know their stuff because they do. This is a great staff...I think they're apprehensive in the fact that they're probably thinking, in the back of their mind, ‘This is one more thing we have to do.’ And it's already a lot of pressure on us to get the kids where we want them anyways.” Teacher O simply stated that his department “just feel like it's more to do.” Teacher W noticed that the staff seems to be “warming up to it. I think at first there is just the initial shut down, shut back, like I don't want to do anything new, but I think that's the nature of change.” Teacher X noticed that “there are pockets of resistance, as there are with any change.”

Several teachers addressed the time constraints. Teacher D said, “I think that we teach a lot of interdisciplinary things without actually doing the collaboration and I think it's, one, because we're all so crazy-busy.” Teacher I noted that “But there's still that struggle with how to tie it in time wise, and how do you not sacrifice the curriculum that you need to cover while building in additional projects?” Teacher M remarked that “The time makes us all nervous, because we are pressed for time automatically. I think that would be probably the most scary part of it. And stressful. It makes everybody stressed and it's just something else that we got to do...added along with everything else.” Teacher P argued that “Lack of dedicated time is a big issue. That's a major problem for all teachers.”

Some teachers questioned the relevancy of the STEM program. Teacher F suggested this belief varies by department. If the content area is not a tested area (i.e. end of course exams or AP), “they can have a negative perception.” Teacher H commented, “They don't really teach you this in college,” and when it comes to the application, especially within her content area, her
department believes, “We can't do much of this. We'll leave it to the science, math and English people and the technology people.” Teacher A stipulated:

I think teachers are just tired of it. You know. I think here's the new thing. Okay. Here's now what we've got to do. Then three years from now it's gonna be something else, and we're all gonna have to collaborate and show our interest in whatever, fill in the blanks. So I think teachers are numb, and I think they're just going through the motions. I don't really know, you know, what is the benefit of it, except to say we're a certified STEM school? You know, will that improve their life skills? Will that improve their ability to get into a college they want, to get scholarships they want? Does it make the educational experience deeper, or do we just have something we can stamp on our door saying we're a STEM accredited school? When we were submitting ideas on interdisciplinary, we made them up. Okay? Because we can't make it happen. Okay? We don't know how to make it happen, so we said, Here's what we did. And we didn't do it.

For those teachers indicting mixed reactions, two key themes emerged which were positive in nature: value and intentionality.

Teacher C observed that she has already done two interdisciplinary projects with other teachers and believes some teachers “really motivated and seeing the value in it.” Teacher D said “I think that, really and truly, a lot of teachers already do things that touch on other disciplines, but without the collaboration part.” Teacher G stated that teachers were “very onboard with the philosophy behind interdisciplinary learning. I think that we all, if we've all done our teacher training, can acknowledge the value of transfer and making those connections with our kids and with each other. Doing the English activity and the math activity, it branched me out. It helped me look at things a new way.” Teacher I brought in a new aspect of the value, remarking that “I think most of our colleagues find multiple disciplines interesting” which was why there was a deep interest in the STEM implementation.” Teacher R remarked that because the staff is “friendly, open and easy going … overall [we’re] pretty accepting in that we're open to sharing ideas. Whether it's a complaint, or it's a way to make something better. I think that kinda chemistry that we have here.”
Regarding intentionality, several perspectives were offered. Teacher H believed half of the faculty was very “excited” and “responsive” about the STEM program implementation, and intentionally found ways to make interdisciplinary connections. Teacher J suggested a common goal for the school and keeping stakeholders informed; by being intentional, the school would inform students “that one class can lead to another… Let the kids know what we're doing because if we're doing it for them.” Teacher K reflected a similar mindset of being intentional with interdisciplinary crossovers: “I think if it’s rolled out correctly and shown that, hey, it’s going to make life a little easier [to make connections]” Teacher S saw the STEM implementation as an opportunity to be “purposeful, you know, stumbling upon something that we actually overlapped versus purposefully intertwining your learning objectives with our learning objectives in the way we teach them.”

Teacher W believed that once teachers understood what the STEM implementation meant, teachers saw “we are actually already doing this, let me think through the way … and then in places where I'm not doing it, how can I better address the processes that we're teaching our students?” Teacher X offered a similar observation, that once teachers understood the elements of the STEM implementation teachers were “excited about it because they already use it…teachers are using project-based learning and inquiry-based learning. All that kind of stuff. So as far as across the board, I think it's probably positive, and the more they understand the scientific approach to things, the STEM approach to things, the more on board they're gonna get.”

Question 12: How do you see the senior thesis fitting into STEM and associated interdisciplinary components?

