Portraits of a Rural Georgia High School STEM Program

A Dissertation submitted
to the Graduate School
Valdosta State University

in partial fulfillment of requirements
for the degree of

DOCTOR OF EDUCATION

in Curriculum and Instruction

in the Department of Leadership, Technology, and Workforce Development
of the Dewar College of Education and Human Services

December 2022

JONATHAN LEE GARNER

M.Ed., Valdosta State University, 2008
B.S., Freed-Hardeman University, 2002

This dissertation, "Portraits of a Rural Georgia High School STEM Program," is approved by:

DocuSigned by:
174FE6D9F01948F...

Dissertation Committee Chair

Gwen Scott Ruttencutter, PhD
Assistant Professor of Leadership, Technology, & Workforce Development

DocuSigned by:
024E37B3E081494...

Committee Members

Kathy Nobles, EdD
Assistant Professor of Leadership, Technology, & Workforce Development

DocuSigned by:
0E8BB1C04C86422...

Committee Members

Forrest Parker, III, PhD Lecturer of Teacher Education

Associate Provost For Graduate Studies and Research

Becky K. da Cruz, PhD, JD Professor of Criminal Justice

Defense Date November 11, 2022

FAIR USE

DUPLICATION

ABSTRACT

This research examined school personnel’s strategies and practices responsible for increasing student science proficiency at a certified rural high school STEM program. In the United States, difficulties have developed in adequately preparing students for careers in STEM sectors, especially in secondary education. This trend has led to increased difficulties for high school graduates competing for high-paying jobs globally. Rural schools have been especially susceptible to inadequately preparing their students academically. I used qualitative research portraiture to generate a mental image of the STEM program at the selected high school. I interviewed three teachers and two administrators in a certified rural high school STEM program regarding their day-to-day interactions within the STEM program. Data collection occurred through observations, interviews, and document analysis. Data were analyzed using coding procedures to generate themes. The findings may provide the foundational structure that can be duplicated with personalized modifications by other schools to increase future STEM program development speed and accuracy. Increased students’ exposure to science, technology, engineering, and mathematics concepts may help provide STEM education for more students increasing the number of students to become more proficient in this area and developing them into the innovative thinkers needed for success 21st-century workplace. Administrators, Boards of Education, and programs in our universities and colleges may also benefit from this study. Findings may help the United States Department of Education, state educational agencies, university systems, school districts, and counselors at all levels to promote schools’ participation in technology-enhanced pedagogy.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

To my family, thank you for your support. To my wife, Malissa, you have allowed me to focus on this endeavor, sometimes at the cost of focusing on our family. Thank you for being there to support all of us. Now that this is done, I hope I am able to return the favor many times over. To my parents, Don and Theresa Garner, thank you for believing in me and encouraging me to complete my education. I wanted to make it to the finish line and your faith in me pushed me to finish. To my in-laws, Dale and Beverly Kay, you have been such a positive influence and been there for all of us throughout the entire process. Thank you for supporting this labor of love.

To my academic supports, thank you so much. Dr. Ruttencutter, you have been nothing short of amazing. Thank you for believing in me and committing to helping me complete this journey. To my committee, your insight and attention to detail has been so encouraging. Thank you all for shaping me into the student I have become.

To my five participants, AM, JH, KM, DW, and MS, thank you for sharing your beautiful stories. The authenticity of your words and experiences has been such an amazing encouragement to me. I truly believe the work you are doing has inspired me to become better and I hope that others will see the good that you have accomplished and learn from it as well. You are all such a bright light for rural educators. Never lose that!

To my work family, thank you for suffering me over the last two years while completing this study. At times, I know I have had to put work on the backburner to get this done. As a collective group, you have listened and provided wisdom, been a source of positivity for me to push forward, and built me up emotionally to help me see this through to the end. Thank you for your encouragement and patience. Dana, doctoral wing represent!

To Heath, we started together and we will finish together. Thank you for being an inspiration for me to better my work as a graduate student. You were there for me as motivation, a sounding board, and the voice of reason. I am thankful this program brought me to know you. I wish you only the best.

DEDICATION

This body of work is dedicated to my two sons, Jacob and Jarrett. I can now answer your question, “Are you done with your schoolwork yet?” Yes, boys, it is done.

Chapter I

INTRODUCTION

Within the United States, a significant difficulty has developed to adequately prepare students for careers in science, technology, engineering, and mathematics (STEM), especially in secondary education (McMullin & Reeve, 2014). Businesses and educators have indicated the need for an enhanced focus to meet the future economy and job market (Boe et al., 2011). According to a study conducted by the Center for Advanced Communications Policy (CACP) for the University System of Georgia (USG), there has been a significant discrepancy in the number of students graduating at the collegiate level with STEM degrees and the number of STEM jobs available in the state with the STEM jobs vastly outnumbering the degrees earned (CACP, 2017). Despite this knowledge, the implementation of STEM in schools has not shown uniformity within Georgia. Implementing a STEM-infused pedagogy involves a seamless integration of “content and concepts from multiple STEM disciplines” into the same classroom environment (Nadelson & Seifert, 2017, p.221). Compared to their rural counterparts, schools in urban and suburban areas show more success at meeting the state’s criteria for STEM certification (STEM/ STEAM Georgia, 2020). Margot and Kettler (2019) determined that there has been insufficient information in the literature to adequately understand what effective implementation looks like in a rural school. They further concluded the need for additional research in rural, suburban, and urban settings involving diverse student populations to learn more about appropriate implementation strategies with STEM (Margot & Kettler, 2019).

Studies in recent years on STEM education and rural schools have justified continued research on this topic (Goodpaster et al., 2018; Gulen, 2018; Margot & Kettler, 2019). Workforce trends have shown a gap developing in the national workforce's ability to adequately meet the needs of an evolving job market due to a lack of STEM knowledge and technical understanding (McMullin & Reeve, 2014). Havice et al. (2018) noted an integrated STEM approach provided students with academically challenging opportunities by requiring the use of critical thinking skills to solve real-world problems through the development of potential solutions. These types of experiences are what students seeking a STEM-related career need to take part in in order to diversify their skillsets and better prepare themselves for the rigors of the collegiate environment and the workplace.

Multiple researchers have indicated the difficulties rural schools deal with are due to significant challenges with funding, resources, and teacher retention (Payne et al., 2018; Goodpaster et al., 2018). McConnell (2017) explained that rural schools would face increasing difficulties with these types of changes. He further indicated that teacher retention at the secondary level becomes even more critical when STEM areas focus on the school. He found that many students develop an ardent desire to learn about STEM-related material in the secondary years (McConnell, 2017). With the continually changing landscape of education and the difficulties facing rural schools, an enhanced focus on STEM successes in these environments may provide the necessary blueprint for rural schools to move forward in their STEM-related curricular goals.

Statement of the Problem

Within the United States, a significant difficulty has developed to adequately prepare students for careers in science, technology, engineering, and mathematics (STEM) fields, especially in secondary education. This current trend has led to increased difficulties for high school graduates competing for high-paying jobs globally. Furthermore, the increased prominence of science and technology in the modern job market compounds the need for essential components of science, technology, engineering, and mathematics (STEM) programs. Rural schools are especially susceptible to inadequately preparing their students academically.

Purpose Statement

The purpose of the study was to determine the strategies and practices used by school personnel who were responsible for increasing student science proficiency in a certified rural high school STEM program.

Research Questions

An essential characteristic of my research questions is that they must address the specific and unique features of what the teachers and administrators have personally accomplished to implement STEM successfully. To realize this objective, I considered all aspects of the participants' lives, past lived experiences, and present involvement in the STEM program.

- RQ 1. What were the lived and career experiences of school personnel who were responsible for increasing student science proficiency in a certified rural high school STEM program?

- RQ 2. What strategies were used by school personnel who were responsible for increasing student science proficiency in a certified rural high school STEM program?
- RQ 3. What practices were used by school personnel who were responsible for increasing student science proficiency in a certified rural high school STEM program?

Significance of the Study

Within the United States, a significant difficulty has developed to adequately prepare students for careers in STEM fields, making it more difficult for them to compete for high-paying jobs in the global economy. Increased science and technology prominence in the modern job market, essential components of science, technology, engineering, and mathematics (STEM) programs remain scant. Rural schools are especially susceptible to inadequately preparing their students academically.

The purpose of the study was to determine the strategies and practices used by school personnel responsible for increasing student science proficiency in a certified rural high school STEM program. This study's findings may provide the foundational structure that can be duplicated with personalized modifications by other schools to increase future STEM program development speed and accuracy. Increased students' exposure to science, technology, engineering, and mathematical concepts may help provide STEM education for more students increasing the number of students to become more proficient in STEM-focused areas. This exposure may also aid in developing them into the innovative thinkers needed for success in the 21st century workplace. Administrators, Boards of Education, and programs in our universities and colleges may also benefit from this study. Findings may help the United States Department of Education, state educational agencies, university systems, school districts, and counselors at all levels to promote schools' participation in technology-enhanced pedagogy. The study may also provide knowledge that may assist American technology industries in recruiting, training, and encouraging more people in technology positions, resulting in opening the talent base for skilled American technologists.

Theoretical Framework

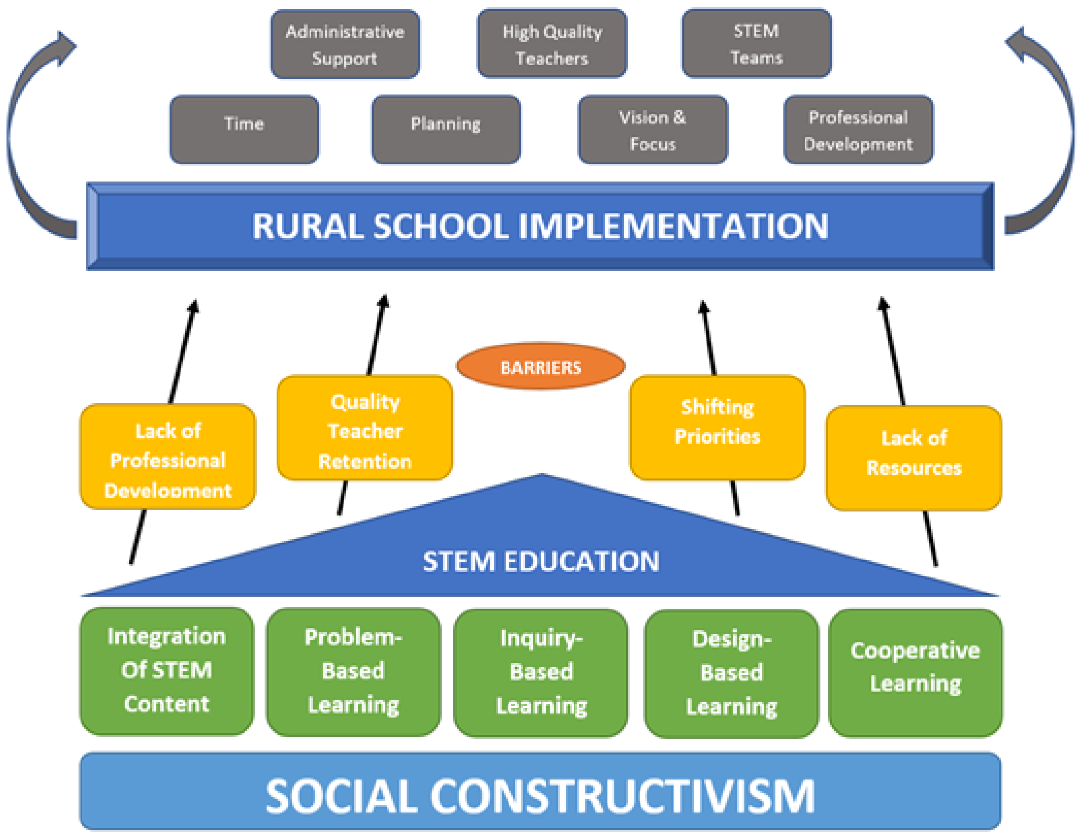
Constructivism was used to gain a fundamental understanding of STEM education. Constructivists contend that learners integrate their prior knowledge into the learning process as they actively construct meaning from classroom experiences (Prawat & Floden, 1994). Constructivists emphasize collaboration and communication among learners through "social negotiation" to form the foundation for current STEM pedagogy in schools (Ertmer & Newby, 2013, p. 57). Students participating may use the social constructivist approach to understand the classroom's unique experiences as they participate with others in an interactive or engaging manner (Ertmer & Newby, 2013). Students use this process to take their prior meaning and understanding of knowledge and actively build a better understanding of content through their classroom experiences placed in the proper context with the outside world (Eastwell, 2002). This type of learning's social component indicates a shared learning process alongside other students instead of being experienced in isolation (Prawat & Floden, 1994). STEM educational practices place a premium on students using time in the classroom to work together and construct the meaning of the world through collaboration to develop their knowledge through tasks containing real-world relevance. Constructivism is pervasive by nature in the STEM-focused classroom, and this theoretical learning construct influences the practical nature of how learning occurs.

Conceptual Framework

Constructivism in the classroom informs the STEM approach's foundation, where students produce or generate meaning in their learning through what they do and experience. Constructivism supports critical characteristics of integrated STEM education, including (a) integration of STEM content (Havice et al., 2018; Lin et al., 2019), (b) problem-based learning (Ertmer et al., 2014), (c) inquiry-based learning (Yildirim & Turk, 2018), (d) design-based learning (Gulen, 2018; Lesseig et al., 2016), and (e) cooperative learning (Ertmer et al., 2014; Wang et al., 2020). STEM implementation involves critical attributes, including (a) a proper vision and focus (Alsbury et al., 2018), (b) adequate planning (Wang et al., 2020), (c) high-quality teachers (Yildirim & Turk, 2018), (d) STEM teacher teams (Wang et al., 2020), (e) administrative support (McConnell, 2017), (f) time (Gonzales et al., 2014), and (g) professional development (Baker et al., 2015; Havice et al., 2018). Barriers that restrict the implementation of integrated STEM education in rural schools include: (a) lack of professional development (Stevenson et al., 2015), (b) quality teacher retention (McConnell, 2017; Stevenson et al., 2015), (c) shifting priorities (Alsbury et al., 2018), and (d) lack of resources (Goodpaster et al., 2018; Payne et al., 2018). These concepts' relationships are crucial in establishing a context for a successful STEM program in Georgia.

Figure 1

Conceptual Framework



Note. This figure illustrates how schools might build STEM education upon social constructivism. It represents the barriers to rural school STEM implementation's critical characteristics, adapted from (Thibaut et al., 2018, Figure 1).

Despite the current understanding of STEM education's constructivist underpinnings, barriers remain that affect rural schools to implement effective programs. As shown above, these barriers are acknowledged to be primary antagonists for rural schools attempting to maintain positive academic momentum and implement new programs. Regardless of these perceived barriers, strategies exist for marginalizing the effect of these problematic characteristics of rural schools. As indicated at the top of the above concept map, these strategies provide areas of focus for personnel in rural schools while working toward success.

Overview of Methodology

The currently available research provides a baseline for acceptable strategies for implementing and maintaining a STEM-focused educational approach. I conducted this qualitative study using portraiture to create a mental image of the STEM program at the selected high school by detailing the experiences of directly involved teachers and administrators (Lawrence-Lightfoot & Davis, 1997). Lawrence-Lightfoot (1983) proposed that the portrait "would be defined by aesthetic, as well as empirical and analytic, dimensions" (p. 13). This approach allowed discovery of the intricate nature of the teachers' and administrators' experiences as they describe in their own words the process of developing and maintaining a STEM program in a rural high school.

Portraiture helped illuminate the strategies and practices in the classroom teachers cling to, due to their effectiveness, through an intense focus on what is beneficial for students. Lawrence-Lightfoot and Davis (1997) explained that portraiture "is an intentionally generous and eclectic process that begins by searching for what is good and healthy" (p. 9). Since so few successful rural STEM programs exist in Georgia, this approach generated engaging narratives of an effective STEM environment in a smaller, more rural community so future practitioners can glean understanding related to their teaching environments.

I chose a methodology consistent with the nature of the qualitative inquiry. Purposeful sampling, precisely a criterion-based sample, was used to select teacher and administrator participants based on their experience with the STEM program through its many stages (Patton, 2002). Participants provided the most significant detail and meaning regarding the development, implementation, and maintenance of the STEM program within the selected school. Data collection occurred through observations from five days of school visits, interview data from teachers and administrators involved in the selected high school STEM program, and administrative documentation analysis within the STEM program at the selected high school. Data collection and analysis were informed using the Georgia Department of Education (GaDOE) STEM Certification Continuum developed by STEM/ STEAM Georgia (2019) to illuminate schools' traits and behaviors having achieved certification (Patton, 2002). Data were analyzed using a series of coding procedures through multiple rounds of analysis, generating themes within the data collected to uncover the true meaning of the selected high school STEM program (Saldaña, 2016).

Limitations

Several potential limitations were planned or accounted for during this study. The nature of qualitative research requires the researcher to act as the primary instrument during the data collection process. Maxwell (2013) indicated "the subjectivity of the researcher…is impossible to deal with…by eliminating the researcher's theories, beliefs, and perceptual lens" (p. 124). Instead, I used my understanding of STEM education as a science teacher and STEM coordinator at my school to comprehend the data that I uncover throughout the research process and accept its meaning. While a potential liability, my experiences helped me mentally grasp the information as I attempted to keep my personal opinions out of the collected data's objectivity.

A secondary limitation involves the nature of the data that is collected. Portraiture as a methodological approach attempts to generate a snapshot of the topic of study. In studying a successful high school STEM program, each participant's primary data collected was self-reported. The data heavily relied on participants recalling facts from past events. When data collection reaches a point where new information is no longer being identified and information becomes repetitive, this point is referred to as data saturation. I collected comprehensive data to achieve a reasonable saturation point and avoid questioning the data's accuracy. Questioning was framed precisely during interviews that promoted reflection by each participant, leading to more in-depth recall and better data production.

A final limitation involves the number of participants selected for the study. While five participants in a qualitative study can be sufficient for acceptable levels of data saturation, not all teachers in the STEM program under consideration were able to be included in the study. It is likely that additional gleanings regarding the strategies and practices of teachers within the program may have been uncovered had all teachers in the STEM program participated.

Chapter Summary

Despite the continued focus on STEM educational practices in recent years, the development of STEM-related initiatives in Georgia high schools has occurred inequitably, favoring larger metropolitan areas over small, rural communities. I addressed the lack of certified STEM programs in rural high schools in Georgia. Focusing on a currently successful rural STEM program yielded positive traits and practices of the program. The educators found within were studied to identify STEM teachers' foundational characteristics, duplicated with personalized modifications at other school sites. The final document may help similar schools increase the speed and accuracy of future STEM program development in rural areas across the state.

STEM educational approaches are rooted in constructivism and require students to progress through inquiry-based learning models to make meaning of their educational experiences through collaboration in the classroom. Rural schools face several challenges in meeting the rigorous requirements of a STEM-focused classroom. Researchers indicate vital strategies that can support implementing STEM in a rural high school setting. Still, there is a lack of literature available to properly discern a clear path toward success for rural schools seeking STEM educational opportunities for their students.

This study utilized portraiture as a qualitative approach to determine the right and wholesome traits found in an established rural high school STEM program in Georgia. As the researcher, I engaged my participants as necessary components of the STEM program under consideration and learned about the practices and strategies to be the most effective in their educational setting. My goal was to develop an image of a thriving rural high school STEM program according to the GaDOE criteria for program certification that would be considered by other high school administrators seeking a similar educational approach.

Definition of Terms

Constructivism. An educational theory that asserts students make meaning of their learning by constructing their understanding based on the experiences they have previously had as well as the interactions they have in the classroom setting (Prawat & Floden, 1994).

CTAE. An acronym identifying Career, Technical, and Agricultural Educational courses. These courses focus on relevant hands-on topics and the application of knowledge.

GaDOE STEM Certification Continuum. A document created by the GaDOE including 19 criteria prospective STEM schools or programs assessed to determine eligibility.

GaDOE. An acronym used to reference the Georgia Department of Education.

High School. Within the context of this study, this refers to a school that educates students in grades 9-12.

Participants. In this study, a participant contributes to the data collection process by agreeing to be interviewed as an active participant in the selected STEM Program.

Portraiture. A qualitative inquiry method that determines individuals' good and wholesome characteristics in a highly descriptive narrative. (Lawrence-Lightfoot, 1983).

Practices. The actual application or use of an idea, belief, or method, as opposed to theories relating to it (Oxford English Dictionary, n.d.).

PBL. An acronym used to reference the educational approach known as problem-based learning focuses on students engaging in ill-structured problems or scenarios requiring students to construct their meaning or knowledge (Ertmer et al., 2014).

Resources. This term refers to specific entities (equipment, technology, software, planning time, professional development) that make educational change easier to implement within the study.

Rural. A term referring to areas that are small in population and not influenced by nearby metropolitan regions. In this study, I use this term to refer to a school located in a rural community.

STEM. An acronym referring to science, technology, engineering, and mathematics education. STEM education involves the seamless integration of content and concepts from multiple STEM disciplines together in the classroom environment (Nadelson & Seifert, 2017).

STEM Program. One STEM implementation model involves a "school within a school" approach that exposes program students to a unique curriculum focused on the primary tenets of STEM and the various existing applications (STEM/ STEAM Georgia, 2020).

STEM Degree. This term is referencing collegiate degrees that focus on a STEM-related field of work.

STEM Job. A specific job type in the economy requiring the use of skills or attributes developed through education or training in STEM subject areas.

Strategies. A plan of action or policy designed to achieve a major or overall aim (Oxford Languages, 2020)

Chapter II

REVIEW OF LITERATURE

Within the United States, a significant difficulty has developed in preparing students for careers in science, technology, engineering, and mathematics (STEM), especially in secondary education (McMullin & Reeve, 2014). According to Havice et al. (2018), many STEM education ideas date back to 1958. Havice et al. argued the National Science Foundation began grouping STEM components at this point and ultimately settled on the STEM acronym in the 1990s. As this model of instruction grew, teachers began taking a closer look at the individual parts of STEM and determined how to connect them in a meaningful way. STEM education has flourished due to the nature of today's global economy and the modernization of the classroom and workforce related to the infusion of modern technology (Gulen, 2018). STEM education aims to help students develop a better understanding of the current workforce's skills and requirements and better prepare themselves for an evolving job market.

This literature review's primary goal was to examine the existing research on the study's major components. In this chapter, I provided a review of the current literature on what is known as STEM education, the foundational principles that undergird STEM education, and a contemporary understanding of implementing STEM in schools. There was limited specific literature pertinent to the successful implementation of STEM education in rural high schools. Therefore, a focus on individual students developing deep understandings in STEM programs was needed.

First, I provided a historical perspective of social constructivism in education that encourages students to think critically about their learning. Throughout the next two sections, I examined why STEM education is a practical educational approach to pursue for today's students. I then summarized the typical characteristics found within a STEM educational approach in modern schools. Following these sections was a brief overview of the state of STEM in Georgia and requirements given by the Georgia Department of Education (GaDOE) for STEM certification. Next are two sections that specifically examined the implementation of STEM and the challenges associated with such a task. I introduced proven strategies and barriers that make a curricular change challenging to accomplish. Finally, I discussed challenges related to rural schools. This review highlighted unique challenges facing rural schools in specific ways. In the last section, I illuminated some of these challenges considering existing literature regarding STEM education.

Statement of the Problem

Within the United States, a significant difficulty has developed to adequately prepare students for careers in science, technology, engineering, and mathematic (STEM) fields, especially in secondary education (McMullin & Reeve, 2014). This current trend has led to increased difficulties for high school graduates competing for high-paying jobs globally (Boe et al., 2011). Increased science and technology prominence in the modern job market exposes essential shortfalls in STEM programs. Rural schools are especially susceptible to inadequately preparing their students academically.

Purpose Statement

The purpose of the study was to determine the strategies and practices used by school personnel who were responsible for increasing student science proficiency in a certified rural high school STEM program.

Research Questions

An essential characteristic of my research questions is that they must address the specific and unique features of what the teachers and administrators have personally accomplished to implement STEM successfully. To realize this objective, I considered all aspects of the participants' lives, past lived experiences, and present involvement in the STEM program.

- RQ 1. What were the lived and career experiences of school personnel who were responsible for increasing student science proficiency in a certified rural high school STEM program?
- RQ 2. What strategies were used by school personnel who were responsible for increasing student science proficiency in a certified rural high school STEM program?
- RQ 3. What practices were used by school personnel who were responsible for increasing student science proficiency in a certified rural high school STEM program?

Significance of the Study

High school students are having an increasingly difficult time gaining proficiency in science knowledge, leading to a student population that is less prepared for a modern job market that focuses on STEM content (Boe et al., 2011). Rural schools are especially susceptible to these challenges due to a limited number of resources available, both monetary and staffing related (Goodpaster et al., 2018; Payne et al., 2018). The purpose of this study was to determine the strategies and practices used by school personnel responsible for increasing student science proficiency at a certified rural STEM high school. This study's findings may provide the foundational structure that can be duplicated with personalized modifications by other schools to increase future STEM program development speed and accuracy. Increased students' exposure to science, technology, engineering, and mathematics concepts may help provide STEM education for more students increasing the number of students to become more proficient in this area and developing into the innovative thinkers needed for success in the 21st century workplace. Administrators, Boards of Education, and programs in US universities and colleges may also benefit from this study. The United States Department of Education, state educational agencies, university systems, school districts, and counselors at all levels may use the results of this study to promote schools' participation in technology-enhanced pedagogy. American technology industries may employ study findings to recruit, train, and encourage more people in technology positions, resulting in opening the talent base for skilled American technologists.

Theoretical Framework

STEM education is rooted in constructivism, which is the theory the learner will integrate their prior knowledge into the learning process as they actively construct meaning from classroom experiences (Akran & Asiroglu, 2018; Prawat & Floden, 1994). Constructivism emphasizes collaboration and communication among learners through "social negotiation" to form the foundation for current STEM pedagogy in schools

(Ertmer & Newby, 2013, p. 57). Students can gain meaning of knowledge through the classroom's unique experiences as they participate with others to develop deep understandings of the subject matter of interest (Ertmer & Newby, 2013). Students use this process to take their prior meaning and interpretation of knowledge and actively build a better understanding of content through their classroom experiences placed in the proper context with the outside world (Eastwell, 2002). This type of learning's social component indicates a shared learning process alongside other students instead of being experienced alone (Prawat & Floden, 1994). STEM educational practices place a premium on students using time in the classroom to work. Students work together and construct the meaning of the world through collaboration to develop their knowledge. Social constructivism is pervasive by nature in the STEM-focused classroom, and this theoretical learning construct influences the practical nature of how learning occurs.

A constructivist believes that learning occurs as learners are actively involved in meaning and knowledge construction rather than passively receiving information. (McKinley, 2015). From the perspective of STEM education, this constructivist approach allows students to transform their learning in these specific content areas and place the knowledge into practice (Akran & Asiroglu, 2018). Furthermore, these educational opportunities afford students the chance to "…make innovative and original discoveries…" and to construct the knowledge on their own (Akran & Asiroglu, 2018, p. 2175).

One key element of the constructivist approach has been evident in students' ability to think critically in constructing their writing. Through the writing process, McKinley (2015) noted students engaged in a more profound thinking process and develop an appropriate argument that supports their rationale when resolving ill-structured assignments or projects. These resolutions can come in the form of argumentation, discerning among appropriate and inappropriate solutions, and expressing written mastery of entire concepts in narrative form. This sort of understanding is possible following a "…sufficiently deep familiarity…" with the core content within a course for the proper levels of synthesis and evaluation to occur (McKinley, 2015, p. 190). This in-depth understanding of content knowledge occurs when students made meaning of their prior experiences and deeply internalized what they learn in class, leading to evaluating, problem-solving, and resolving academic conflict.

Why STEM Education?

The modern workplace has developed so that technological literacy drives the economy, and computer automation is no longer an entity of the future (Honey et al., 2014). The workers of today and tomorrow are entangled in a technology-rich environment and will continue to be. The importance of developing a STEM-focused culture as a practical option in schools at early ages and continuing throughout a child's education has been understated. According to Christensen and Knezek (2017), students do not receive enough opportunities to learn about these career possibilities. Christensen and Knezek argued that the lack of opportunity leads to students not being adequately informed of their future options while in school resulting in a reduced number of choices for a career after school and a lack of candidates for more technical jobs.

Furthermore, students' positive perceptions regarding STEM-related jobs affect their ability to be useful citizens in society (Christensen & Knezek, 2017). Helping guide students choose a career path is critical when considering how the career field is changing. These STEM-related careers are increasingly becoming prominent in the job field and will affect the nation regarding global competitiveness in the future (Lin et al., 2018). Trends indicate a developing gap related to STEM jobs in our national workforce's current abilities and the technical expertise needed to correctly fill essential positions (McMullin & Reeve, 2014). Gonzales et al. (2014) asserted extended learning opportunities, such as STEM-related activities, help expose students to the skills needed in the 21st century. These sources indicate the importance of finding and developing talent in schools to produce high-quality, competent workers in the future.

With changes in society and the workforce, employers seek individuals who think critically and solve problems independently and with others. Nadelson and Seifert (2017) noted this expectation of synthesizing information becomes the modern-day worker's current expectation. With technology and information becoming entrenched within the workforce, students need to become proficient in considering copious amounts of data and determining the proper solutions to solve large-scale problems, including those involving societal infrastructure, energy consumption, and the impact of human populations on global climate. Nadelson and Seifert bridge these thoughts together with the need for employing STEM education in today's schools. They argue an integrated STEM approach, that is, one that seamlessly utilizes multiple disciplines simultaneously in the classroom, is paramount in importance to help students learn to synthesize information and solve these large-scale challenges appearing in the workforce today.

According to Akran and Asiroglu (2018), teachers report the positive impact of a STEM educational approach in the classroom. They found teachers believe STEM education enhances interest in course material and boosts intrinsic motivation on the part of the student. They also indicated the growth students experience toward using technology both in the classroom and in their lives. Lesseig et al. (2016) found teachers believed in implementing specific design challenges in their classrooms. Teachers indicated these challenges led to an increased level of perseverance on the students' part when working on these projects. Teachers reported the unique design of these challenges prompted students to value completing the tasks strongly. They encouraged students to develop problem-solving and critical thinking skills using modern engineering design practices and enhancing their 21st century skills (Lesseig et al., 2016).

Various STEM education researchers have established the impact of STEM on marginalized student populations (Alvarado & Muniz, 2018; Glennie et al., 2019). Alvarado and Muniz (2018) determined that STEM-focused education significantly impacts minority students' educational trajectory. They found that if minority students participated in these programs, they were much more likely to choose an AP STEM course while in high school and ultimately choose a STEM major once in college (Alvarado & Muniz, 2018). Glennie et al. (2019) emphasized the importance of marginalized students being exposed to STEM courses earlier in high school, if possible. They noted students were failing to take college preparatory classes in STEM content areas during the ninth and tenth grades severely limited their options for advanced STEM courses before high school graduation. Alvarado and Muniz (2018) established the importance of exposure to advanced content through increased pass rates of STEM classes and other advanced coursework, including AP courses. They concluded that STEM students show to be less likely to struggle with chronic attendance issues, behavioral problems, and graduating on time. These results also align with those in a separate study of North Carolina students by Glennie et al. (2019). In their research, underrepresented STEM students found an extreme benefit to a modified school structure that emphasized STEM content. They indicated "…the supports provided by these schools not only facilitate their college and career readiness but also keep them engaged with high school" (Glennie et al, 2019, p. 250).

Characteristics of STEM Education

STEM education is a uniquely specific pedagogical approach in the classroom. Gilson and Matthews (2019) surveyed teachers in STEM education and determined five vital instructional strategies that succinctly describe the sum of STEM pedagogy. These instructional characteristics of STEM include: (a) emphasizing hands-on learning, (b) using inquiry-based teaching methods, (c) requiring student collaboration with peers, (d) promoting the value of learning from mistakes, and (e) promoting creative thinking by asking students questions with no single answer or solution path (Gilson & Matthews, 2019, p. 248). The researchers also determined specific characteristics of STEM through classroom observations. They concluded that the students' learning environments in question promoted flexibility in teacher/student interactions, leading to student growth through appropriate classroom rigor.

Furthermore, classrooms provided adequate support to students on a dynamic basis. Teachers continually assessed students both formally and informally as needed. The school showed the classroom focus on the student, and the teacher's role is to establish a safe, comfortable learning environment. Students are encouraged to use each other through collaborative support. As a result of these implementations, students reported elevated engagement levels and enthusiasm for learning due to the "...overall positive school culture" present on campus (p. 256).

There are various formats of STEM education. According to Ertmer et al. (2014), problem-based learning (PBL) carries a great deal of promise when properly utilizing technology. They pointed out students use problem-based scenarios to become actively engaged in the learning process resulting in a greater sense of ownership in their learning. A teacher's ability to implement STEM in a PBL format requires them to assume a facilitative role, involve students more actively, and assess students in alternate ways than a traditional classroom setting (Ertmer et al., 2014). STEM education profoundly contributes to a student developing creative thinking, problem-solving skills, the ability to innovate in their thinking, and the ability to critically consider sources and information to integrate with the most concise fashion through an inquiry-based learning approach (Ertmer et al., 2014; Thibaut et al., 2018; Yildirim & Turk, 2018). As the teacher takes on more of a role to assist students in their learning, they take command of their education and apply knowledge in specific constructive contexts.

One of the foundations of a STEM educational approach is implementing communication and collaboration among students and teachers (Al Salami et al., 2017; Margot & Kettler, 2019; Wang et al., 2020). Students need to communicate to build interpersonal skills and develop the ability to problem-solve as a group member. The constructivist position also indicates learning occurs in a social context (Ertmer & Newby, 2013). The academic interactions among students fuel the classroom's learning process and help mold the learner in a constructive manner (McKinley, 2015). Baker et al. (2015) noted a 20% increase in end-of-course assessments among students who participated in an openly collaborative learning environment than their current peers in a traditional learning environment. They also pointed out a lack of time in the classroom and teachers' tendency to stay rooted in their disciplines and areas contributed to difficulties in successfully implementing a collaborative work environment between teachers. Wang et al. (2020) indicated teachers' beliefs in collaboration in the classroom would significantly impact the successful implementation of interdisciplinary STEM pedagogy in a high school setting. Student collaboration allows for the development of 21st century skills. They use "…open-ended, hands-on design challenges that provide students with the opportunity to not only learn about engineering design processes and engineering practices but also deepen their understanding of disciplinary core ideas" (Thibaut et al., 2018, p. 8). Here we see the underpinnings of social constructivism as an educational philosophy in action through the collaborative nature of a STEM-focused classroom environment.

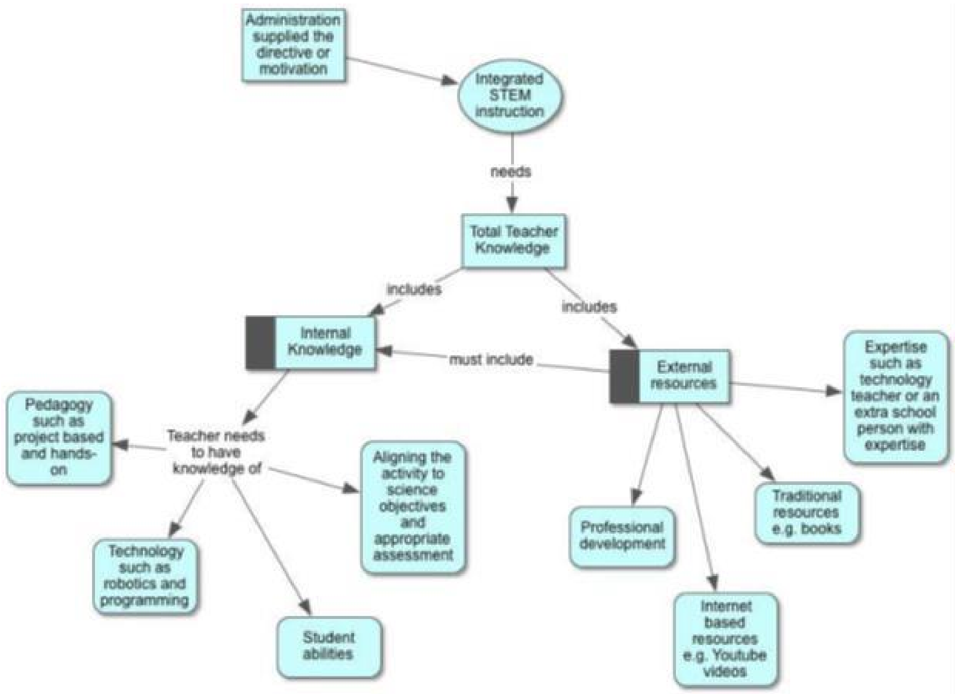
One of the most prevalent applications of STEM has been the implementation of an integrative STEM approach. Nadelson and Seifert (2017) defined integrated STEM as "…the seamless amalgamation of content and concepts from multiple STEM disciplines" (p. 221). The authors articulated that as the integration occurs, each discipline is simultaneously incorporated into the curriculum and, therefore, used seamlessly to tackle whatever project is required. The challenge with this seamless integration for both teachers and students is to recognize when specific content knowledge and practices need to be utilized appropriately (Nadelson & Seifert, 2017). According to Havice et al. (2018), this integrated approach provides students with opportunities to thrive academically by exposing them to real-world problems to develop solutions using various cross-curricular skills. This approach helps students develop connections across multiple disciplines while working interactively and collaboratively (Havice et al., 2018).