The senior thesis serves as a capstone to the students’ education and is designed to be collaborative and cross-curricular. All teachers responded both positively and in-depth when
answering this question. Several key themes emerged from these conversations: higher-order thinking, mentors, and interdisciplinary connections.

In terms of higher-order thinking, Teacher A believed that the senior thesis was the culminating project that empowers students “put it all together” and the thesis becomes a “thing of beauty [which] is really a definitive of magnet school and something that helps them, because that's gonna translate to everything. Can you put a research project together that shows here's the problem, here's how I worked through, here's how I researched for it?” Teacher E also remarked that students take existing problems and collect “data that either comes from experiments or research. They have to look at that” and then to add to the current academic conversation.

Teacher G saw the thesis as:

a really good product that has those three components of inquiry, problem solving and product. So, it's a really cool capstone to their time here. I think the fact that it's this very extensive research paper, it has to include a scientific method, it has to include English, and then it has to include whatever subject area that they're researching and doing this work on. So, I think it is a really cool coming together of all of those things… I think that there's something to be said for teaching all of our kids that high level of inquiry in whatever subject they're pursuing.

Teacher L noted that the senior thesis requires students to ask “How do you synthesize it all together?...And then, to see how that all comes together to formulate the thesis.” Teacher S stipulated that the thesis allows students to inquire about real-life problems, how to possibly solve those problems and in the process allows students “to be more engaged” in their learning.

Teacher I offered insight into how she thought the senior thesis aided students: “I think it's a great, very practical way for them to be tying in multiple disciplines, because it is exactly what they'll have to do in their university studies, and very likely in their careers as well.” Teacher R also identified the senior thesis as being a perfect outlet for higher-order thinking skills and real-world skills: “no matter what kind of thesis a student undertakes, they have to do a lot of investigation and they aren't secluded to just one area. They really have to explore multiple
fields. That's what makes it real. That the world isn't piece by piece, it's a very complicated web. So that's what the thesis is able to do. It's a lot of work they have to do, but with good reason. They realize that the world is not simple. The world is not a textbook, and the world is gonna kick your butt. So, you gotta do the work to gain understanding. And be able to demonstrate that understanding.”

As teachers define their roles within the senior thesis, the idea of facilitator emerged. Teacher A believed that “But that senior thesis, to be able to make that a well-oiled machine, where we really put together the theories of inquiry product base, all that, interdisciplinary elements.” Students must collaborate with teachers and teachers are “a mentor, a coach, or whatever, and that is awesome.” Teachers B, C, and D saw their roles in the senior thesis as an expert students could come to for help. Teacher B acknowledged that he is a “mentor” and Teacher D not only acts as an advisor but connected a student with an expert outside of the school to act as an additional mentor. Teacher P remarked that “So I'm working with one group in particular. I'm working with a pair of students right now and I see that as being a very important, a vibrant part of what they're doing at the moment because they have a pretty in depth, psychological experiment in the works. The big thing they've been talking to me about has been experimentation. How to appropriately ask questions? How to effectively write a survey? How to get subjects? How to do all of that in an ethical fashion?

Teacher F believed that not only do teachers acting as advisors help students but creates a sense of “interdisciplinary collaboration.” Teacher J echoed the idea of interdisciplinary collaboration and argued “all of our thesis stakeholders that are doing this have their hands in multiple disciplines.” Teacher M viewed the senior thesis as “STEM on steroids… Because every student is getting to do their own inquiry problem. I mean it's like they're doing their own
thing. I love to go and see their projects at the end. I mean it's like all of it in one thing. And everybody doing it separate. So they're working with their teachers. They're working with their community. And it's so interesting. Things I hadn't even thought about. I learn from the kids so much in those times.” Teacher W commented that the thesis allows students “to choose something that they're interested in, and that very well could pull from multiple components, multiple departments. It's really neat for me to be able to think back on some of the language presentations that we've had in the past that have either dealt with, not just language learning, but language and demographics, or language and health. And so I think a student naturally, because of the way the thesis is built, will naturally pull from different disciplines in order to get the research that they need.”

**Sidebar Conversations**

Each interview was based on the pre-determined interview conversations; however, there were times when conversations addressed other facets of the STEM program implementation. Several teachers specifically spoke to the benefits that have resulted from the program implementation. Teacher C said “this whole thing I’m thankful for, because I did get to meet someone that I may never have talked to and we went and did something together with our kids.” When asked if he felt that he used the engineering process in his classroom, despite not being a STEM classroom, Teacher Q responded, “This very morning, I had conversation with some students about the scientific method and its place in history, from Descartes and Bacon and how they questioned everything. And we were talking about that with history, how you know ... how do we know what we're taught is true if we don't have proof, anyways, dealing with forming hypotheses and going with your best information but maybe not taking something as the gospel truth until you have some type of source, multiple sources that are quoting the same thing.”
Two teachers addressed elements of fixed and growth mindsets. Teacher O believes refusal to see the power of active learning is “an antiquated way of teaching, and I think it's, in a lot of ways a bad way of teaching, because when we connect our subject matter with other disciplines we show the validity of it, we show how everything works together that we need to have, you know all the disciplines together, that one discipline isn't an island. And, that's why I don't understand is why we're still teaching that way, I'll be honest with you, but that's the system, and yeah, I get that. But, myself, as a teacher can change that in my own classroom.”