Integrative STEM can also encourage students to become active problem-solvers and provide unique situations to help students develop positive reinforcing thoughts about their work (Gulen, 2018; Lesseig et al., 2016; Lin et al., 2018). By being placed in these particular situations, students can develop the ability to analyze real problems and use their knowledge from multiple disciplines to create a live scenario. The researchers in each of these studies indicated a PBL environment would have the opportunity to thrive in an integrative classroom environment where multiple disciplines are presented to students simultaneously, allowing them to see the connections between them. Integrated STEM also will enable students to see the relevance of the content learned attached to the context of a specific problem or challenge (Ertmer et al., 2014).

Ntemngwa and Oliver (2018) examined the benefits students accrue when they participate in integrated STEM projects. This approach exposed them simultaneously to practices and content from multiple disciplines. In this study, teachers felt the integrated STEM approach facilitated students acquiring problem-solving skills. Ntemngwa and Oliver suggested a difference between learning problem-solving skills individually instead of doing so as a group member. Students readily applied and developed problem-solving skills during the project while working together on integrated content. Ntemngwa and Oliver used the illustration in Figure 2 to demonstrate teacher knowledge needed for integrated STEM instruction.

Figure 2

Teacher Knowledge of Integrated STEM



Note. From (Ntemngwa & Oliver, 2018, p. 30)

In their study, Ntemngwa and Oliver (2018) found that although teachers did not possess all the above traits, the implementation of the integrated STEM approach still was judged to be successful. They concluded the more a teacher develops their internal knowledge and adequately utilizes the available external resources to enhance the inner experience of STEM content, the more successful an integrated approach may be.

Fan and Yu (2017) examined the use of the integrated STEM approach in technology education. They found that this approach helps students formulate their content knowledge and apply the knowledge when problem-solving. They suggested the STEM integrated approach can help facilitate a student's understanding of "…the connections between the four STEM subjects, know how to bring these content areas together to generate more effective solutions, and consequently become better problem solvers" (Fan & Yu, 2017, p. 108). They concluded that students involved in the integrative approach made significant gains in their problem prediction and analytical skills. They deduced the instructional units provided to the experimental group of students enabled them to contend with "…abstract concepts of scientific principles and mathematics computation using a computer simulation..." as well as "...mechanism design and working function with physical models" (Fan & Yu, 2017, p. 125). The integrative STEM-based curriculum synergizes these advanced modalities of thinking and comprehension. Students experienced increased success in the classroom as a result.

An integrated approach has positives and negatives within STEM. Pearson (2017) asserted integrating content may be useful for the student because the mind tends to organize related concepts more effectively than unconnected ideas. He further established that content integration could also provide difficulties for the student due to the increased demands on student thought and working memory. Pearson (2017) reported that while integrating content is pertinent for a STEM-focused classroom, teachers should monitor a student's mind's strain, and the connections to real-world examples should remain specific and direct.

In another study, Tofel-Grehl and Callahan (2014) examined STEM high school communities to understand STEM education's undergirding in modern schools. They found that STEM schools developed an appropriate school culture among administrators, teachers, and students. They also valued the intellectual traits of students rather than social characteristics. Students did not sense a strong feeling of competition among peers but were more inclined to work together for collaborative learning purposes. Administrators specifically noted the superior levels of focus on academics the students portrayed, and the students were motivated toward success independently of each other. Teachers emphasized, "…a sense of community focused on learning and absence of competition between students as well as a collegial and supportive faculty family" (Tofel-Grehl & Callahan, 2014, p.254). Teachers readily indicated there was a "culture of intense dedication" and "...a faculty culture of collegiality and teamwork..." (p. 254). Students echoed many of the comments shared by administrators and teachers. They felt the school supported their academic efforts and indicated the intensely intellectual surroundings led to "...tremendous pressure to achieve and high teacher expectations..." (p. 255).

Administrators in Tofel-Grehl's and Callahan's (2014) study indicated that students' skills in these research-focused environments uniquely prepared students for STEM-related fields of study in college. Administrators also felt the hiring process benefitted teachers with previous experience in these more rigorous fields of study when they were in school to transfer skills from teacher to student effectively. Teachers indicated the open-ended research approach "...afforded students a more divergent approach to problem-solving" (Tofel-Grehl & Callahan, 2014, p.257). Students referred very positively to the experience they received in working within research environments. One example noted a particular student spent an entire semester at a local university working in a medical laboratory on a new cardiac medication. Following the internship's completion, the student felt heavily invested in the work, which allowed the development of a more profound interest in chemistry as a potential college study field. The opportunity for students to immerse themselves in unique, research-driven experiences promoted a sense of ownership. It increased their desire to consider a focus of research in a STEM-related field (Tofel-Grehl & Callahan, 2014).

Tofel-Grehl and Callahan (2014) found that administrators took inquiry learning to mean specific hands-on learning opportunities by the student that primarily occurred in either lab activities or during individual research on the part of the student. In the study, teachers strongly felt that inquiry-based learning is only useful when students can apply learned knowledge and transfer it into new and relevant situations. Students voiced their approval of teachers taking class time to allow hands-on learning exercises. A finding of this study was that inquiry learning supplemented a traditional format of lecture-driven instruction. Students were also willing to note "…the importance of the opportunity to do things rather than only listen to lectures about them" (Tofel-Grehl & Callahan, 2014, p. 260).

Finally, Tofel-Grehl and Callahan (2014) revealed that a scientific learning environment encouraged students to assume responsibility for their education and independent learning. Administrators and teachers in the study observed students outside of class busily working on assignments for their classes. These assignments included finishing projects and covering material the teachers deemed too basic to be covered within standard class time. Teachers also indicated students' willingness to see them outside of class if they needed clarification or additional teaching on a topic. Regardless of the more solemn than usual workload, this was an atmosphere that the students appreciated and thrived in. Students noted "…a great deal of their growth and learning as students stemmed from the requirement that they learn to think for themselves and solve real problems without a teacher telling them how" (Tofel-Grehl & Callahan, 2014, p.

262). Despite appreciating the work environment, students mentioned becoming independent learners was new to them upon enrollment in their STEM-focused school.

STEM in Georgia

The Georgia Department of Education has implemented a specific initiative designed to increase STEM pedagogy saturation throughout the state. This initiative, known as STEM/ STEAM Georgia "…is dedicated to preparing students for 21st century workplace careers by providing high-quality educational opportunities in science, technology, engineering, arts, and mathematics fields" (STEM/ STEAM Georgia, 2020). Resources on the official website available to schools seeking to implement a greater STEM focus from the GaDOE include introductory materials for schools interested in certification, professional development opportunities throughout the calendar year, an online collaborative platform for teachers within the state, updated lists of active STEM schools at all grade levels, and the establishment of an annual STEM/ STEAM Forum held in Augusta, Georgia each October.

According to the GaDOE, STEM education in Georgia currently utilizes two implementation models (STEM/ STEAM Georgia, 2020). One model requires the entire school to develop and implement a STEM-focused mindset in the classroom. The second model is a school-within-a-school format that serves at least 10% of the student population in a specialized STEM-focus curriculum. According to the STEM/ STEAM Georgia website (2020), the program format incorporating the school-within-a-school model is the overwhelming choice for high schools is due to a program being a better fit in the high school environment. The STEM/ STEAM Georgia (2019) STEM Certification Continuum includes 19 different criteria explicitly considered when determining a school's successful implementation of a STEM curriculum. These criteria include the comparative diversity of the STEM cohort compared to the rest of the school, performance with CTAE disciplines, appropriate teacher certifications, and evidence of collaborative planning between teachers of various fields (STEM/ STEAM Georgia, 2020). Infusing a STEM-focused fundamental change in curriculum and pedagogy in Georgia is a complex process and presumes a great deal of planning with local stakeholders.

The certification process is one area requiring a significant investment of time and resources at the school level (STEM/ STEAM Georgia, 2020). Initially, school officials and personnel will need to learn about what STEM looks like in practice by reviewing the official website's documentation and visiting a GaDOE certified STEM school to observe a successful implementation. Next, teachers and administrators should then implement their STEM approach for at least two years to gain hands-on experience of how the school environment will change due to this unique curricular approach. Once school officials determine they meet state certification requirements through self-assessment, they schedule a pre-visit with a GaDOE STEM specialist to decide whether or not it meets the appropriate criteria. The pre-visit results will allow the school to continue adjusting its approach and prepare for its official site visit from a panel of educators across multiple disciplines. This site visit will determine certification status once an official completes an application for STEM certification.

The literature guides Georgia from an informed, research-driven perspective on the requirements laid out by Georgia on successful STEM pedagogy. In the study conducted by Glennie et al. (2019), a STEM logic model incorporates the design principles seen in Georgia STEM programs. The logic model focused on: (a) a rigorous, college preparatory curriculum, (b) collaborative group work and project-based learning, (c) increasing relevance by making connections across subjects, and (d) utilizing partnerships with post-secondary institutions and local businesses (p. 238). The researchers highlighted the importance of maintaining a representative diversity and supporting economically disadvantaged students within a school's identified STEM student population. Georgia STEM certification hinges on an equitable representation within a STEM program to all school population demographics.

A core aspect of STEM implementation in Georgia schools is journal writing in the STEM context (STEM/ STEAM Georgia, 2020). The purpose of journal writing in STEM schools and programs is for students to write out the critical thinking processes they take part in and to see their progression as a significant project unfolds. Waschle et al. (2015) conducted a study on journal writing in science educational settings and found positive effects on students' comprehension, interest in subject material, and critical reflection skills. The researchers found when students wrote their thoughts; they promoted their understanding of content. The writing of journal entries showed a much more significant impact than the completion of regular homework assignments, "…including concept mapping, summarizing and question answering, on measures of comprehension, critical reflection, and self-reported interest…" in their topic of study (Waschle et al., 2015, p. 59). The researchers also reported students were required to use deeper thought processes while completing their journals, such as "…cognitive and metacognitive strategies…" (p. 59). The implementation of journal writing in STEM-focused classrooms shows the deeper levels of thinking and application students are participating in while being immersed in problem-solving-based scenarios.

STEM Implementation

Transforming a school environment into a STEM approach that is friendly and welcoming is an arduous task. According to Alsbury et al. (2018), the two variables yielding the greatest effect size in making large organizational changes were:

- Having an attainable and precise vision
- Planning appropriately to see the vision become a reality.

Alsbury et al. also indicated that many educational reforms fail due to a lack of focus on priorities within a school or system. They emphasized careful planning should become a priority among all decision-makers throughout any implementation of significant curricular change, especially one involving a predominant STEM approach.

According to Nadelson and Seifert (2017), schools may see a spectrum of implementation in the process of moving toward an integrated approach with STEM. This implementation may begin in a more segregated fashion, with each discipline acting separately from the others. There also may initially be a highly structured environment in the classroom and instruction may remain teacher-focused. As integration continues to develop, students will begin to spend more time discovering knowledge through a more significant number of ill-structured problems designed to force the student into a greater level of content synthesis. As the integration of STEM content develops, there will be a progression or mixture of pedagogical aspects in the classroom of a segregated and integrated approach. The goal is to allow for the seamless integration of multiple content areas within the classroom to promote success in all areas.

It is necessary to determine goals or expectations among those involved to successfully implement significant instructional change, such as infusing a school's STEM educational approach. Pearson was one of several individuals who worked on the report entitled "Integration in K-12 STEM Education: Status, Prospects, and an Agenda for Research" (Honey et al., 2014) through the National Academy of Engineering and the Board on Science Education of the National Academies of Sciences, Engineering, and Medicine. In a follow-up to this expansive report, Pearson (2017) discussed a framework for STEM integration,

> Based on its review of the literature and of a sample of integrated STEM initiatives, the committee developed a descriptive framework with four high-level features: goals, outcomes, nature of integration, and implementation. The framework is intended to provide researchers and practitioners with a common language to describe and advance their work. Goals of programs may include building STEM literacy and 21st century competencies, developing a STEM capable workforce, and boosting interest in engagement in STEM. Outcomes include learning and achievement, STEM course-taking, STEM-related employment, development of a so-called STEM identity, and the ability to transfer understanding across STEM disciplines. Nature of integration concerns the subjects that are connected, which disciplines are dominant, and the duration, size, and complexity of the initiative. Implementation includes the instructional design, such as the use of problem-based learning and engineering design, type of educator supports present, including pre- and in-service professional

> development, and adjustments to the learning environment such as extended class periods or team teaching. (p. 224)

These characteristics are broad and sweeping in scope but encapsulate the meaning of implementing a STEM pedagogy within a school. Schools should have an unclouded vision for implementation (Alsbury et al., 2018). The curricular focus should remain on preparing students for 21st century jobs by developing the prerequisite skills needed. Courses should be focused on STEM content and integrated into meaningful ways. The instructional model's design should fit the intended population of students.

Several trends have indicated schools' efforts to implement a successful STEM curriculum properly. According to Gonzales et al. (2014), two campuses in a study required the students to take four years of selected math and science courses and other specialized opportunities for courses that augment their STEM focus (Gonzales et al., 2014). In another study, Yildirim and Turk (2018) found that high-quality STEM teachers are well versed in STEM instruction, classroom pedagogy, the ability to integrate content knowledge in the classroom, and understand modern, 21st century skills. Wang et al. (2020) identified three to five teachers from different subject areas as ideal for STEM teams within a school. These researchers highlighted the importance of establishing a curricular roadmap and setting the pedagogy in motion with groups of teachers collaborating on a deeper level to make the content relevant for students.

Proudfoot et al. (2018) encouraged educators to modify and improve their classroom practices by increasing STEM pedagogical and content knowledge. Teachers have indicated one of the most important steps while implementing a STEM program was experiencing proper professional development, support, and guidance involving all

STEM initiatives at the local level (Margot & Kettler, 2019). This type of significant shift in the classroom will not occur in a short amount of time, and teachers will heavily rely on thorough and relevant professional development opportunities (Gonzales et al., 2014; Havice et al., 2018). Baker et al. (2015) argued that teachers' professional development should focus not only on content but also on the scientific inquiry characteristics of STEM and the pedagogy supplementing instructional elements. Baker et al. emphasized that this training can occur with seasoned teachers and those about to enter the profession.

Researchers in several teacher training studies found that pre-service teachers require preparation for working in a STEM educational environment (Ertmer et al., 2014; Margot & Kettler, 2019; Yildirim & Turk, 2018). Yildirim and Turk (2018) found that trained pre-service STEM teachers can utilize technology and engineering practices in the classroom effectively. They felt much more capable of working with students on these topics. Ertmer et al. (2014), in their study on PBL environments, indicated substantial gains in content knowledge for pre-service teachers in the described workshop. Teacher efficacy and their weight on STEM education influence how teachers participate in meaningful training to properly implement STEM curriculum at the classroom and school level (Margot & Kettler, 2019). These researchers illustrate the importance of pre-service and in-classroom training. The nature of a STEM environment, filled with academic rigor and complex problem solving, requires much more preparation due to the teacher's high demands (Margot & Kettler, 2019).

There is no "one size fits all" in professional development. A study conducted by Al Salami et al. (2017) revealed the importance of implementing professional development that builds up collaborative planning skills between teachers before delivering an interdisciplinary unit taught to their students. Through this collaborative planning, session teachers rely on collaboration with others from various disciplines. Chiyaka et al. (2017) explained that STEM teachers were more likely to participate in the professional development of any type than non-STEM teachers. Al Salami et al. (2017) revealed that high school teachers have increased acceptance of an interdisciplinary teaching approach and were more prone to collaborate with colleagues in trying new teaching strategies.

School leaders have a powerful influence on enacting institutional change involving a STEM-related approach (Alsbury et al., 2018). Plans for teachers' support should help improve the school's overall functionality and promote STEM implementation success in the long term (Alsbury et al., 2018). Support from the school's leadership should cover various school policies, such as overall teacher morale, teaching resources, student discipline, the prevailing culture within the school, and staff collaboration related to a STEM approach (McConnell, 2017). The rigorous nature of a STEM classroom necessitates supportive policies by the administration so STEM teachers can focus their time and energy on teaching and learning. McConnell (2017) also pointed out this support is necessary to retain high-quality teachers within the math and science classrooms that will be driving the STEM-focused curricular momentum. He stated these teachers need to be in an environment that indicates they are working on an essential and valued initiative. In conclusion, he argued there is a realization amongst the leaders within schools that change does not occur swiftly or efficiently in education. They engaged all available support to ensure success.

School leaders are consistently searching for methods to empower teachers when instituting instructional change or pushing new pedagogical boundaries. Sebastian et al. (2016) studied diverse ways principal leadership could lead to student growth in the classroom. Two of the eight pathways studied are statistically significant. The first pathway started with principal leadership, moving into teacher leadership, learning climate, classroom instruction, and student achievement growth. The second pathway started with principal leadership, moving into teacher professional development and program quality, classroom instruction, and student achievement growth. The researchers found principals can significantly impact teachers in their schools by maintaining a positive school climate related to the level of trust teachers placed in their leaders. A failure on the part of school leaders to empower their teachers led to unsuccessful school reform efforts (Sebastian et al., 2016).