Teacher L suggested that one barrier for teachers getting out of their fixed mindset, especially in terms of interdisciplinary collaboration was “we figure out our way of doing things, and some of them, we just stick in those ways, and I mean, to me, I think we should always be evolving, right? Always being better and improving our craft, but also, at content….So, maybe it's a lack of understanding of the other subject. Like, we can't see those connections until we get together and start discussing them.”

Focus Group

The focus group was comprised of the five senior teachers who have been involved in establishing various elements of the STEM-program for more than two years. The researcher asked questions developed from the pre-implementation questionnaire and teacher interviews. The focus group interview was conducted on December 20, 2018 and lasted 45 minutes. In order to ensure that focus group responses were interpreted accurately, an audio recording and journal were used. Peer debriefing was used after the coding and transcriptions were complete to ensure the process was conducted with fidelity. An impartial peer reviewer evaluated the methods and data to confirm the research was both valid and credible. Member checks enabled
participants to review and confirm both notes and transcripts in order to ensure that responses had been interpreted correctly.

**Question:** So where do you think the disconnect is, as far as seeing the value between the act of learning but yet not being able to interdisciplinary collaboration? Do you think as a school we don't inherently see the value?

Teacher 1 believed that the school as a whole sees the value of interdisciplinary collaboration but acknowledged time is an issue, a theme that also emerged from the individual teacher interviews: “because of everything else we're involved in, we don't have the time allocated, and when we do have the time allocated, it's OK, we've got a meeting for you to go to…instead of ‘Hey, this is your time to collaborate.’ We need more time to collaborate first, and once we can collaborate, once we go through that process, then we can document what we've done.” Teacher 2 added that “there appears to be such a focus on data collection and documentation and evidence, so even if we're doing it, then you have to sit down and take notes on what you did, or you have to make copies of what you did. There always has to be something extra that goes along with it, and I do, I think it's a time.”

**Question:** Do you think, too, there is misconception about that STEM inherently is, as far as teachers here? When I did my interviews, and I interviewed 24 teachers, and my very first question was, What is STEM? Over half said just the acronym. They could not define exactly what STEM meant. Why do you think that is?

Teacher 3 believed that STEM “is still looked at as vocational arts… And they build stuff down there…And they don't look at it as a problem-solving class that could be across the board.” Teacher 1, however, disagreed, and offered that “Science is more exploratory, experimentation, research-based, so it's more of a STEM.” Teacher 3 conceded the point and offered that perhaps the misconception came from a lack of education: “if you educate everybody on what it [STEM] is, what the process is, what we call it, and then identify certain things that they do in the
classroom, which we did in one in-service, then they kind of understand that.” Teacher 2 offered further thoughts about education: “I feel STEM is, I don't want to say fairly new, but at least, see I graduated years ago, but the acronym is fairly new, and I know when I was growing up, it was never mentioned, and now…it's brought up all the time. It's STEM this, STEM that. So I think that depending on when you were educated in education, it might depend on your full understanding of it. So if they [teachers] were to go back through education now, it's probably pushed a little more, and then you understand that it is more than science, technology, engineering, and math.”

*Question: Why do you think the interdisciplinary collaboration is challenging? Take time out of the equation. What do you really think it is?*

Teacher 3 said time could not be eliminated from the equation:

> I can teach the concept in one class period with a whiteboard and be done in 47 minutes. Or I can do a project and be done in a week. And consider, did the class get what I needed them to get, in the 47 minutes, or did it take a week? If I can do it in 47 minutes, why would I spend a week doing it? But a project's gonna take you three to five days to get done, if it's a good project and it's meaningful. And that's something, that if I'm looking at hitting all these standards in a year, I can't spend weeks, because I'll only hit 36 standards as opposed to the 55 standards it might have.

Teacher 2 said that part of the issue was teachers viewed interdisciplinary collaboration as a “dog and pony show.” She then added that AP does impact instructional decisions. “But for them there's so much pressure on AP and then also the state standard tests, that when they see ‘Oh, we're gonna get STEM certified,’ it feels like another check in the box rather than fully understanding how beneficial it really is.”