Professional development should allow teachers and leaders to learn instructional change to reinforce the intended outcomes of implementing STEM pedagogy (Alsbury et al., 2018; Bruce-Davis et al., 2014). Alsbury et al. (2018) suggested the formation of a "…collaborative cross-district leadership team…" with the intent "…to identify and eliminate organizational barriers and to develop and support positive organizational characteristics and processes that promote improved implementation and sustainability of innovative programs in the school district" (p. 142, 144). Alsbury et al. recognized in their study the importance of designing professional development that "…should create opportunities and roles for school administrators to increase their familiarity with STEM education and involve them" (p. 83). They encouraged leaders to remain open to feedback from all stakeholders during their instructional restructuring efforts to make proper adjustments as new obstacles or problems arise.

Bruce-Davis et al. (2014) investigated administrators', teachers', and students' perceptions within a STEM high school setting of curricular and instructional strategies and practices. Bruce-Davis et al. (2014) revealed three significant findings: "(a) a common vision of a challenging and engaging learning environment, (b) a focus on applying curricular and instructional strategies to real-world problems, and (c) an appreciation for academic and affective support in the challenging learning environment" (p. 283). These revelations highlight educators' viewpoints from inside a STEM educational system.

Bruce-Davis et al. (2014) found that all educators maintained a single vision of how a fair, yet challenging learning environment would look. They noted the importance everyone in the school placed on the academically rigorous environment—the students placed upon themselves expectations higher than a typical student regarding their education by being STEM students. Teachers and administrators across these STEM schools acknowledged "…the importance of challenging students to think critically and creatively through authentic learning experiences" (p. 283). Teachers also emphasized the importance of literacy in scientific disciplines for their students. Students also developed a sense of academic community through their desire to work together in sharing the struggles they have in the classroom. Teachers and administrators promoted high student expectations beyond the high school classroom, hoping they would continue their STEM-based education.

Bruce-Davis et al.'s (2014) study illuminated proper curricular and instructional strategies. The teachers in the study reflected on their experiences using various curricular and instructional methods under STEM pedagogy. These strategies "…were classified as PBL, questioning techniques, inquiry-based learning, guided independent research studies, and discussion groups" (p. 285). While the teachers showed themselves to be aware of their course alignment standards, this did not prevent them from deviating from a set plan of instruction. They enjoyed the opportunity to branch out as needed from these restrictions and become more flexible, providing the additional rigor students need by implementing real-world problem-solving. Teachers also mentioned the extensive time required for students to properly work through "…independent laboratory investigations" and how beneficial this was to their development as independent learners (p. 287). Using questioning techniques, teachers required their students to always "think outside the box" and not accept answers to problems without the necessary evidence to support their conclusions (p. 288). These strategies collectively were found to help shape the students into critical thinkers and become producers of knowledge.

Bruce-Davis et al. (2014) also found that teachers appreciated academic and practical support in the challenging learning environment. Teachers recognized the importance of maintaining a school culture, providing the proper support for students to maintain a rigorous academic environment. This culture was critical because students seek help when things become difficult and always take advantage of constructive collaboration when working. One administrator described student support when indicating the school's individuals acted like a family and looked out for one another. Students valued the relationships they forged with their teachers and regarded them as a primary reason they felt safe when soliciting help with academic challenges. Assistance was not limited to just the classroom; it was commonplace for students to stay after school for rigorous coursework. The educators in the building collectively believed in the importance of working in a unified fashion "…by collaborating on developing interdisciplinary curricula, meeting regularly to discuss student progress, or participating in professional learning communities" (pp. 290-291). The appreciation shown by teachers and administrators when working together was paramount in their minds for students to remain successful in a STEM-inclusive environment.

Difficulties in Implementing STEM

Significant changes in the inner workings of a large institution, such as a school, do not occur without difficulties during the process. A natural barrier to the proper implementation of STEM pedagogy is the lack of content knowledge in science-based disciplines (Baker et al., 2015). Institutional barriers such as adjusting bell schedules, maintaining current pacing guides, the constant emphasis on state exams, and the natural disconnect existing between disciplines at the secondary level all bring serious challenges to overcome (Baker et al., 2008; Lesseig et al., 2016). Al Salami et al. (2017) found in their study middle school and high school teachers alike experienced significant challenges with securing supplies and expenses, time constraints, and group support and evaluation as substantial challenges. McConnell (2017) argued that schools struggle with adequately staffing math and science teachers who are influential in reaching students from an instructional standpoint across the nation. He also pointed out developing solutions for these types of problems is no easy task, but they can be easier to resolve than other major reforms within a school. Van den Hurk et al. (2019) also found that gender differences throughout educational STEM initiatives heavily favored men over women. Even teachers noted struggles were also apparent involving the lack of flexibility in scheduling classes for STEM-specific courses (Lesseig et al., 2016). Thus, challenges in making a major institutional change toward STEM are varied and significant.

Teachers may struggle with implementing a different approach such as STEM within the classroom. According to Yildirim and Turk (2018), teachers focus on problems in the classroom involving implementation. These problems include lack of time planning, lack of materials to use in the classroom, and an ill-structured classroom environment for such a sizeable pedagogical change (Yildirim & Turk, 2018). Ertmer et al. (2014) asserted that teachers in the classroom showed the lowest confidence levels when developing the materials for students to complete inquiry activities and guiding students in constructive PBL-based discussion settings. Teachers also indicated integrating STEM elements into the existing curriculum was difficult to accomplish (Lesseig et al., 2016). Some of this difficulty in properly integrating STEM arises from many less than favorable personnel scenarios such as teachers teaching out of their certification field (National Research Council [NRC], 2013). The NRC report (2013) indicated that while the decentralized organization in the United States does promote a level of freedom in decision making, the lack of a clear direction to pursue STEM implementation presents challenges. The contemporary nature of implementing STEM and the lack of a simple answer to implementation challenges can lead to struggles both at the school level and within the classroom.

Integrating STEM disciplines also brings its own set of challenges. Nadelson and Seifert (2017) identified several difficulties related to the integration of a STEM curriculum. These include the effort required to integrate content in a segregated teaching environment and ensure teachers can obtain and maintain competent STEM content knowledge levels. These teachers' challenges require a significant shift in pedagogical priorities and restructuring the school curriculum's substantial components. Lesseig et al. (2016) pointed out both science and mathematics involve instructional materials that are "…disciplinarily discreet, and typical school structures, especially at grades 6 through 12, reinforced the distinction" (p. 177). The same study also highlighted difficulties involving scheduling, adding "the traditional model of isolated mathematics, science, and CTE courses was not conducive to interdisciplinary work" (p. 184).

When integrating STEM was more complicated, the associated challenges were not specific to a particular discipline. Weinberg (2017) noted a lack of integration in STEM programs, especially involving mathematics. He suggested, "…these programs are either: (1) not targeting content that can readily be described mathematically or (2) failing to mathematically describe content appropriately" (p. 91). The redirected focus on STEM integration can come with the cost of less actual content delivered to students. Dare et al. (2014) found that physics content is sometimes hindered in delivery to achieve a greater level of hands-on, integrated coursework focused on various aspects of the engineering design process. Agriculture teachers had the lowest confidence levels in understanding engineering concepts to use in their classrooms than all other integrated subject material (Smith et al., 2015). Pre-service professional development could significantly impact future educators in the field. These problems can collectively elicit frustration from teachers attempting to change their classroom approach to a more integrated focus.

Implementing PBL, a key component of STEM pedagogy, provides difficulty for teachers. Odell et al. (2019) underscored in their writing some of these challenges. They specifically pointed out that teachers must reconsider how they approach teaching in the classroom since PBL is such a different method from traditional pedagogy. When working on projects, students need time to think through the critical analysis required. Lesseig et al. (2016) elaborated on this point when accentuating the "…need to step back and allow students to struggle, fail, and perhaps go off in unintended directions, all of which may be uncomfortable" (p. 182). This uncomfortable feeling is what teachers find challenging to overcome, despite the need to present students with a similar classroom environment. Some of the study teachers were willing to be flexible in their approach to replace some of their traditional class time but were hesitant to extend past one or two instructional days. Odell et al. (2019) indicated a lack of consistent expectations by school administration and evaluation forms that did not align with a PBL approach. This "…lack of fidelity…" gave teachers a feeling of uncertainty, and they did not seem to understand expectations in their classrooms (p. 9). A unique approach such as PBL also was found to be more difficult for teachers with greater than 15 years of experience to implement. The researchers felt this "…conflict with their personal teaching philosophy…" could be avoided in teachers with fewer years of experience who were more open to trying new classroom teaching procedures (p. 9).

There is an elevated level of importance to classroom teachers and support staff in the school being knowledgeable of STEM pedagogy. Johnston (2018) conducted a study of rural librarians in schools across three southeastern states regarding their roles in supporting STEM education in their schools. One point consistently considered was the librarians' need to understand better the classroom's STEM content and the associated curriculum standards. This underscores a challenge in implementing STEM in schools. Teachers need support from individuals outside of the classroom, and school librarians are a viable option if the content is accessible to them. All 26 librarians in the study indicated they did not believe their associated preparation programs equipped them with the knowledge they needed to help support STEM education. Furthermore, several participants reported problems collaborating with science and math teachers to accomplish their goals.

Librarians participating in Johnston's (2018) study mentioned the importance of assisting STEM content teachers through other means. For example, they could help in teaching students specific strategies of critical thinking and analysis. Particular examples mentioned included the "…engineering design process, inquiry-based learning, and computational thinking…" to teach students how to work through specific challenges in their problem-based coursework (p. 70). The librarians voiced how they would partner with the STEM teachers to help support their instruction, especially in the purchasing and use "…of a variety of technology and digital resources…" (p. 70). Study participants did not have "…knowledge on how to integrate the resources effectively in the STEM areas" (p. 70). With technology being an integral part of the 21st century workplace, "…preparing students to be equipped with the skills and knowledge they need to succeed…" is of foremost importance (p. 71). One unique way many rural librarians indicated their support to STEM teachers was writing grants to help purchase equipment or other resources. In this study, Johnson illustrated that librarians who are successful in meeting their STEM teachers' needs are skilled and flexible in assisting their peers within the school.

With STEM pedagogy being so complex and different from a traditional approach, teachers can struggle with their classroom practice. A potential solution, if utilized, would be proper professional development to aid teachers in the advancement of their skillsets to better help students in the classroom (Baker et al., 2015). Singer et al. (2016) conducted a qualitative study to analyze teachers' taped lessons in their classrooms before participating in a summer professional development opportunity. They found "…teachers struggle with four main pedagogical themes: (1) fundamental mathematical and scientific concepts; (2) model building; (3) scientific discourse; and (4) conceptual coherence" (p. 35). Participants of this study revealed that many teachers lacked the deeper level of content knowledge needed for a fully immersive STEM approach, especially mathematics and science content areas. The researchers accentuated the importance of ensuring teachers are aware of how students perceive their participation in "…reflective discussions focused on the pedagogical design of the lessons…"; teachers are then provided an opportunity to "…experience the affordances and limitations of a particular activity from the student's perspective…" (p. 42). Singer et al. found "…a positive shift in teachers' content and pedagogical knowledge in classroom lessons associated with design-based curriculum" (p. 43). These results amplify the importance of quality professional development for teachers in delivering STEM content to students in the classroom.

Personnel decisions also factor in the difficulties surrounding a successful STEM implementation within a school. According to McConnell (2017), retaining quality math and science teachers in the United States' high schools is a significant problem. He argued this problem carries a secondary effect in that fewer math and science teachers lead to a reduced impact on students in these subjects, which can negatively impact the number of students seeking jobs in STEM fields. All teachers need to be informed about the possibilities and opportunities available when teaching in a STEM environment to ensure a match between the best teachers and a STEM-related teaching position (Havice et al., 2018). Pedersen and West (2017) indicated the female STEM teachers reported "less open communication with administrators" than male teachers and articulated less cooperation among peers and more behavioral problems with students (pp. 98-99). The researchers did not find a single statistically significant relationship reported where male teachers indicated the work environment was more harmful than female teachers. While encouraging female teachers to participate in STEM students' education is needed, careful selection of these teachers should be paramount. Alsbury et al. (2018) indicated careful consideration of teachers, students, and leadership when making personnel decisions for a successful STEM implementation.

Rural School Challenges

Rural communities have unique challenges, such as specific populations of disadvantaged students, including minority populations and larger concentrations of socioeconomically disadvantaged students. Henley and Roberts (2016) noted perceived barriers to higher education, explicitly gaining entry to a collegiate STEM environment among rural students. For example, they found an insufficient number of advanced and STEM-focused classes offered at the high school level in the rural environments settings they studied. The high schools in rural regions did an inadequate job pushing students to choose a career during the educational process. They also found little or no motivation on the part of students to pursue a STEM career while completing coursework in high school. In one of the rural school environments they studied, they observed that calculus, an advanced mathematics course highly beneficial to prospective STEM students in high school and college, was not offered. Students were encouraged "…to just go to trade school and get a trade…" instead of providing opportunities to push them academically (p. 24). The authors also recognized rural areas lag more developed regions regarding industry embedded within the community. There is less opportunity for career options due to a lack of "…the infrastructure that technology STEM jobs rely on…" (p. 24). Henley and Roberts concluded that more students relocate for better-paying jobs leaving the rural community without a means for improving.

Goodpaster et al. (2018) and Payne et al. (2018) underscored that rural schools face several issues that make success in the classroom more difficult. These issues include a lack of meaningful educational funding and resources, falling populations, and continual problems hiring qualified candidates for teaching positions. They indicated that hiring quality teachers was a significant concern since qualified educators often overlook these communities. Stevenson et al. (2015) argued that the challenges involved with filling teaching positions and retaining those in rural communities have directly impacted students' focus and emphasis on their futures. McConnell (2017) magnified the importance of maintaining rural teachers in math and science classrooms at the secondary level, where many students develop an ardent desire toward STEM-related content. He argued these schools are more difficult to initially fill with quality staff, making teacher retention more problematic.

Even if staff retention is not a primary issue, course offerings and preparing students for postsecondary coursework can still be problematic in rural schools. According to Stipanovic and Woo (2017), rural schools have higher densities of poverty and fewer course options from which students may choose. If variety is an issue, schools will decide to teach the mandatory courses, and the advanced options will not be part of the discussion. Stipanovic and Woo also noted the students in the study who attended these schools reported limited options for course selection. They were placed on waitlists due to a lack of funding available for additional courses. Henley and Roberts (2016) shared survey responses indicating inadequate preparation at the high school level due to a lack of high-level classes offered, such as calculus. They reported advanced science and engineering options were not available. Students identified these constraints led to "…inadequate high school preparation" (p. 25).

Alsbury et al. (2018) posited since rural schools do not fit many traditional education models and can be unique, implementing a STEM curriculum needs to be designed as a custom fit model for the change to be impactful to the school. They argued that smaller systems could have continually shifting priorities, which can cause a lack of sustainability regarding the meaningful change. Alsbury et al. believe reform will achieve the most robust success when developing a vision and correctly executing a plan. Furthermore, they also indicated that the longer a specific initiative was supported and continued, the school's teachers began to experience greater buy-in, allowing greater STEM sustainability levels in the changes taking place.

Ertmer et al. (2014) contended that students within a rural school striving to implement STEM successfully seem to be more likely to react positively toward this type of institutional change if they can see the relevance between the classroom and the local economic landscape. Stevenson et al. (2015) indicated sustaining this type of success leads back to developing professional development opportunities that are high in quality, which is a more challenging task in smaller, more rural communities. They believe teachers in these schools need properly structured help to build up their pedagogical practice and properly collaborate with colleagues in the school. Similarly, administrators of rural schools also need help in mentoring teachers working directly with these efforts and coaching them in ways that will bring positive results (Stevenson et al., 2015).

Chapter Summary

The United States is experiencing significant difficulty preparing students for careers in science, technology, engineering, and mathematics (STEM), especially in secondary education (McMullin & Reeve, 2014). Akran and Asiroglu (2018) and Prawat and Floden (1994) contended that more schools are moving in this direction from a curricular standpoint. STEM education is rooted in constructivism, which is the theory the learner will integrate their prior knowledge into the learning process as they actively construct meaning from classroom experiences. Constructivism emphasizes collaboration and communication among learners through "…social negotiation…" to form the foundation for current STEM pedagogy in schools (Ertmer & Newby, 2013, p. 57). One key element of the constructivist approach is when students think critically in the construction of their writing and their general analysis skills.

Modern educators are placing new expectations on students and workers requiring a greater diversity of skills in today's job market. Technology is driving the economy, and computer automation is no longer an entity of the future. Today's workers are working in a technology-rich environment and will continue to do so. The importance of developing a STEM-focused culture as a practical option in schools at early ages and continuing throughout higher education is understated. Students are not receiving enough opportunities to learn about these career possibilities while in school (Christensen & Knezek, 2017). With changes in society and the workforce, employers seek individuals who can think for themselves, think critically, and solve problems both independently and with others. This independent expectation of synthesizing information becomes the modern-day worker's current expectation (Nadelson & Seifert, 2017). With technology and information becoming so readily available within the workforce, students need to become proficient in considering substantial amounts of information and determining the proper solutions to solve large-scale problems. Teachers indicated positive effects using STEM educational approach in their classrooms by enhancing course materials leading to increased student motivation (Akran & Asiroglu, 2018) and the positive impact of STEM on marginalized student populations (Alvarado & Muniz, 2018; Glennie et al., 2019).

STEM education is a uniquely specific pedagogical approach in the classroom with specific instructional strategies involved, including emphasizing hands-on learning, using inquiry-based teaching methods, requiring student collaboration with peers, promoting the value of learning from mistakes, and promoting creative thinking by asking students questions with no single answer or solution path (Gilson & Matthews, 2019). STEM educational practices can be realized in a variety of formats, specifically PBL. A PBL format utilizing technology helps students become actively engaged in the learning process (Ertmer et al., 2014). Communication and collaboration among students and teachers enhance STEM education (Al Salami, 2017; Margot & Kettler, 2019; Wang et al., 2020). Students need to communicate with one another to build interpersonal skills and develop problem-solve within a group setting.