The focus group suggested that the challenge to true success with interdisciplinary collaboration is a mix of factors. Teacher 1 said:

> Tying everything in together, like [Teacher 3] was saying ... in my AP class, I've got so much content I've gotta teach. I've gotta get these things covered. I've gotta keep the scores up. If scores go down, it's not good. And I would love to do these experiments. Because when I do those, the kids enjoy it, they have a great time, they get something out of it, but it takes up more of my time, where I could just lecture, cover the material some
other way to get through it… I would love to collaborate with other teachers…if I know we can do one project together, cover these standards, then maybe I can give in a little bit more.

When asked what would be needed to make interdisciplinary collaboration happen, two themes emerged: time and pre-set STEM lessons. Teacher 1 revisited the idea wanting time “to really sit down and talk through it and plan it out.” Teacher 2 noted that some school systems provide the content to their teachers. A benefit of that type of policy is “if one teacher is doing a STEM project at one school, chances are three other teachers are three other schools are also doing that STEM project, because someone created that project and gave it to them.” Teacher 2 acknowledged that the school allowed “much more freedom” in curriculum decisions but it does “limit us in terms of time.” This freedom, at times, is a “double-edged sword.”

*Question: How does the senior thesis in your mind, then, fit the criterion of STEM, the interdisciplinary collaboration, the ultimate interdisciplinary project?*

Teacher 2 noted that the kids “are actually thinking beyond just creating a project. They're thinking about consumer viewpoints, and they're thinking about economics. They're actually breaking stuff down and that's awesome. Teacher 1 added “seniors see these concepts being hit in the other disciplines.”

Regarding the senior thesis and the necessary collaboration, Teacher 2 believed teachers simply needed to recognize their expertise in their content areas and act as advisors for the students. When that happens, teachers become “a fantastic resource for them… a part of the STEM process, and [they] didn't have to do anything other than simply talk to them about their area of knowledge.” Teacher 4 reinforced the idea of teachers acting as advisors with the senior thesis and how it helped students make connections outside of the school: “These are also people that can give you a mentor in the field.”
Teacher 5 considers the thesis as an opportunity to reach out to the local university as well, allowing both students and teachers to make new connections:

I know we have professors over there who would love to reach out, who have reached out. Last year two students got a professor as a mentor. I don't know this professor from anybody I've seen in the world. They asked, and he said yes. But he said yes. The [university] has a new crop of professors who are young, and I think are looking to be able to help... But it's a valuable resource.

*Question: How do you think teacher's efficacy is or is not being impacted as we go through the STEM process? Do you see teachers maybe opening up and understanding that cross-curricular collaboration might be good and make me a better teacher?*

Teacher 3 believed that there is a group of teachers not comfortable at all with the interdisciplinary collaboration. Teacher 2, however, believed that these teachers “do it every single day.” She continued by saying

They feel like it's another check in the box, but they don't realize how much they're actually utilizing it. Because our STEM process is loosely based off of the scientific method and it's just problem-solving… So if you are defining the problem and then researching the problem, developing solutions, and then testing those solutions, that's it. And it's not that hard. If you see it on a sheet of paper and it's got all these words, it's gonna overwhelm you, but I think they're getting overwhelmed. I think they're probably more effective using it than they think.”

Teacher 4 added that sometimes the process is overwhelming and believed “there’s 20 things out there that were done last semester that they’re not realizing there was a connection.”

**Classroom Observations**

Eleven classroom observations were conducted. These observations were 20 minutes in length and only provided a snapshot of what was occurring within the classroom at that particular moment. In three classes, teachers lectured, using the aid of the white board to solve problems or a PowerPoint to introduce a new unit. Student behavior during these specific classes was mixed; some students listened and took notes, while other students appeared distracted.
In the other classrooms observed, teachers utilized various types of active learning. Two classes were engaged in problem-solving activities. Because of the nature of the activities, both students and teachers were engaged in discussion seeking to solve problems using various approaches. Three classes were engaged in collaborative, student-centered learning; students were assigned a task and asked to use the various skills within the group to solve the problem. The teacher floated between groups to aid students as needed. The majority of students were engaged in the process.

Three classes were designed where students predominately led the class in some manner. One class was engaged in an activity called Four Corners, where students had to move to various locations in the room to defend, challenge, or qualify their position to a statement made by the teacher, requiring students to justify their position, using evidence from the unit of study. Once the teacher posed the statement, he allowed the students to steer the discussion and offered minimal comments. Another class was engaged in a Socratic Seminar; students had prepared for the discussion prior to the class. When the teacher indicated that students should begin, one student asked a question to start the discussion. The final class observed was a class where students were working on a project of their own design. The teacher acted as a facilitator as students needed help.
CHAPTER 5: FINDINGS, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Summary of Study

The purpose of this qualitative study was to identify how high school teachers at a high-achieving magnet school, who have not traditionally worked on interdisciplinary projects, respond when a STEM program is implemented. The study sought to determine whether teachers’ attitudes shift when asked to collaborate in cross-curricular projects during a STEM program implementation, and whether that collaboration led to a shift in instructional strategies. Data collection included two surveys (pre- and post-implementation), teacher interviews, a focus group, and classroom observations. This chapter presents a summary of the problem, discussion, implications, conclusions, and recommendations.