One of the most prevalent STEM applications has been implementing an integrative STEM approach, which brings multiple content areas and concepts together simultaneously in the classroom (Nadelson & Seifert, 2017). Integrative STEM can also encourage students to become active problem-solvers and provide unique situations to help students develop positive reinforcing thoughts about their work (Gulen, 2018; Lesseig et al., 2016; Lin et al., 2018). Students benefit when they participate in integrated STEM projects, which exposes them simultaneously to practices and content from multiple disciplines leading to students acquiring problem-solving skills more consistently (Ntemngwa & Oliver, 2018). The integrated STEM approach enables students to formulate their content knowledge and apply them when problem-solving (Fan & Yu, 2017).

The Georgia Department of Education has implemented a specific initiative designed to increase STEM pedagogy saturation in schools throughout the state known as STEM/ STEAM Georgia. STEM education in Georgia currently utilizes two models of implementation (STEM/ STEAM Georgia, 2020). High schools have overwhelmingly opted to adopt STEM program models that incorporate the school-within-a-school model because the program format is a better fit in the high school environment. However, infusing a STEM-focused fundamental change in curriculum and pedagogy in Georgia is a complex process. It presumes a great deal of planning on local stakeholders due to the certification process's planning and time investment between two and three years. The requirements laid out by the state of Georgia align with current literature indicating the characteristics of successful STEM pedagogy, which include: (a) a rigorous, college preparatory curriculum, (b) collaborative group work and project-based learning, (c) increasing relevance by making connections across subjects, and (d) utilizing partnerships with post-secondary institutions and local businesses (Glennie et al., 2019, p. 238).

Transforming a school environment into a STEM approach that is friendly and welcoming is an arduous task (Alsbury et al., 2018). An implementation may begin in a more segregated fashion with a gradual progression into an integrated environment. During this time, students begin to spend more time discovering knowledge through a more significant number of ill-structured problems designed to force the student into a greater level of content synthesis (Nadelson & Seifert, 2017). It is necessary to determine in advance a set of goals or expectations with those involved to successfully implement significant instructional change, such as infusing a STEM educational approach into a school (Pearson, 2017). High-quality STEM teachers should be well versed in STEM instruction, have a firm grasp of knowledge of classroom pedagogy, maintain the ability to properly integrate content expertise in the classroom in the proper contexts, and have a good understanding of modern, 21st century skills (Yildirim & Turk, (2018). These teachers must also be willing to modify and improve their classroom practices by increasing STEM pedagogical and content knowledge (Proudfoot et al., 2018). This improvement can and should occur through proper professional development, support, and guidance involving all STEM initiatives at the local level (Margot & Kettler, 2019). Leaders should plan appropriately to support teachers to improve the school's overall functionality and promote STEM implementation success in the long term (Alsbury et al., 2018). A consistent trait in school leaders is finding methods to empower teachers when instituting instructional change or pushing new pedagogical boundaries (Sebastian et al., 2016).

Significant changes in the inner workings of a large institution, such as a school, do not occur without difficulties during the process. Institutional barriers such as adjusting bell schedules, maintaining current pacing guides, the constant emphasis on state exams, and the natural disconnect existing between disciplines at the secondary level all bring serious challenges to overcome (Baker et al., 2008; Lesseig et al., 2016). A natural barrier to the proper implementation of STEM pedagogy is a lack of content knowledge in science-based disciplines (Baker et al., 2015). Teachers may struggle with implementing a different approach such as STEM within the classroom. Teachers focus on classroom problems involving implementation, including lack of time planning, lack of materials to use in the classroom, and an ill-structured classroom environment for such a sizeable pedagogical change (Yildirim & Turk, 2018).

The challenges that arise because of significant change require a substantial shift in the teachers' pedagogical priorities and the restructuring of the school curriculum's concrete components. Making the problems with integrating STEM more complicated, the challenges associated were not specific to a particular discipline. Teachers must reconsider how they approach teaching in the classroom since PBL is such a different pedagogical application from what is done by many. When working on projects, students need time to think through the critical analysis required (Lesseig et al., 2016). Support staff in the school can also become a significant part of the solution when implementing STEM. For example, librarians in schools can provide a critical assistive role if professionally trained to be competent in some facets of STEM pedagogy and technology implementation (Johnston, 2018). With STEM being so involved and different from a traditional approach, teachers can struggle with their classroom practice. A potential solution, if utilized, would be proper professional development to aid teachers in the advancement of their skillsets to help students in the classroom more effectively. Retaining quality math and science teachers in the United States' high schools is a significant problem (McConnell, 2017).

Rural communities have unique challenges, such as specific populations of minorities and larger concentrations of socioeconomically disadvantaged students. Rural schools face several issues that make success in the classroom more difficult (Goodpaster et al., 2018; Payne et al., 2018). These issues include a lack of meaningful educational funding and resources, falling populations, and continual problems hiring qualified candidates for teaching positions. Staff retention can sometimes become problematic in rural settings. If staff retention is not a primary issue, course offerings and preparing students for postsecondary coursework can be challenging in rural schools (Stipanovic & Woo, 2017).

Chapter III

METHODOLOGY

Science, technology, engineering, and mathematics (STEM) education is underrepresented in rural areas. Researchers need to conduct more studies on how STEM education moves into and becomes influential within rural schools (Margot & Kettler, 2019). Within Georgia, over 80% of the Georgia Department of Education (GaDOE) certified high school STEM programs are in or around major urban areas. The researcher needed to explore a successful rural high school STEM program in Georgia to understand its traits and characteristics better. I developed a series of teachers' and administrators' portraits within a certified high school STEM program to illuminate the features that enable their success. In this chapter, I focus on the methods and procedures used to guide data collection and analysis. I have provided the rationale for the research design, explained the proposed setting, my role within the study, the methods used for participant selection, and data collection and analysis. Furthermore, I have examined potential issues concerning the study's validity and take the proposed action to eliminate any adverse effects.

Research Design and Rationale

As an educator, it is prudent to focus and design my research to improve my working environment and increase my field knowledge. Maxwell (2013) explicitly encourages this approach and recommends researchers align their research with their personal, intellectual, and practical goals. I developed every aspect of my research design around these core goals to directly contribute to my chosen topic. As the STEM coordinator and a science teacher at my school, I have a personal stake in implementing a successful STEM program that can impact students' high school careers. Since I work in a rural community that is developing a STEM program, I believe there needs to be a significant contribution to the knowledge base of STEM implementation in rural high school settings for other schools to consider and emulate in the future.

To this end, I believe this qualitative study on a rural high school STEM program is the most prudent option. In Maxwell's (2013) text *Qualitative Research Design*, he explicitly addresses several academic goals that fit this study's purpose. Providing context regarding how participants in a thriving rural STEM program make sense of their day-to-day interactions is crucial in the research process I have undertaken. Working within a STEM program is also critical to understanding how the STEM program influences teachers' behaviors. Determining the processes that occur within a rural STEM program that allows teachers to assess their overall success in their classrooms is also pertinent (Maxwell, 2013).

Research Questions

An essential characteristic of my research questions is that they must address the specific and unique characteristics of what the teachers and administrators have personally accomplished to implement STEM successfully. To realize this objective, I considered all aspects of the participants' lives, past lived experiences, and present involvement in the STEM program.

- RQ 1. What were the lived and career experiences of school personnel who were responsible for increasing student science proficiency in a certified rural high school STEM program?
- RQ 2. What strategies were used by school personnel who were responsible for increasing student science proficiency in a certified rural high school STEM program?
- RQ 3. What practices were used by school personnel who were responsible for increasing student science proficiency in a certified rural high school STEM program?

Several aspects of qualitative research are essential in working toward answering my research questions. Each of the questions above helps to understand the "what" and "how" of STEM program implementation. Patton (2002) discussed program studies and when they can be highly effective. He indicated that process studies are essential from the standpoint that "What we do is no more important than *how* we do it" (p. 159). Patton further adds that qualitative inquiry is highly appropriate for studying a process because a qualitative approach requires detailed descriptions of the relationships people maintain and capturing their experiences in their own words. Everyone's unique perceptions factor in analyzing the development, implementation, and maintenance of a rural high school STEM program. The program's development is filled with crucial information from several teachers' and administrators' perspectives.

I conducted this qualitative study using portraiture to create a mental image of the STEM program at a selected high school by detailing teachers' and administrators' experiences directly involved (Lawrence-Lightfoot & Davis, 1997). Lawrence-Lightfoot

(1983) proposed that the portrait "...would be defined by aesthetic, as well as empirical and analytic, dimensions" (p. 13). This approach allowed discovery of the intricate nature of the teachers' and administrators' experiences as they described in their own words the process of developing and maintaining a STEM program in a rural high school. Portraiture helped to illuminate the practices that classroom teachers cling to due to their effectiveness through an intense focus on what is beneficial for students. Lawrence-Lightfoot and Davis (1997) explained that portraiture "...is an intentionally generous and eclectic process that begins by searching for what is good and healthy" (p. 9). Since only two certified rural high school STEM programs exist in Georgia, this approach generated an engaging narrative of an effective STEM environment in a smaller, more rural community so future practitioners can glean understanding relating to their teaching environments.

Throughout the qualitative process of portraiture, my researcher's voice will play an integral role. Lawrence-Lightfoot and Davis (1997) indicated the portraitist's voice would be pervasive throughout the research. This voice presence is to remain "...restrained, disciplined, and carefully controlled" (p. 85). My voice will not shroud the participants' reality but instead facilitate each participant in having their voice heard and expressed accurately. Despite the ever-present existence of my researcher's voice, the portraitist's work "...is deeply empirical, grounded in systematically collected data, skeptical questioning (of self and actors), and rigorous examination of biases..." (p. 85). These characteristics act as safeguards to ensure the participants' voices are heard loud and clear and permit the portraitist to watch for unintended revelations during the study vigilantly.

There is a great amount of significance attached to the descriptions yielded in portraiture as a qualitative approach. Lawrence-Lightfoot and Davis (1997) stressed the importance of "...thin and thick description, seeking to include both vividly detailed..." (p. 91). Thin descriptions, including what, who, where, and when of the setting, are crucial to establishing a baseline of knowledge. Thick stories, those that provide significant context from a variety of sources allowing the reader to imagine the setting as others do in real-time, are vital as well. Collectively, these forms provide the necessary "...texture and authenticity to the portrait" (p. 91).

A key component of my voice is in the form of dialogue during interviews. Lawrence-Lightfoot and Davis (1997) spoke of this pivotal aspect of the portraitist when indicating, "Here the conversation chronicles the developing relationship between them, the emerging trust and intimacy, capturing the dance of dialogue" (p. 103). They add that the reader will hear the dialogue between the portraitist and the participant, the phrasing of questions, the methodological approach, and how the researcher interprets these interactions. Lawrence-Lightfoot and Davis liken this delicate process between portraitists and participants to "...singing a duet" (p. 103). All manners of the researcher's voice must be "...purposeful and conscious" with an explicit goal of never dominating any situation and always responding appropriately to any change in verbal dynamics (p. 105).

A final consideration of the selected research design involves considering benefits gained from the completion of the study. According to Lawrence-Lightfoot and Davis (1997), my involvement in the study as the portraitist must "...give shape to but not distort...the developing portrait", and the manner that I articulate my questions must

"...clarify but not mislead...the developing understanding" (p. 106). These characteristics give rise to the lens that will develop around the study. How will the reader be guided in their interpretation of the resulting portrait? As a STEM coordinator at my school, I wish for this study to guide the reader into seeking the meaning of how STEM can be successful at their school by examining others' success. Lawrence-Lightfoot and Davis notably pointed out that "...voice necessarily and meaningfully imbues the lens of the portraitist's vision with particular facets and hues..." leading to the notion that "...voice most tangibly represents the self of the portraitist" (p. 107). Understanding the relationship between the researcher and voice is required. Moderating the effect of the portraitist's voice throughout the study is essential as well.

Setting

This study occurred at a rural Georgia high school that has successfully implemented a STEM program and has also received STEM certification through the Georgia Department of Education (GaDOE). Exact statistics of the research site will not be given to maintain anonymity. There are seven teachers actively working within the STEM program. The STEM program at the proposed research site has been in operation for eight years and is in its fourth year of operation under GaDOE certification. With the vast majority of STEM programs in Georgia high schools being in or near large urban areas, the participants at the research site provided a clear picture of the successful implementation of a STEM program without the benefits of being near larger, more developed urban areas. I created pseudonyms for the school and every participant in the study to ensure confidentiality.

Role of the Researcher

My background as a science educator and serving as the STEM coordinator at my school are essential and highly relevant to completing this study. I have been in the classroom teaching high school students in a rural community for over 15 years. Within the last two years, initiatives have been put into place to begin a STEM program at my school. It is necessary to glean understanding from education professionals who have navigated the complexities of developing a successful, booming STEM program. As a researcher, I believe this study's completion will help my school seamlessly implement a STEM program over the next several years.

The nature of qualitative research places a heavy emphasis on the role the researcher plays in the process. Patton (2002) identified the researcher as the primary data gathering instrument. He further stated the "...credibility of qualitative methods, therefore, hinges to a great extent on the skill, competence, and rigor of the person doing fieldwork" (p. 14). This process began with the relationship that I developed with the school's gatekeepers and continue through each participant's study (Maxwell, 2013). My ability to communicate with the participants at the chosen site of study facilitated high-quality qualitative data collection. Conversely, if I showed an inability to adequately explain my position and develop relationships with those at the research site, I would have significantly hampered the study's overall scope.

The researcher's values are critical in any study. Maxwell (2013) indicates researcher values can have a profound effect, either positive or negative, on the course of a study. Throughout this study, my primary motivation was the desire to learn what effective rural STEM looks like and recreate these characteristics to allow other rural schools a more straightforward path toward STEM program implementation in Georgia. Considering this information, I diligently worked to maintain my values throughout the study. I wanted my goals and ideas to drive this research to the most accurate conclusion possible. Despite my best interests in the study's direction, it was still crucial that I monitor the potential dangers of researcher bias and work to control these negative influences throughout the study.

An essential component in the researcher's toolkit is the experiential knowledge they carry with them during the research process. In this case, I am a STEM coordinator at a rural Georgia high school. My experiential knowledge helped identify key components and characteristics of a successful STEM program in Georgia based on the foundational understanding of the requirements to gain STEM certification in the state. With rural schools dealing with different, unique challenges, the identifying strategies utilized to navigate these perceived barriers were instrumental in developing a complete picture of successful STEM implementation in a rural Georgia high school.

I have a professional relationship with one participant in the study. One of the teachers, which also serves as the STEM coordinator at the proposed research site, is a teacher I met at a GaDOE STEM Leadership Program in January of 2020. Through conversation, I learned about their school becoming STEM certified within the last three years, and I was interested because the school I work at shares several similar characteristics. There is no conflict with this participant or site selection because I do not regularly communicate with this teacher. None of my decisions have any impact on this participant in any shape or form. Our professional relationship's nature only allowed me to discover this rural high school STEM program's existence and seek it out for a potential match in a research study.

Participant Selection

I used purposeful sampling procedures to identify participants for this study. I selected participants who provided me with the richest data that I could use to create the most accurate portrait of the school's STEM program. Therefore, I used the following selection criterion to select my sample of teachers and administrators based on their experience with the STEM program through its many stages (Patton, 2002). All participants must have the following characteristics to qualify to participate in this study: (1) They must be teachers or administrators, (2) They must be currently involved in the STEM program, (3) They must hold valid renewable teaching certificates in the state of Georgia, (4) They must be engaged in the STEM program currently, and (5) They must have experience in the GaDOE implementation and certification process the STEM program experienced in the past according to the STEM/ STEAM (2019) *High School STEM Certification Continuum*.

I first sought permission to contact teachers from the school principal. I asked the principal to help me identify teachers who fit my inclusion criteria into the study. I recruited a sample of three teachers and two administrators at the school. These individuals provided their perspective of work in the classroom during implementation and the current daily activities in which they are involved. These teachers provided a varied yet cohesive view of the STEM program's inner workings at the selected school. Discussion with the principal also yielded two potential administrators to participate in the study: the principal and the CTAE director. These individuals have the closest working relationship with the STEM program. They provided a good perspective of the STEM program from an organizational standpoint, from a collaborative standpoint, and how it blends with the rest of the school. Their knowledge of these characteristics yielded rich data that corroborates what I gained from the teacher participants. Each participant was identified and selected if they meet the above criteria. I collected appropriate data until I reached a data saturation level following the qualitative research method.

Data Collection

Qualitative data collection focuses on learning the intricate details of a particular topic through observations, interviews, and reading of numerous data sources. The exact method employed in data collection depends heavily upon the circumstances surrounding a specific study. I took great care to discover the depth of information regarding the STEM program that is under consideration "...with careful attention to detail, context, and nuance; that data collection need not be constrained predetermined analytical categories..." (Patton, 2002, p. 227). Of most importance was the context of the underlying study. Rural STEM programs are scarce in Georgia's high schools. It was paramount that I used data collection procedures to help illuminate the characteristics unique to a rural STEM implementation.

I used a combination of qualitative inquiry techniques to gain the required knowledge to develop an accurate portrait of STEM teachers and administrators in a rural Georgia high school STEM program. I utilized three data sources: interviews, observations, and the analysis of school documentation regarding the STEM program under consideration. The exact nature of data collection was dependent on the COVID-19 restrictions in place at the research site. I completed all data collection in a face-to-face manner except for one interview that needed to be completed via telephone due to a participant being unable to meet in person. I followed the school's COVID-19 protocols regarding my contact with participants during the data collection process.