Research Problem

Magnet schools afford students the opportunity to increase their academic achievement by offering specialized curricula. There is a large body of research that focuses on lower-achieving students engaged in a STEM program and the benefits of a STEM education. There are also studies that have specifically centered on specialized STEM schools and teacher beliefs about student ability (Tofel-Grehl & Callahan, 2017). However, minimal research is available for either high-achieving students or the educators who teach those students in schools that are already high-preforming and offer a rigorous curriculum (National Science Foundation, 2012).

Research Questions

1. How are magnet school teacher attitudes toward interdisciplinary projects affected during a STEM program implementation?

2. What are the nature and extent of changes in magnet school teachers’ use of interdisciplinary collaboration during a STEM program implementation?
Discussion

The research questions were answered through survey responses, teacher interviews, a focus group, and classroom observations. The interviews and focus group were recorded and transcribed. All of the responses were coded using open coding, axial coding, and selective coding. The following is a brief discussion of the categories identified through the coding process.

Knowledge and Training

Knowledge and training were a common theme for research question one, which was revealed through axial coding after open coding was conducted. This category indicated that educators’ attitudes toward interdisciplinary projects are impacted when knowledge base is increased and appropriate training is provided.

STEM

The first data collection set was the pre-implementation survey, which sought to determine a baseline of teacher knowledge concerning STEM and its components (i.e. active learning, interdisciplinary collaboration). Half of the participants indicated that they were either somewhat knowledgeable or not knowledgeable about STEM. Multiple teachers in their interviews noted that the first meeting when the STEM program was first introduced created confusion and frustration. Teacher expectations and student benefits were unclear in the first meeting. While teachers were not concerned about being able to teach their content, they expressed frustration in not understanding the specifics of the program implementation.

This frustration impeded teachers’ sense of self-efficacy. Without a clear understanding of why and how the STEM implementation would directly benefit the students and being unsure of their ability to effectively incorporate the necessary learning strategies into the classroom,
teachers resisted. However, as the school year progressed, teachers began to vocalize a stronger understanding of STEM and how it benefited students. Misconceptions that STEM was only from the science, technology, engineering and mathematics fields began to dissipate. The primary reason for the shift were the interdisciplinary PLCs and in-service meetings that specifically focused on STEM training and expanding teacher knowledge.

**Active Learning**

Teachers were asked to define the three broad categories of active learning (inquiry, problem, and product). While these types of learning had been mentioned during the interdisciplinary PLCs and in-service meetings, they had not been expanded upon, and during the interviews, teacher answers reflected various levels of understanding. Classroom observations, however, indicated that teachers are consistently incorporating different types of active learning as part of their instructional strategies. While teachers may not have been able to offer textbook definitions of inquiry, problem, or product-based learning, they were including these types of active learning in the classroom. Students were observed to be both problem-solvers and collaborators in a variety of activities.

**Interdisciplinary Collaboration**

On the post-implementation survey, all teachers, with the exception of one, believed that collaboration with other teachers improves teacher efficacy. Being cognizant of overlaps within disciplines is a value that teachers discern; however, one impediment faced by teachers when trying to create successful interdisciplinary collaborations is not understanding how to do so effectively.

It is necessary when beginning a STEM-program implementation to provide practical, applicable examples of interdisciplinary projects. One teacher noted that students are given
exemplars and rubrics when beginning new assignments; for teachers beginning a new process, guidance is good and examples are better.

Teachers did not know what other teachers were doing in their classrooms, which was also a hindrance. Teachers recognized the value in ensuring that students made connections with other disciplines. During their interviews, many teachers noted that they make interdisciplinary connections within their classrooms, but they do not collaborate with the teachers in those other disciplines. A major component of the lack of knowledge stemmed from not having the time to meet with other departments. Departments have common planning during the school day; the only time for teachers to meet with other disciplines are on in-service days or outside of the school day.

**Cost Benefit**

Cost benefit was a common theme for research questions 1 and 2, which was revealed through axial coding after open coding was conducted. For research question 1, this category indicated that educators’ attitudes toward interdisciplinary projects are impacted when teachers recognize the benefits for students. For research question 2, this category indicated that for any successful program implementation, stakeholder buy-in is essential. Teachers undergoing a STEM program implementation need to ascertain how the cost of taking the time to collaborate with teachers in other departments and creating interdisciplinary projects will directly benefit both students and teachers.

**Interdisciplinary Collaboration**

Part of the challenge in implementing a STEM program is that some teachers can be territorial, making collaboration with teachers in other disciplines difficult.
There were teachers who had participated in interdisciplinary collaborations over the years, but these collaborations were inconsistent. Some of the inconsistencies stemmed from collaborations being one-time opportunities (i.e. German class and Strings [music] class attended a German symphony and then made connections within their respective classrooms). Other inconsistencies came from faculty turnover (i.e. an English teacher left who had collaborated with a Math teacher on the novel *A Curious Incident of the Dog at Midnight*; Music teacher left who had collaborated with Physics teacher on sound waves). Other inconsistent collaborations occurred when projects happened one year but not the next.

*Senior Thesis and Interdisciplinary Projects*

For the school studied, the capstone for students is the senior thesis, an interdisciplinary project which provides seniors the opportunity to synthesize what they have learned, demonstrate college-level scholarship, and complete an original process or product that contributes to the greater field of study. During the interviews and focus group, the senior thesis was specifically discussed, given its interdisciplinary component. All teachers believed that the senior thesis was a powerful factor in bridging students’ high school education to post-secondary paths. Additionally, each teacher offered some vignette about personal experiences with the thesis itself, either acting as a mentor or advisor for students.

However, the first survey and teacher interviews suggested some disconnect for teachers in recognizing that the benefits noted in relation to the senior thesis would also be the same benefits for students participating in other interdisciplinary projects (30% had never participated in an interdisciplinary project). This attitude did seem to shift, as evidenced by the results of the second survey (all teachers surveys had completed at least one interdisciplinary project during the implementation).
Change

Change was a common theme for research questions 1 and 2, which was revealed through axial coding after open coding was conducted. For research question 1, this category indicated that educators’ attitudes toward interdisciplinary projects are impacted as teachers are challenged to change or modify their instructional process. For research question 2, this category revealed that teachers’ use of interdisciplinary collaboration was directly linked with their growth mindset.

Teachers were transparent when it came to change: change is difficult. It is especially difficult when one has already developed successful classroom strategies and procedures. Teachers tend to be creatures of habit who prefer to rely on “tried and true” methods and do not like trying something new. When the STEM program was first introduced, many teachers verbalized an initial negative reaction for the aforementioned reasons. Teachers noted that it was very easy to simply shut the classroom door and focus specifically on course content. The danger, noted by some, when shutting the door was that teachers more easily fell into a rut and became resistant to branching out of their comfort zones.

Many teachers indicated that the STEM implementation was asking them to fundamentally change what they were doing in the classroom; however, as teachers began to understand the purpose and scope of the STEM implementation, they became more receptive to change. One teacher, while excited about making steps toward change, cautioned that the change should be a gradual process.

While teachers noted that change was challenging, they also recognized that evolving in their craft was crucial for student success. Change, for these teachers, included being intentional in their interdisciplinary collaborations and consistently incorporating active learning within the
classroom. Over the course of the STEM program implementation, teachers indicated an increase of active learning with the classroom. Teachers also reported an increase of interdisciplinary projects. Another behavior change was that 90.9% of teachers surveyed indicated that collaboration with other teachers impacted teacher efficacy.

**Time**

Time was a common theme for research question 2, which was revealed through axial coding after open coding was conducted. Lack of time directly impacts how and if teachers collaborate. It is a variety of timing issues – from daily constraints (i.e. 47 minute class periods), timing interruptions (i.e. bubbling for ACT), and course constraints (i.e. AP content). Many teachers teach six classes with one planning period and feel pressure from lack of time and the added stress to thoroughly prepare students for their end-of-course and AP exams. Multiple AP teachers stressed this particular time concern, underscoring how vital covering content was in order to prepare students adequately for the AP exams in May. Additionally, finding connections with other courses was challenging and time-consuming. Several teachers noted that while departments had common planning periods, it was rare to share a planning period with other departments. The only time teachers have to truly meet with teachers from other departments is during in-service time or before/after school.

Timing interruptions proved to be another impediment for teachers. Teachers specifically mentioned that snow days, testing preparation (bubbling for standardized testing), and a 7-period day in lieu of a 6-period day impacted if and how often they met with other teachers.

Course constraints, particularly for AP teachers, prevented more interdisciplinary collaborations from happening. Each AP teacher interviewed expressed a willingness to work
with other teachers but an unwillingness to take the time to implement interdisciplinary projects within the classroom. This was especially evident in semester-long AP classes, which had to address a year’s worth of material in 18 weeks. One teacher recognized the benefit of collaboration but argued that he realistically could not take any of his class time. Given the choice between 2-3 day long projects, whether interdisciplinary or not, or single period direct instruction which addresses the same standards, objectives, and content, all the AP teachers said they would choose direct instruction.