Interviews

I used Seidman's *three-interview series* for interviews (Seidman, 2013). This approach is useful as it "...leads to an emphasis on exploring the meaning of peoples' experiences in the context of their lives" (p. 20). Seidman's three interview series is most appropriate for this study. It allowed me to develop a relationship with each participant and provide them the needed platform to share their story of involvement in a successful STEM program and how their life experiences led them to this point in their career. Lawrence-Lightfoot and Davis (1997) specifically reference the importance of a developed relationship. They indicated that "...portraitists view relationships as potentially meaningful and significant to the lives of the actors, and that we try to make the time together comfortable, respectful, and benign" (p. 141). This approach, they continue, helps to build "...trust and rapport..." by showing the participants the portraitist's emphasis on "...the search for goodness...", "...empathetic regard...", and the "...development of symmetry, reciprocity, and boundary negotiation..." with those participating in the study (p. 141). This approach provided a sense of safety and limited a potentially guarded or defensive response on those providing data in the study.

All three interviews took place between March of 2021 and June of 2021. I based the interview guides for each of the three interviews in the series on various criteria. First, I considered the questions I used and the experience I gained from conducting a focus group interview in a pilot study of a rural Georgia middle school

STEM program in the spring of 2019. The data obtained from my interviewing of multiple educators yielded several insights that helped me better focus my desire to study rural STEM program implementation. The questions were large in scope to allow for conversational answers. The resulting dialogue provided meaningful insight into the teachers' successes at the selected school in my pilot study. Second, my involvement as the STEM coordinator at my school has provided me an objective understanding of what STEM looks like from a GaDOE perspective. This STEM perspective comes from my usage of the STEM/ STEAM Georgia (2019) *High School STEM Certification Continuum* and my experience working alongside GaDOE STEM specialists in leadership and implementation workshops. These sources, along with knowledge gained from a thorough review of the literature, developed each of the three interview guides needed to collect all data.

I executed each interview guide using a conversational approach. Through this approach, I hoped to gain more accurate and personalized data from each participant. This helped me better develop the STEM program's picture using their own words, ideas, and meanings (Patton, 2002). The first interview (see Appendix A) covered each participant's path into the education profession and established a baseline for their educational philosophy based on their life experiences leading up to beginning the educational field. The second interview (see Appendix B) delved into each participant's perspective and experience with the STEM program. The final interview (see Appendix C) involved the participants reflecting on the meaning of their experiences within the STEM program's confines. Patton indicated the interview guide approach allows the interviewer "...to explore, probe, and ask questions that will elucidate and illuminate..."

the focus within each specific interview (p. 343). The interview guide format also provided an opportunity for me "...to build a conversation within a particular subject area, to word questions spontaneously, and to establish a conversational style" (p. 343).

I maintained a conversational aspect within each interview to allow participants to lead and direct the narrative they generate. Instead of specific questions being developed and listed, general topics of discussion outlined the discussion flow. Each participant provided structure to the encounter while the overall approach allowed "...interviewing a number of different people more systematic and comprehensive by delimiting in advance the issues to be explored" (p. 343). I illuminated participants' educational background, life experiences, past experiences with STEM elements such as science or math and sought to discover how technology use has molded their past life experiences in their earlier, more formative years in the first interview (see Appendix A). I focused on a participant's view of the school culture, STEM program culture, their perception of the goals of the STEM program, their role within the STEM program, specific interactions and occurrences during curricular planning, and their definition of success within the STEM program in interview two (see Appendix B). I focused on questions that elicit reflection from each participant regarding how they connect their personal life experiences with work experiences in interview three (see Appendix C). These specific factors contribute to them working in a STEM program, making sense of their STEM program experiences, and determining how past life experiences led them to their current professional position in the STEM program. These questions collectively provided the depth I needed to craft an appropriate narrative that adequately portrays each participant and their role and impact in the STEM program.

Observations

Observation within qualitative research involves reporting on the firsthand experience of an entity or event. According to Patton (2002), direct observation allows a detailed description of the setting, full of detail. Direct observation provides a more appropriate context around the phenomenon under study. The context of a rural school environment must be considered and focused upon throughout the investigation since the research under consideration involves a rural high school STEM program. This firsthand experience also allows the placement of data collected during interviews with each participant in the proper context. Patton explicitly mentions the importance of describing "...the physical environment within which the program takes place" (p. 280). He further adds the detail should be sufficient to allow the reader to visualize the setting under consideration using carefully selected, highly descriptive, and objective adjectives. Noting characteristics of a teacher's classroom while discussing an experience, the description places additional context around the events as they are unveiled.

I recorded observational data from school visits in a notebook while in the field. The research included five separate one-day on-campus visits. Administrators determined the number of days I can be in the school conducting my observations. My observations consisted of classroom and laboratory tours and walking around the school grounds. Due to current pandemic restrictions, the proposed research site's principal requested that I conduct my school visits on virtual instruction days when students are not present to avoid any possible spread of illness. I used observations to make meaning of the knowledge and data gained during interviews. All observational data collected were informed using the GaDOE *High School STEM Certification Continuum* developed by

STEM/ STEAM Georgia (2019). The observational data collected connected to the traits and behaviors that should be evident in schools that have achieved STEM certification in Georgia (Patton, 2002).

Documents

Documentation within a program or organization can be pregnant with knowledge and information about the day-to-day decisions and general directives. Patton (2002) indicates the importance of documents as they act "as stimulus for paths of inquiry that can be pursued only through direct observation and interviewing" (p. 294). Within the STEM program, documents outlining key facets such as vision and mission statements, planning agendas, financial reports, scheduling maps, and brainstorming results provided important context regarding how the school could move forward with its intended plans during implementation as well as provided needed triangulation of data collected during interviews. The variety of documentation also provided reference materials during interviews to generate prompts for discussion points during data collection. I took pictures of the school grounds, classrooms, laboratory areas, and hallways associated with the STEM program. When combined with the informational and perspective-filled data from interviews, these images significantly enhanced the quality of the portrait developed of the school's STEM program.

Data Analysis

According to Patton (2002), "Qualitative analysis transforms data into findings" (p. 432). As brief as this may seem, the directive is also quite clear. The art of qualitative analysis centers on transforming data and synthesizing a new creation stringently based on the research process's facts. Data analysis allows the researcher to "...decorate the garment and enhance its quality" (p. 432). My greatest challenge in this process was to determine what data provided the most significant meaning within the defined context of a STEM program. Patton mentions that "Purpose guides analysis" (p. 434). I approached the wealth of data from hours of interviews, observations, and documents with a systematic focus on the traits and characteristics that make STEM work at the selected school.

Data analysis were a continuous iterative process throughout and after the collection of all data. Patton (2002) chronicles the nature of qualitative research when indicating that "Patterns take shape. Possible themes spring to mind. Hypotheses emerge that inform subsequent fieldwork" (p. 436). This ever-evolving nature of the qualitative analyses were led by the data but refined through the lens of my careful eye. The results have "...br[ought] closure...deepening insights into and confirming (or disconfirming) patterns that seem to have appeared" (p. 436). This approach required a constant analysis of the data collected, so the study's direction adjusted as needed for the portraitist to develop as accurate of a picture as can be produced within the study's confines. Lawrence-Lightfoot and Davis (1997) confirm the importance of this approach by stating, "Any system of data organization and synthesis must be flexible enough to allow the researcher to shift gears and change direction as she moves from fieldwork to analysis and back to data collection" (p. 188). They also indicate a portraitist's tools of "synthesis, reflection, and analysis" are crucial in maintaining a constant awareness to allow the data to lead the portraitist to reveal the meaning within the study (p. 189).

I narrowed the text down into chunks after the transcripts were completed. These chunks of data were identified as the most vital in portraying the characteristics of the

STEM program from each participant's perspective. Focusing on the chunked data, I used highlighting to identify categories of codes and transferred all codes onto notecards for further sorting and organization. The coding analysis for themes was completed based on the work done by Saldaña (2016). *In vivo coding* was used to capture the live action of what occurs inside the STEM program, both during the developmental process and in the daily interactions of a fully operational STEM program. I used e*motion coding* to explore the participant experiences' emotional aspects and social interactions relative to the STEM program. *Process coding* determined what routines or continual activities occur within the STEM program, leading to success in implementing and maintaining positive momentum. The data from each of these coding strategies were merged into larger themes during subsequent coding cycles to illustrate the school's portraits and the study participants (Saldaña, 2016).

Validity

Validity is an essential element in the completion of research at every level. The data collected, the themes developed, and conclusions determined must hold a level of trust based on how I conducted myself in the field. Identifying potential threats to my study's validity and defining a strategy to mitigate these adverse effects was paramount to consider before collecting data and throughout the collection and analysis processes.

As outlined by Patton (2002), I employed several strategies to ensure the data collected and results are valid. First, there will be "...intensive, long-term involvement with the research site" (p. 126). The collection of data occurred over four calendar months during the spring and summer of 2021. During this time, I developed relationships and trust with the participants through a more relaxed, conversational approach to collecting data. Second, long-term involvement led to collecting information-rich data from the interviews, observations, and documentation studied and analyzed. By managing richly detailed accounts of teachers and administrators operating within a rural Georgia high school STEM program, I developed appropriate and accurate themes and generated proper conclusions as a result. I gave participants adequate opportunity during the interview process to reflect on the meaning of their involvement in the STEM program. I asked questions that allowed the participants to reflect on their previous responses and validated my initial conclusions generated during the iterative process of data analysis.

Additionally, Patton (2002) discusses an approach referred to as "triangulated reflexive inquiry" (p. 495). Three sets of questions, each within their distinct category, must be considered. As indicated in his text on p. 495, these questions are:

a) Questions of self-reflexivity: "What do I know? How do I know what I know? What shapes and has shaped my perspective?"
b) Questions of reflexivity about those studied: "How do those studied know what they know? What shapes and has shaped their worldview? How do they perceive me, the inquirer?"
c) Questions of reflexivity about the audience: "How do those who receive my findings make sense of what I give them? What perspectives do they bring to the findings I offer? How do their perceptions of me and mine of them affect what I report and how I report it?"

When considering applying this approach to ensuring validity within a study involving portraiture, several strengths become apparent. Through these question-based strategies, portraiture as a methodology is strengthened through the researcher's actions, greater depth in the narrative developed, and how the reader will ultimately view the picture of what is taking place within the research site's confines.

Throughout this study, I considered how my experiential knowledge impacts the study's direction and regularly assessed how my perceptions could affect its validity. I used my subjective lens to provide additional depth, meaning, and authenticity to the results through my professional experience with STEM educational practices (Maxwell, 2013). Maxwell stated that "a particular researcher's values and expectations" could have an influence on a study and that the influence "may either be positive or negative" (p. 124). My time and effort previously spent with STEM specialists in the GaDOE have helped me better understand the state's expectations for schools implementing a STEM program. This knowledge of the certification process allowed me to better identify and comprehend vital elements of the data as the participants in the study shared with me throughout their interviews. Because of these factors and my passion for learning how to implement a STEM program in my school correctly, I could relate to the participants throughout the interview process and believe the data collected was significant.

Second, I put into practice interview protocols to help remain reflexive regarding the participants and sought to develop meaning from what they know and how they have come to know about STEM in the high school setting. To address any potential bias that may have existed, I constantly deferred my preferences to those of the participants in this study. I maintained a rationale that the participants were a part of a state-certified STEM program, and I was not. Therefore, the knowledge and experiences they have to share are of more value than any preconceptions of my own. My knowledge was used to provide context and meaning to the data collected.

Finally, I have written this study so that rural schools throughout the United States' southeastern region can understand the results, regardless of their exact school composition. I see this study as an opportunity to provide a needed boost to rural high schools seeking to infuse a STEM program into their curriculum. I believe these aspects of the completed study highlights my integrity as a researcher.

Ethical Procedures

I conducted this study in a manner that is considered ethical and transparent according to the guidelines of the Valdosta State University (VSU) Institutional Review Board (IRB). I took several measures to ensure fair treatment of all study participants. I submitted a request for IRB approval from VSU following the research proposal's successful defense to gain the proper permissions for my research to begin. Upon the successful acceptance by the IRB at VSU (see Appendix D), participant contact, recruitment, and data collection began. I provided all participants with a copy of the abstract, every interview guide, and the Institutional Review Board approval documents for this study. This transparency helped ensure full disclosure to each individual that I intended to be free of any deception. Before I asked each participant to provide their informed consent, they were aware that participation in this research study is voluntary at all points. I have guaranteed strict confidentiality throughout the research and in the dissertation's eventual completion. Each participant was aware that there was no indication of any direct or indirect harm resulting from participation in the study. The nature of portraiture seeks values and characteristics that are good and wholesome. Still, participants were made aware of possible harms that could unintentionally arise associated with this study.

I am fully aware that the nature of interviewing as a data-gathering process will result in some form of invasion of privacy. I used pseudonyms in all documentation to protect the identities of the individuals participating in the study. I masked the school's geographical location by providing only generalizations about the school site and population numbers to maintain a certain comfort level on each participant's part during the study. Following the VSU IRB protocol, I did not require participants to sign their informed consent forms. I provided research participants' names in the VSU IRB document. I stored all audio and digital video recordings in a nondescript, password-protected folder in cloud storage created explicitly for this study's security. Also, all written notes and codes were stored under lock and key in my home to ensure that I alone maintained access to all physical and electronic data that could compromise the identities of those involved in the study. Each participant was made aware of all data collection and interview methods before beginning their study involvement. Finally, I am aware of the state of Georgia's Code of Ethics. I remained in direct compliance with them as I become involved in these teachers' and administrators' lives in a thriving rural high school STEM program.

Chapter Summary

I examined teachers' and administrators' life and work experience in a rural Georgia high school's STEM program to understand the experiences, successes, and strategies they employ in the classroom. Following discussion with the school principal, I used purposeful sampling to identify and interview teachers and administrators at the selected with the most excellent and most in-depth knowledge of the development, implementation, and maintenance of a successful GaDOE certified STEM program. I used Seidman's (2006) three interview series approach, observations of the school grounds, and examination of school documents related to the STEM program to collect the relevant data needed to gain a proper understanding of the STEM program under consideration. I developed a portrait of each participant in the study based on the culminating analysis of all data collected. I created a collective picture reflective of the STEM program's vivid imagery and focus on how the individual portraits blend seamlessly.

This study's focus must be on the right and wholesome aspects of the STEM program under consideration (Lawrence-Lightfoot, 1983). Knowing what is positive and effective in the educational realm can provide a blueprint toward success for other teachers and administrators attempting to navigate the waters of STEM in a rural community. I hope that the results of this study will encourage educators in different rural high school settings to become more proactive in the implementation of a STEM-based approach in their schools. The literature on rural school STEM implementation is lacking. This study would begin filling the literature gap within the context of a rural high school in the southeastern portion of the United States.

Chapter IV

PORTRAITS

This chapter contains the results from my interviews with five participants at the selected school. Each of these individuals provided me with a candid and detailed look into their professional lives and experiences as they participated in developing a successful STEM program within a rural Georgia high school. First, a description of the STEM program, the courses involved, and the organization within the school is provided. Next, brief biographies of each participant are given. Finally, following these essential components, each portrait will be included in no particular order.

The STEM Program

The STEM program provides accelerated content opportunities with real-world relevance to accepted students who complete the coursework. The first two years of the program focus on meeting the vast majority of high school courses required for graduation. Although the school is set up on a four-block semester, the STEM courses are treated as "skinny" classes and meet all year long. These skinny blocks allow Career, Technical, and Agricultural Education (CTAE) pathway courses to be embedded into the paired academic courses for project-based learning in the program. CTAE pathways are sequences of three high school courses focusing on topics including welding, healthcare, engineering, construction, computer sciences, veterinary medicine, animal science, plant science, business classes, graphic design, food science, and many more. The first course in the three-course sequence acts as an introductory course for the pathway. The second and third courses provide advanced learning on the specified topic, and students take a certification test after completing the pathway.

One year-long skinny block in the ninth grade provides students with physics, geometry, and an engineering course. The other year-long skinny block that same year includes a chemistry course, world literature course, and another engineering course. The engineering CTAE courses are embedded into the academics and the content standards are taught simultaneously. This format also allows two content teachers to be in the classroom simultaneously while instructing their students. This structure provides students with seamless transitions from one content area to the next. Also, the 25% reduction in seat time due to a traditional block period is retained by extending the class to a yearlong format. In the other blocks on their schedules, students will take a civics class and fill in with needed electives.

The tenth-grade year for STEM students involves a single year-long skinny block with biology, introduction to healthcare, essentials of healthcare, and human anatomy. The human anatomy course credit is embedded within the essentials of healthcare course by the Georgia Department of Education (GaDOE). Students also take advanced algebra, American literature, and world history as other specific academics. The rest of the available blocks are filled with needed electives at the high school level.

Once a student in the STEM program reaches the eleventh grade, options for course selection become available, and there is an increased focus on dual enrollment courses and AP courses. Dual enrollment courses allow students to take college-level courses that also satisfy their high school requirements for graduation. AP courses are high school courses taught at a collegiate level of rigor. At the end of the school year, students will have the opportunity to take the AP test in the course, and if they achieve a high enough score, they will be awarded collegiate credit on top of high school credit. The courses a student will take depend on whether they choose a medical/pre-medicine/nursing focus of instruction or instead opt for an engineering focus.

If a student opts to complete the medical course sequence outlined by the school, specific courses are laid out as options for them when determining their scheduling at the high school. Their junior year options for dual enrollment include college statistics, two introductory collegiate English courses, and two collegiate chemistry courses. Their senior year suggested options for dual enrollment include two college human anatomy courses, a college speech course, two college history courses, and two college Spanish courses. During these last two years, these students will also be completing other high school courses, such as economics, precalculus, AP biology, AP environmental science, AP human geography, internship or work-based learning opportunities, and the final course in the healthcare CTAE pathway.

If a student opts to complete the engineering course sequence outlined by the school, there are different options for them when determining their scheduling. Their junior year options for dual enrollment include college statistics, two introductory collegiate English courses, and two collegiate chemistry courses. Their senior year suggested options for dual enrollment include college calculus, a college speech course, two college history courses, two college Spanish courses, and a college calculus course. During these last two years, these students will also be completing other high school courses, such as economics, precalculus, AP biology, AP environmental science, AP human geography, AP physics, and internship or work-based learning opportunities.

The final goal of the scope and sequencing of the courses offered in the STEM program is to provide the rigor and preparation students need to tackle challenging collegiate courses upon graduating while also accelerating them into their desired profession while still in high school. The teachers and administration believe in providing unique opportunities through inquiry-based learning, project-based learning, integration of CTAE courses and pathways into academic environments, and internship and work-based learning opportunities at the high school. Through these closely organized and directed means, the students can complete a rigorous college or jobsite preparatory course sequence to maximize their chances for success following high school.