**Conclusions**

This study explored the effect of a STEM program implementation on magnet school teacher attitudes toward interdisciplinary projects and what the nature and extent of magnet school teachers’ use of interdisciplinary collaboration was during a STEM program implementation. Two surveys, teacher interviews, a focus group, and classroom observations were used as a basis for this study.

During a STEM program implementation, teacher attitudes toward interdisciplinary projects were at first negatively impacted because of the poor introduction of the program and because teachers believed that another “hoop to jump through” had been added; however, as training became more focused about the purpose behind the STEM program, teacher attitudes began to shift. Teachers began to express an appreciation for the multiple facets of learning a STEM-focus provided and looked forward to establishing stronger collaborations with teachers in other departments.

Teachers’ use of interdisciplinary collaboration during a STEM program implementation, while there was an increase, had mixed results. AP teachers, although they expressed a desire to collaborate, were less likely to collaborate because of time and content constraints. Some
teachers failed to ascertain how certain disciplines could connect with other disciplines. This inability to make connections with other disciplines seemed to stem from a lack of understanding of other disciplines’ curriculum and objectives. Most teachers noted that interdisciplinary collaboration would improve their efficacy within the classroom, but time was the hardest obstacle to overcome.

Implications

This study indicated that while magnet school teachers note the benefits of interdisciplinary collaboration and projects for both students and teachers, there are several impediments regarding successful implementation: time, course restraints, and unwillingness to change. This study found that in order to successfully implement a STEM program, several actions must occur. Intentional and consistent professional development and interdisciplinary PLC opportunities for teachers to collaborate must be provided. These times must be focused and specific to the components of a STEM program. Time must be given for teachers to change instructional paradigms, allowing teachers to implement effective active learning within the classroom. Time must also be given for teachers to collaborate with their peers in order to effectively develop interdisciplinary projects. Teachers believed that collaboration would improve their efficacy.

This study also found that teachers believe that students benefit from interdisciplinary projects. When students are exposed to multiple facets of learning, they are more able to synthesize information. This power of transfer promotes higher-order thinking and other skills necessary in order to be successful in post-secondary pursuits. One discrepancy discovered during the study was that while teachers saw the value of interdisciplinary projects and the senior thesis, many failed to make the connection that the senior thesis was an interdisciplinary project.
This finding reinforces the idea that focused training is a necessary element for successful STEM implementation.

**Limitations and Delimitations**

The data gathered was limited because there is only one magnet school in the Middle Tennessee school district where the study was conducted. Additionally, the data was limited to only those teachers who are directly involved in the STEM program. This minimized interview responses and focus groups where participants may or may not have been comfortable expressing their true opinions concerning the STEM program and the required PLC and interdisciplinary projects.

**Recommendations for Further Study**

To gain a better understanding of how teacher attitudes toward interdisciplinary projects are affected and what the nature and extent of those changes are in relation to interdisciplinary collaboration during a STEM program implementation, additional research needs to occur. Further research can be conducted which examines teachers’ perceptions of the cost benefits of interdisciplinary projects and collaboration. This study found that teachers struggled to discern how cross-curricular connections would be beneficial in the classroom; this came in part from a failure to understand other teachers’ content and objectives. A study scrutinizing how and why these perceptions were developed and how best to shift those perceptions is recommended.

While research has been conducted at public STEM-focused schools, there is still little research that specifically examines high-achieving AP teachers and students undergoing a STEM program implementation. One concern raised during this study was the lack of time and ability to create interdisciplinary projects while effectively preparing students for the AP exam. However, a quantitative study would offer some insight as to whether taking time to incorporate
interdisciplinary projects and participate in interdisciplinary PLCs did or did not improve student AP scores.

Summary

Research suggests that there are distinct advantages for students when teachers collaborate and participate in interdisciplinary collaboration. These two elements are integral to a STEM program implementation because interdisciplinary learning offers innovative and engaging learning opportunities for students. This study showed that teachers acknowledge that students do benefit from interdisciplinary collaboration, but there are obstacles in making a successful transition to a STEM focus. Teacher attitudes toward interdisciplinary projects are affected during a STEM program implementation, and professional development and specific training in the interdisciplinary PLCs is necessary to ensure a smooth transition. Time was an essential element in helping facilitate increased teacher interdisciplinary collaboration. Dedicating time toward interdisciplinary collaboration enabled teachers to discover instructional strategies, gain new perspectives and develop a clearer understanding of other discipline’s objectives and content.
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116


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Appendix A
Pre-Implementation Questionnaire

1, General Knowledge:
Prior to the 2018-2019 school year, how knowledgeable were you towards STEM and its application to any classroom setting?