Biographies

There are five participants in the study. Three of the participants are either current or former teachers in the STEM program. The other two participants are administrators in the school that directly work with the STEM program in some capacity. Each participant has varying levels of experience in education and the STEM program. Information about each participant is provided to clarify contextual statements throughout their individual portraits.

AM is a white female educator that has worked for 26 years in education and holds a Doctoral degree in her field. She has worked at the school for seven years, and three of those years were associated directly with the STEM program during its development and implementation as an English teacher. However, she is not currently working directly with the STEM program as she currently holds the role of Media Specialist at the school.

JH is a white female educator that has worked for 13 years in education and holds a Master's degree in her field. She has worked at the school for 11 years, and three of those years are associated directly with the STEM program as the current English teacher. Her experience is derived from the program's experiences following state certification.

KM is a white male educator that has worked for five years in education and holds a Master's degree in his field. He has worked at the school for four years. All four of those years are associated with the STEM program's development and implementation as the CTAE director.

DW is a white male educator that has worked for 23 years in education and holds a Specialist's degree in his field. He has worked at the school for 16 years, and seven of those years have been associated with the STEM program as the principal. His experience spans the period of time during program development and implementation into the present time.

MS is a white female educator that has worked for 21 years in education and holds a Specialist's degree in her field. She has worked at the school for eight years. She has been associated directly with the STEM program during its development and implementation as a chemistry and physics teacher and as the acting STEM director of the program.

Portraits

AM

Throughout her career, AM has held various titles within the educational profession. The list includes being an English Language Arts (ELA) teacher, media specialist, assistant principal, and instructional technologist. Her experience has also ranged across both middle and high school. She spoke of an appreciation of her responsibilities in each of these positions and how they helped her become better within her current role in the school. She could even see herself returning to administration if the right situation became available. As she described her administrative experience at the middle school level, “I was able to feed the STEM program at the middle school. So that was very beneficial.” She found value in being able to facilitate success for the teachers focusing on STEM at that point in her career and deemed that to be rewarding.

Educational Endeavors and Experience. AM considers her educational experiences as a student dating back to middle school as affecting her time as an educator. Perhaps the initial negative experience with math led her toward an appreciation for ELA. When speaking about those experiences of her education as a student, she reminisced as follows:

> Well, I have to back up to middle school because I've never liked math. And the reason being that I have a distinct memory in sixth-grade math of the teacher saying, “Are you stupid or something?” when I asked a question. I wasn't stupid. I just literally didn't understand. And so, from that point on, I think my math experiences were just, you know, just get by. And so, I didn't gravitate towards math and science, [but] I still love biology. But that was it for science. Biology was my favorite. I know I did fail a math class. Took it again, and got an A. I had a great teacher. So, math was okay. But um, yeah, high school for me was English and history. I took advanced classes in those things, but not science and math. So, at the same time, though, I was working a part-time job at a pharmacy, and as a pharmacy tech back then, because you didn't have to have certification. And I

> thought, well, pharmacy [was] interesting. I thought that because [of] math and science. But I went ahead … [and] took some classes in chemistry, and thought again, this is not my field. I don't know what's wrong here. I'm gonna not work out. But I took pre-med biology. Did great in chemistry. Math? No. So figured out that I should go with what I was good at, which is reading literature, and decided to major in English.

AM almost spoke of her experiences as though she was constantly receiving these slight hints and nudges toward the subjects that she truly excelled in, despite the constant appearance of a variety of other professions, such as pharmacy.

The lingering effect of the middle school math teacher was profound. She spoke of this experience as a significant life-shaping point in her personal history.

> I really did feel stupid when that teacher said that. And I know that's crazy because it was this one person, but it literally affected [me] and I kept being in honors math classes because I was. I don't know why I was. And finally when I got to high school, I changed that [and] went to regular [classes], but I still struggled. And I feel like that, in my mind, it was just very difficult for me to do anything with the physical sciences. And the chemistry [was difficult] because of the math concepts there. It was just, that I didn't grasp it as easily. Now that year that I failed math and then took it again, the algebra … teacher was very patient and just really did things in a visual way for me to grasp it. And that was the first time I actually understood. So it took a very long time for me to do that. But then senior year, I struggled again … my teacher had breast cancer and had to be out for the last part. So I didn't get the instruction [I needed]. I think I would have

> done better, of course, had she been there. But that getting that A in algebra two class [junior year] was just pretty affirming for me. So I knew I wasn't completely ignorant about math. I felt really good about that. But I still didn't enjoy it.

Despite clearly rising past those obstacles on her own, this middle school teacher's effect seems significant in her mind. She emphasized some successes later in high school, but the math challenges were prevalent enough to steer away from when considering a career choice.

Perhaps a significant reason for AM's success came from her Algebra teacher when she retook the course. She described her as willing to work with students who struggled with math content.

> She was a teacher I hadn't had before. It was a female teacher. She was very patient to explain things multiple times. Multiple ways. So, if you didn't get it the first time, she would say, "Okay, let's try this way." And she would do that. So you got individual attention when you ask for it, there was never the concept that you're stupid for asking a question. So, she was very patient, and … she would explain things to help people who were struggling with it.

AM seemed to appreciate this teacher's extra mile in her academic life. Not only did she benefit from learning the math content, but she also gained confidence in an area that she considered a struggle.

AM attended college in a progressive educational environment, where there was a transparent approach to learning through discussion and hands-on techniques in small group settings throughout her undergraduate and graduate coursework. She even described her collegiate days as being "progressivist and constructivist" in nature. This approach had a profound impact on AM, and she believes it led to her better embracing a STEM approach in the classroom.

> And I think that having gone through so many years with Piedmont [College] that really has impacted my teaching, because that's where I got the idea where you needed to have kids learning by doing, discussing it, letting them fail, that's not a bad thing. And letting them fix failure because they were like, “There are very few times when we can't redo something. You take your driver's test until you get it. If you're a lawyer, and you fail the bar, you take it again.” So there are very few things where it's been one and done. And so that really informed my teaching to more than one chance, show me what you know, in whatever way that's going to work for you. So lots of choices. With that, you know, there's no one way to do it, right? There are many paths to the answer and many answers. See math doesn't do that. There's one answer, you might be able to get there multiple ways to answer and to me, that's very limiting and very difficult to wrap my head around.

Not only does she affirm her appreciation for a constructivist approach while in college, but AM also reaffirms her dislike for what she perceives as a restrictive learning environment when considering a mathematical perspective.

School Culture. AM indicated that school culture could play a pivotal role in executing classroom activities and completing individualized goals. This culture allows teachers to work together as a cohesive unit for the betterment of the students through their instruction. She immediately recognizes the level of expectations at the school and has for quite some time.

> The school culture here has always been very high expectations [by the administration] from the time I've been here, this [being] my seventh year at the school. So, they have had a reputation and still do as being an exceptional school for students and teachers. People want to work here. The kids have so many opportunities to be in higher level classes, AP, honors. We have seven levels of RTI [Response to Intervention], which a lot of schools don't have. We have everything from resource SPED [Special Education] to your STEM as the highest. So, we have those, so I'd say there's a level of achievement and expectations that make it a pretty positive place to work. School culture, you know, there's always pockets of dissatisfaction, but overall, I think there's a pretty strong feeling we do a lot to keep the kids engaged.

The focus seems to be on a defined reputation built and maintained over several years. Understanding that not everyone will always be happy about every decision is understood, but the overall culture is positive and inviting for the students. The equity around the school is clearly defined as well.

> You have the pockets of kids who are not going to be bought into anything, who are kind of negative naysayers, but by and large, I mean, they know that there's a culture of excellence and we don't tolerate [anything]. You [as a teacher] know if they're going to do something wrong, they're held accountable, and that counts for athletes, down to the kids that aren't involved in anything..... So there's that culture. I think that we're trying to keep them accountable and we have high expectations and when they excel, we celebrate them, whatever that is.

AM characterizes this level of expectation for all students, not just those within the STEM program. Clear expectations allow for an understood level of transparency with the community and what the school requires of each student.

STEM as the ELA Teacher. Rigor and repetition: this is the life of an ELA teacher in the STEM program, according to AM. She acknowledges throughout our conversations the unique role she played when the STEM program was in its infancy. There was a consistent belief in her classroom that excellence was a must and multiple tries were always welcomed if the results showed growth.

> Grade 'em hard. Be super rigorous, don't just give them something because they turned it in. There's no effort here. If you did it wrong, you're gonna fail. You got to do this right. So, ride them just as hard as you would, you expect them to do it right, knowing they're not going to get it all right because they don't have all those skills yet. But you're going to see where they are, and then you're going to be able to teach them the skills they need to do better. And so, some of them are really good and they're gonna pass some A's, right off the bat. Most of them with the essays I got from them, if they didn't cite their source they got an automatic F, that was, that was it. I'm like, "I'm sorry I told you in there how to do it, you didn't do it. You didn't read the directions … so you got this bad grade. So now how are you going to fix it?" And so, I would do a lesson on this is what you should have done, and I might just do it with that group that was bad because not everybody needed it. Grade them hard, be tough on them because a lot of them are not failed [in previous classes], and they need to see what that's like, and they need to learn from it.

AM quickly continues discussing how her grading impacts these students. She understands the level of work the student needs to put in to show proper mastery and the reward that should be available for a student who is willing to put the time in.

> And then they get the grade, it's not [an] average. They get a new grade, and if they need to do it three times or four times, that's fine too. So sometimes you're doing that first essay in December, again, and you're so tired of reading it, but they finally got it. So, it's kind of nice. [It] happens less and less as you go on, and same with the science test they would get corrections on. They have to come in and do those, they didn't have to make corrections, but you would expect them, they will because they don't want a bad grade. So, just making sure that they get a realistic idea of what they know and don't know, and then let them fix it because very seldom in life are you not going to get a redo. If you fail your driving test, you're gonna go take it again until you get your license. Failed the bar? You're gonna go take it again. So … they're not going to move on because they didn't get the first part, they need to get that before they go on. Literature builds, though, so give them another essay … And you don't get parents as angry because it's like, "They don't have to have this 65 [for a final grade]. All they have to do is fix it and I gave him all these comments. Oh, you didn't see those let me get that to you." And then they're like, oh well I can do it again... So, you know you don't have the parent push back in STEM … But when they know that it's not "you just failed your test and that's it," that the kid can fix it, they're on your side. They know they're going to get their kid to do it, so I can't blame you as a teacher, because you've offered every opportunity to succeed.

She believes strongly in giving the students every opportunity to be successful. AM wants these students to realize success and is willing to provide them individualized time to accomplish that.

AM does wish that some of the students had the same zeal for excellence in her class that they show in the more mathematical and scientific courses.

> And so, you know, some of them settle for a bad grade. And that's okay. Especially with English and the STEM program. That's not why they joined the STEM program. So, I had to think about that too, you know for this kid who is never gonna do anything with writing. Can he speak? Yes. He's pretty good at speaking and that's true. A lot of times they're very good at articulating things that just aren't as good [at] the nuts and bolts of an essay. You're gonna be doing this in real life with your communication skills.

In the end, communication is essential. AM understands the communication skills needed to positively impact all facets of life.

These communication skills were the topic of conversation as our interviews continued. AM identified students in the STEM program as being very good at analytical tasks, but their ability to verbally communicate and other soft skills needed continuous refinement.

> Communication skills were the most important, being able to stand up and give a presentation with all the good things that we know they should do: making eye contact, talking loudly enough so everyone in the back can hear, and having the presentation go along with that, having the gestures, making sure that they didn't have too much on a slide. You know, we said 10 words [on] the slide is more than

> enough. And so that's hard for them. And so, I started learning how pictures tell a better story. So, communication skills for me, [are] really important.

Other communicative skills tied to literature are a focal point as well. AM specifically points out being able to interpret literary passages to generate meaning in what is being read.

> As far as … making sure you can analyze literature and not just read it but understand why something is the way it is. They had to get to the deeper parts of it so you can't just say, "Well you know I found this simile." What about it? Why does it matter? How's that going to connect to a theme? Why did the author choose that instead of something else? So we just got a little deeper with literature and why that was the way it was, and anytime we could tie back into our science themes we would. So, the things we picked always had to go back to the science too.

AM feels very strong about maintaining connections with the content being learned in class. She didn't want the subjects to remain isolated in their silos. Instead, AM believes the individual disciplines are strengthened when woven together in a seamless fashion during instructional time.

The continuity of maintaining an interdisciplinary instructional approach was important in her classes. In addition, AM believed the connections needed to be made between science and ELA to show relevance between the subjects.

> So, when we did our unit on the Odyssey, everything was tied back to light: reflection, refraction, all of those things that tied in, and then we just tied that in

> with characters so that they're seeing how the stuff they read isn't just for literature, let's look for our science pieces [as well].

One of the biggest points of emphasis AM made repeatedly during interviews involved using the content from one class to make the necessary connections in the other class.

> Our first unit is on religions as well as the chemical and physical properties of buildings and how you're going to build a structure that reflects that religion … We read *The Alchemist* which ties in three world religions, and then they did projects researching … six to eight world religions, and then they had to read a piece of the sacred text and then tie that back into what was valued in the religion. They also had to research the kind of structures that their religion had … So they looked at the chemical and physical properties of the things that they might use to build a structure that fit that religion and they have to design and build it, not out of the structure, not out of those components because some of them are obviously not reachable, but they might 3D print something. They might build something out of wood or whatever it was, so they had to come up with this large presentation at the end that shared all of these things in a succinct way with outside judges who are experts in world religion, and some of the physics and chemistry parts and, you know, they were very, very daunted by that task because most of them were like I don't want to talk to anybody, much [fewer] people I don't know, and so it's pretty challenging, but they have little pieces along the way. Where are you doing checkpoints? So, we might have something in class where they just talked about what that literary piece means, and how that ties back. They might prepare a [portion of] food that goes on with their religion and

> talk about why that was important, but they're also working on the chemistry part and the physics part. So, it's kind of neat.

AM enjoyed the collaboration. She enjoyed watching the students struggle with the challenges of each unit and how the content is connected.

There was also a special appreciation by AM for the effect of collaborative interdisciplinary projects on her STEM program students. These effects drove the way she did everything, from interacting with the kids to building them up to how collaborative planning and assessment development took place.

> Well, as an English teacher I had a lot more impact because I was working with those kids individually every day. Knowing what you wanted out of the project in the end, we always started with the end, what does it mean to need them to know and be able to do what is the standard? That's what you start with because you don't want to just put a bunch of stuff together and be like, “Well that's gonna be fun.” It has to all relate back to what you're trying to get them to learn, so that was always important for us. We'd always start with the assessment. What do we need them to do at the end that's going to tie back into this whole goal? So, I would always do the rubric development with [the STEM director]. We worked really closely together. I mean, we had a whole summer we spent before we ever started the STEM program trying to tie all that together. And then as we went on, we would just tweak it and make it better, but just making sure that our units all aligned with the standards and the assessments all fit exactly what we're going through.

She alludes to the ability of students to determine whether work is meaningful in the classroom or not. AM then distinctly speaks to avoiding the "fluff."

> Kids hate busy work. I hate busy work. It all needed to matter. And so I think I impacted it that way in keeping us focused and keeping us organized and making sure that we had what we needed to do at the end, in a way that makes sense to everybody.

She seemed to enjoy reflecting on her role as the ELA teacher in STEM. She wanted the chance to help guide the interconnectedness of all the content being thrust together.

When discussing her time in the classroom and how it was spent, AM provided some detail that helps frame everything that occurs within her room. With so much activity going on it was difficult to gauge how time was being spent. She indicated that about 25% of the time in her classroom was spent in direct, traditional instruction.

> Sometimes you do have to have direct instruction. I mean, I don't know what stoichiometry is. They're gonna look at that and follow that and do all that. But most of the time, for me, sitting and giving them lecture notes is stupid. They can look that stuff up. So, I would just give them the notes, and we would talk about the notes and save an hour, two hours, you know, that you might spend [in] a lecture classroom because that's not the important thing. I wanted them to apply what they were learning.

She even provided examples of how she would accomplish this approach in class.

> So, if you're gonna talk about literary devices, 'Okay, go find me a simile in this song, and then explain to me why that works.'...So, you know, it's like keep going

> that extra little bit. They've been doing that stuff forever. They can identify a simile in a bag...they don't need me to teach them that again.

Her classes understood that the students should have learned what they were taught in previous years. Instead, it was time to use and apply their knowledge to make the connections stick.

I specifically asked for a lesson, unit, or project that was explicitly memorable to AM. I wanted an example of how she works to implement ELA within a STEM-focused environment. She thought for a moment and then began discussing one of her pedagogical highlights during her time teaching in the program.

> The literary theory [project] with *The Odyssey.* That's probably one of my favorite things because they're collaboratively working, they're doing something, and it's, you know, related to the science piece. So, let's say that one of the things we played with is trying to [create] different colors of the plastic, you know, to see how that changed things. And that was really hard to find those when we came up with that grand idea, so it didn't work out. But we talked about using the different colored plastic in their presentation to show how that would change things with color. [It] didn't work so, [they saw] that we fail too, which is important for them to see. We talked about how we wanted to do that, and we never could make it happen, so we're like, 'Well how are you guys going to show us that the perspective changes when you shift the topic, when you shift from [an] archetype, to whatever it is you're doing?' So they had to go through four different lenses for scenes from *The Odyssey*. So, let's say that they chose Odysseus on the island of Helios with the cows...and they are all going to die. So, they have to look at that

> [from] four different perspectives and tie it back to a theme and see how the theme changes. So, for me, [they are] working in groups and figuring that out and [to] listen to them talk about it, I mean moving from group to group, that's when things click because I love to see them working in groups, asking questions, me asking them questions and asking me questions. And then the science pieces build in too because they're having to talk about the life piece and all that. And so it was all together and it's just perfect. So that that to me is just like you're in that zone. That's perfect.

AM reveled in the chance to take two different topics and marry them together, creating a unique learning opportunity from what would typically be considered an odd fit by the traditional classroom teacher and approach. She constantly affirms her reasoning for working in this manner involves helping the students develop a better understanding of the content in both classes through the connections made between them.