- Extremely Knowledgeable
- Very Knowledgeable
- Knowledgeable
- Somewhat Knowledgeable
- Not Knowledgeable

2. The following questions ask about implementation of STEM within the classroom.

- Weekly
- Monthly
- Twice a semester
- Two to three time a year
- Never

A. Prior to the 2018-2019 school year, did you incorporate inquiry-based learning into your classroom curriculum?

B. Prior to the 2018-2019 school year, did you incorporate product-based learning into your classroom curriculum?

C. Prior to the 2018-2019 school year, did you incorporate problem-based learning into your classroom curriculum?

D. Prior to the 2018-2019 school year, had you ever collaborated on an interdisciplinary project at CMS?

E. Prior to the 2018-2019 school year, had you have participated in an interdisciplinary PLC?
3. The following questions ask about your attitude towards STEM and elements associated with STEM.

Very Positive  
Positive  
Neutral  
Negative  
Very Negative

A. Prior to the 2018-2019 school year, what was your attitude about the engineering process?

B. Prior to the 2018-2019 school year, what was your attitude about cross-curricular learning?

C. Prior to the 2018-2019 school year, what was your attitude towards active learning (inquire-based learning, product/problem-based learning)?

D. What is your attitude towards implementing the STEM process into your curriculum?

E. What is your attitude toward interdisciplinary projects?

4. Prior to the 2018-2019 school year, had you ever acted as a mentor for a senior thesis project?  
* This does not include any time serving as a senior advisor
Appendix B
Base Individual Teacher Questions

1. Since the beginning of the 2018-2019 school year, what is your attitude about the engineering process?

2. Since the beginning of the 2018-2019 school year, what is your attitude about cross-curricular learning?

3. Since the beginning of the 2018-2019 school year, what is your attitude towards active learning (inquire-based learning, product/problem-based learning)?

4. Since the beginning of 2018-2019, what is your attitude towards implementing the STEM process into your curriculum?

5. Since the beginning of the 2018-2019, what is your attitude toward interdisciplinary projects?

6. Since the beginning of the 2018-2019 school year, how knowledgeable are you now towards STEM and its application to any classroom setting?

7. Since the beginning of the 2018-2019 school year, did you incorporate inquiry-based learning into your classroom curriculum?

8. Since the beginning of the 2018-2019 school year, did you incorporate product-based learning into your classroom curriculum?

9. Since the beginning of the 2018-2019 school year, did you incorporate problem-based learning into your classroom curriculum?

10. Since the beginning of the 2018-2019 school year, how often have you collaborated on an interdisciplinary project at CMS?

11. Since the beginning of the 2018-2019 school year, have you used the interdisciplinary PLC as a tool to aid instructional strategies?

12. Since the beginning of the 2018-2018 school year, have you acted in the capacity of mentor or field of study advisor for the senior thesis?
Appendix C
Post-Implementation Survey

1. **General Knowledge**

How knowledgeable do you currently feel concerning STEM and its application to any classroom setting?

   - Extremely knowledgeable
   - Very Knowledgeable
   - Knowledgeable
   - Somewhat Knowledgeable
   - Not Knowledgeable

2. **The following questions ask about STEM implementation within the classroom.**

   - Daily
   - Weekly
   - Monthly
   - Once a nine weeks
   - Once a semester

   A. Considering this current school year (2018-2019), how often have you incorporated inquiry-based learning in your classroom?

   B. Considering this current school year (2018-2019), how often have you incorporated product-based learning in your classroom

   C. Considering this current school year (2018-2019), how often have you incorporated problem-based learning in your classroom?

   D. Considering the current school year (2018-2019) school year, how often have you collaborated on an interdisciplinary project?
3. The following questions ask about teacher efficacy and knowledge.

   Strongly Agree
   Agree
   Neutral
   Disagree
   Strongly Disagree

   A. Considering the current school year (2018-2019), have the interdisciplinary PLCs and in-service meetings enhanced or reinforced your knowledge of STEM and its components?

   B. Do you believe that collaborating with other teachers can or has improved your efficacy as a teacher?

4. The following questions ask about your attitude towards STEM and elements associated with STEM.

   Very Positive
   Positive
   Neutral
   Negative
   Very Negative

   A. What is your attitude about the engineering process?

   B. What is your attitude about cross-curricular learning?

   C. What is your attitude towards active learning (inquiry-based learning, product/problem-based learning) and its role within the classroom?

   D. What is your attitude towards implementing the STEM process into your curriculum?

   E. What is your attitude toward interdisciplinary projects?