STEM as the Media Specialist. Later in her career, AM assumed the role of media specialist at the school. This change in role came about as the administration sought to keep an acceptable balance within the school. AM relishes the opportunity to continue helping students from a different perspective. As someone that has worn multiple professional hats, from teacher to administrator, to media specialist, AM understands that flexibility in supporting both teachers and students is key to realizing the successes that can take place within a school.

> [Working as the media specialist], that's really what I do now. And that's how I've always interacted with the teachers. How can I help you teach this better? How can you reach that kid that's not getting it? Because I was that kid with math. So

what can we do? I'll dig and I'll find math resources. I don't understand math as well as an expression. But I can tell when a math tool is going to help a kid who may not have gotten it before. A lot of times it's through those hands-on pieces, you know, if they can make something physical that helps them understand it, that's going to be it. So, I can pull that. And I can [use] project-based learning...that's what we do with STEM is PBL. And that just fits every button in my head, for this is how we need to teach all kids, not just STEM kids.

AM believes her impact can be felt by providing additional resources to the teachers and students outside the classroom. In her mind, the time teachers sometimes do not have to accelerate or remediate students can be provided in the media center.

AM understands she is a resource for the kids at present. She is there to help integrate a technology piece, such as using academic databases or learning to use new gadgets. When students are working on an assignment she can help proofread their work, and she is there as a helping hand.

We use Galileo [an academic database] extensively so I teach the kids how to use that. Georgia Library Learning Online, which is, you know, it's the way to write your dissertation. I wrote my dissertation with this, so they've not heard of it. A lot of times I'm like well let's talk about this and so we will go through a hands-on process where I'm like, okay pick a topic and then I show them how to narrow from there 3.5 million hits down to 150 and see what we can get … Yeah, we talked about Boolean modifiers and how that's an algebra thing and you bring up that science and so we talked about all that and it's really kind of neat. So research, I love research and I love writing … So we go through all of that, and

> I've done that pretty much every year with the kids. So I did it as an English teacher versus a media specialist. I still do it, because [the STEM director] invites me in, it was my thing … So, just more of a support piece of information technology, you know how to how to access things, how to cite APA format, MLA format, teaching them some hacks on Google Docs, and like how to do hanging indents, you know, just things that they don't really know because they just don't know.

Despite many students' digital exposure, the exposure isn’t typically channeled into academia. Instead, AM found that many students lack the formal technology skills, such as using a word processor or spreadsheet, needed to be productive in society, so she focuses on those. She tries to teach them there is more to internet searches than Wikipedia and how to determine if a resource is legitimate or not. She wants to act as a living, breathing resource for the kids. In her words, she is there for “information and support.”

Her long-term goals involve changing the footprint of the media center to become so much more than just a home for books and other print media. She envisions it becoming more of a “learning commons” where students can come for support or to extend their knowledge, depending on their needs and wants. She has added a 3D printer in the media center and wants to flesh out a full-blown makerspace area where students can sit down and build or design something only limited by their creativity using items from basic cardboard and tape up to electronic gadgets. She also wants to enhance her space with more equipment such as Raspberry Pi units, so students can spend time learning about aspects of coding, engineering, and computer science. She sees the media center as a way to foster creativity, not only for the STEM kids in the program but also for all students in the school who may have an interest.

Collaboration With Peers. AM doesn't see value in working in isolation, which can be problematic in the high school ecosystem. To their admission of guilt, teachers find themselves teaching in silos at the high school level since they are content specialists. She commented, "I realized that kids need to see relevance and connection. I mean, you can't teach things in isolation. It doesn't work very well. So anytime we could work together collaboratively, we did." This was about her time at a smaller school before joining the STEM program. Even at that time, AM saw a need for more interdisciplinary connections between subjects and wanted to help solve it. She also had the luxury of working with the current STEM coordinator at that previous school and already had the relationship built. This relationship was built up to the point that the STEM coordinator reached out to AM and recruited her to come over to work.

> So I'm like, "Well, I don't know." But I did. I came over here. And that was before the STEM program started. But, you know, with our background, what we knew, it just seemed like a great thing to start a STEM program where we could integrate all of the [content areas] … I knew how important it was for kids to see the connections across disciplines and to see how that was going to apply to real life. Most importantly, because if you can't get them engaged and see how it's going to connect to what they're going to do in the future.

In AM's mind, this was the start of something great that could impact kids in a way they had yet to experience.

The nature of collaboration requires everyone to develop and maintain trust with their peers, which could sometimes be uncomfortable. AM spoke at length about having to set aside personal interests for the sake of the group. She told of constantly making sure everyone was in step with each other philosophically on issues such as classroom teaching, student expectations, and how to grade student work. She spoke of her working relationship with the STEM director as they collaborated on ELA and Chemistry while contrasting that with what didn't work within the program.

> We work really well together. To do that, we both get excited about kids getting excited about learning and we want to bring [the energy] as much as we can because you know there are some people we don't work as well with. And if they don't see our way of thinking, it's harder to work with them, and if they're not with the whole grading thing [we use to allow multiple opportunities to learn through mastery], we want to make sure that they're doing what we're doing with the grading. You can't have one group that's going to be like, "Nope, you failed. Sorry, moving on." I can't do that. They have to fit our STEM philosophy of, 'They're failing, what can we do to fix that? How are you going to help them learn that concept?' You can't just let them go on. It's got to be learned before they go on to the next thing.

Her words when discussing the working relationship with the STEM director were always so positive. She appreciated the creative aspects that they both brought to the table when teaching together, which served as a model in her mind of how co-teaching and collaboration within the STEM program were meant to work. AM noted, "A lot of times too because of the way we could blend things … it was just such a seamless experience and we've worked together so many years that, you know, we have no ego problems. That’s great co-teaching.”

The planning meetings at the beginning developmental stages of the STEM program were a significant undertaking. AM spoke of the planning needed to take place the summer before the program started. The academic teachers got together to discuss how to begin putting together a puzzle that didn’t exist yet.

> We went through what we needed to cover. So we had all our standards laid out, and then we talked about the best things to pull in. So … all of us are working together in the same room, thinking about projects and plans and what tied in. … You really need everybody in the same room, and you need to know what standards you're trying to get a look at [across] the whole year. And we plan for the whole year. I didn't mean it didn't change, but we laid it out in a big spreadsheet grid, and we named them by units, and we brainstorm what's going to go in each unit so we can cover all these [topics]. And I didn't go in the textbook order, because we just needed it to fit where it fits best.

She also indicated the large-scale planning was geared with the result in mind and considered what large, overarching themes needed to be established throughout each STEM classroom in their collaborative units. Once the finish line was established, they would collectively find the best way to get there.

> We never started with the first things that were written and went to the end it's, that's just not how I ever taught my classes anyway. So, themes. So that was my big thing. Like, these are themes that tend to be universal, how can we tie this in? And so that's where we’d find literary pieces, a big one, some small ones, we pull

> into science concepts. That's how that worked. And so, things would happen along the way because, you know, we wanted to do something more fun. That's how the stoichiometry *Julius Caesar* [project] came into play. [The STEM director] had a student teacher visiting from Young Harris, and we're like we're trying to come up with a project to tie in *Julius Caesar* and stoichiometry and all this and we just started brainstorming with this kid from college and she helped us get that going. And so we actually did end up getting the characters as elements, so each character was assigned, and the kids had to balance the equation and talk about what happened with that equation based on the characters' traits and they had to prove it with text from the source too. So, it was this great project … So we created an example to give the kids, so that was just great fun. I enjoyed that a lot. So that's part of it as, when you're planning, you need to do the thing yourself too, [so] that you can see where you're going to have pitfalls.

The level of collaboration and openness, especially bringing in a fledgling teacher to the planning process, is remarkable evidence of how these teachers develop powerful, cross-disciplinary instructional pieces.

Building Student Relationships. When discussing working with students and everything that entails this aspect of teaching, AM spoke freely about how the students work in the classroom and what strategies she found that did a respectable job of impacting their learning in a positive manner. Firstly, setting the tone and becoming trustworthy is paramount.

> You have to build trust and respect. And it teaches them better ways of interacting with other adults as they move on. Because I think that's important. And, we don't

> always write the best questions. We come in with a perspective of what we're looking for, trying to evaluate [them and their work]. But they may read it totally differently. And you can tell that they understand the concepts. It's just maybe not the way you worded it. So, to me it's all about understanding, not about dinging them because they didn't answer that question correctly.

AM focused on the importance of building trust and respect. Once that trust is developed between teacher and student, she felt she could remain consistently rigorous in her academic approach to push students to succeed in their inquiry-based learning environment. She emphasized further how vital it is for the students to understand why they and their work are being analyzed so thoroughly. AM believes that once they know "the why," they will accept "the why" as the program's greater good.

> I think [building] relationships is a big part of it because they knew that the teachers cared. I mean, obviously, [in] the beginning, they didn't, but as time went on, that relationship grew and they knew they can trust [whomever] the teachers in the STEM program were. We worked with them. If they had a problem, we were there to listen, but also the fact that they were doing exciting things. Labs are fun, their inquiry, their discovery, it's kind of a mystery, and it was okay to fail. So, you weren't just worried that you were going to mess up and there's your grade, so I think it was that discovery aspect for the kids that, "What are we going to do today?" What was fun? What are we gonna do so they kind of knew even if it was something complicated, they knew that we'd be there throughout the process. So, I think that's part of it that they didn't feel like they were just coming

> to sit, be passive and just listen to somebody drone on about, you know, the properties of matter.

This level of comfort that AM believes the teachers in the program provided was crucial to ensure the students would accept the challenges before them, knowing the students would be supported throughout the learning process.

When the students have spent a year or two in the program and become accustomed to the processes, they develop new relationships with the teachers. AM describes this shift from strictly a teacher approach to an all-around role of teacher, counselor, confidant, and even mentor wrapped into one package.

> Well, towards the second part of their freshman year and definitely upper levels, your sophomores, juniors, they're relying on you for college references, for all the things that you're gonna need as an adult. So any question they had, you know, if they were scared to go ask somebody else they would ask [the STEM director]. Yeah, so that that's always good, you created a bond with them because you're with them for three hours, the freshmen, you know, over the course of a year...

AM speaks of the STEM director's relationship with these students as nothing short of remarkable. The relationships are built by investing time and emotion into the kids while guiding the students through the critical thinking process.

> And it would be just enough to get their brains working, you know, so just such a high level of engagement, and they enjoyed coming to school. We have so many field trips. It's hands-on. Fantastic, love it, and the kids got really excited about that and they felt special, because we celebrate them, and we do so much for them and with them. They become family. They call her momma [the STEM director].

> They sure do. She's like, another mom, and I know they can go to her because she's our STEM director. They see her a lot more than anybody else.

AM also reminisces about students from the past whom she taught at the beginning of the program. Connections still exist today between AM and some of those students. Bonds were created that have yet to be broken.

The connections do not completely fizzle, AM reveals. The past students that she still receives updates from have continued to push her to continue her work as an educator.

> I'm still in touch with a lot of those kids that were in that first cohort. And [the]second [cohort as well]. And then the kids that I've gotten close to now come seek me out in the media center to talk to me and tell me what's going on. I don't necessarily teach them, but I've connected with them somehow in some way and so those, those are success moments for me that they remember [me]. So, they come to find me when they need something related to English, you know, they're like, "How can we do this?" and so, they're good kids. I just like it. They asked you for those letters of recommendation for their schools and their scholarships because they know that you know them. It's not going to be a form letter. You're going to tell them specific examples of how this kid is a critical thinker or how this kid did [something significant], so I can write those letters for the STEM kids because I know them. You get to know them and you know their strengths and weaknesses and you can tell them, even to their face, what they're good at and what they need to work on, but they know that already because you already

> critique them in class. So, it's just you get really close to them. And I think that's a huge part of the STEM program is that sense of family...

The connotation of a family is a viable part of AM's professional work with the kids. Being in a small-town school, the developed bonds and connections are important because the students value the personal relationships they make with their teachers. AM noted the students respond strongly to this approach. The students are individuals, not components of a herd being shuffled from one place to another and respond accordingly with quality work.

Defining Success in the STEM Program. How success is defined in an entire academic program is a complicated endeavor. First, goals must be determined and set; AM spoke directly to this.

> We wanted to integrate all those subject areas so that every unit was interdisciplinary and connected with all four subjects, every time. And we wanted kids to see how that tied to real-life skills … But that's a really big piece of it that they had to do real-world things so at the end of every unit there was a public performance piece like we would invite judges outside of school, to come and evaluate the things they created or the presentations they were doing, and we gave those judges rubrics that the kids had too, and we said they're going to be looking at all these things and they're going to grade you and what they tell you got is your grade. We're going to give you a grade too for what you've done, but what really matters is what those outside people think because they're the experts in their field.

This level of authentic accountability is what AM indicated they are striving for in the STEM program. She passionately spoke about authentic experiences for the students, experiences that allowed them to learn within context.

AM does not hide her joy in teaching students within the STEM program. She speaks to her time within the program teaching ELA as her favorite “because there's such a high level of engagement. The kids are learning and doing and they just know that you know, it's okay to fail because they can fix that and it's going to be okay.” She appreciates the culture that has been established when combined with students who are driven to be high achieving.

> They're very grade conscious because they're high achieving kids anyway so you have to teach them that. You got 65 on that first paper, but you're going to get better because you see all these comments I wrote, and you're gonna fix that … It may be December when you're happy with that paper. So learning to fail and achieve [is so important] … how are you gonna fix that, what are you gonna do, there's so much questioning, and I love that.

Expecting the best work from the students consistently and providing multiple opportunities to realize this level of excellence within the program defines success, according to AM. Students are willing to work until they get it right. They want to understand. They want to be successful. Maintaining that drive and pushing them just past their limits shows the success of the program.

AM perceives the ability of the program to make these interdisciplinary connections as one of the successful aspects of the program. She believes these connections lead to student growth by removing subject-level isolation of content.

> So one of the goals again was interdisciplinary connection across all the subject matters so that it's real-world relevant because life is very seldom science [or] math. It's not like that. So we wanted them to see the connections across disciplines, and we wanted to make sure they work collaboratively well with whomever they got assigned to because in real life you don't always get to pick your teams. You might have a job where you work by yourself, but it's a global world, and we want them to be able to do that, so presentation skills were really important. That communication piece, that's really what we emphasize with English: the writing, speaking, the listening, making sure that they could do that because STEM isn't really so much about that most of the time. Those are huge skills for employment and employability is a very important school skill, that's one of our big goals. So we want that. We want them to be able to be competitive as they go off, you know. Once they get out of the STEM program we want them to get into the best colleges where they want to go, you know, be competitive with other students.

AM wants soft skills to be developed in her students. These skills include the ability to communicate effectively, understanding the nuance of speaking and listening to others, as well as grasping the writing process. She understands the scientific components of STEM make a student stand out, but the communicative aspect of individuality is what can polish off the rough edges and mold a student into something remarkable.

AM believes the STEM program allows the students to better compete for whatever their hopes and dreams are outside of high school. She speaks of former students and how they developed throughout their four years in school. The young adults they became, the dreams they could make a reality, the schools they gained acceptance to, and the real-life skills that were developed and refined throughout the program inspired her to continue working with excellence in the program. She believes strongly in the elevated level of authenticity that the program provides to students that stick with it throughout high school.

Words of Wisdom. AM provided words of wisdom for teachers or schools that want to implement STEM for their students. She believes there must be universal buy-in at all levels, that a shared vision exists by all stakeholders, and a willingness to collaborate from the top down.

> [Buy-in must start] from their administrators, whoever is in charge of making scheduling happen, and money flow, because they need to have the buy-in from that before anything's gonna happen. And they need to make sure that the people that are aligned to carry this out have a common vision about grading and that there's shared time to collaborate and they're okay with collaborating, and they're not stuck in their little silo. They need to be able to get out of those silos and work and see the value in changing their curriculum, sometimes chopping out old pieces, because they're still going to get it, it just may not include that favorite product you had that [was] more dessert than the main course. So they have to be willing to let go of the reins, they have to be willing to let kids explore and not have all the answers. It's okay not to have the answers. So they just need to have that same kind of attitude that … we're going to try all this. If it doesn't work out, what are we gonna do differently to make this successful? So I think it's just getting the right people on board to make it work. And having whoever's in

> charge of all of that to help with the scheduling … when we first started this, we had a lot of time in the summer … to come together and work on things … we just got into it so much.

She finished her thoughts by discussing how much joy the team members had in working together when the program started. They enjoyed each other, respected each other, and made sacrifices for the common good of the program. In her eyes, the collective interest of the program was the most important of those within. For that experience, she was extremely grateful.

JH

Growing Up. JH is a product of the town the school is located in. She grew up, graduated high school, made friends, and built great relationships with her teachers there. The nature of her thoughts and descriptions of growing up are fond. She comes from a family of teachers and a family that places a heavy value on education in general.

Although she enjoyed the small town, JH did not stay there. Instead, she indicated that early in her adult life, she moved around a lot, including stints in Las Vegas and Chicago. These experiences saw her opening a software company, selling the company off, being in corporate sales, and becoming a juvenile probation officer. She attributes her life experiences as a significant contributor to where she is today.

> I really truly believe that all the experiences I have had that led up to right now and where I am in the STEM program and as an educator, as a person, in general, is that learning to adapt to new situations because I have had to do it so often. And when I look at my personal life definitely, you know, curveballs are thrown. Plans fell apart. Nothing went the way I thought it was gonna go. Like learning how to

> step back from that, pick out the lesson, figure out what that lesson is to move on in my life has been a theme for me. Since a young adult, I definitely see that playing out in where I am right now in the STEM Academy because that is what we do, right? We try something that doesn't work. We step back; we analyze it. Why didn't it work? What can we do different? How can we make it better? Do we need to scrap it and move on? And then that's what we do. So, I think that my life experiences, even though it may look like a curvy road, it definitely led me straight to where I am right now.

Following life circumstances that ended in her becoming a single parent, she moved back to her familiar hometown to raise her kids in an environment JH felt she could trust. Her first exposure to the STEM program fell in the role of parent as her older child became a student at the high school.

Components of the Program. When discussing faculty at the school, JH quickly acknowledged the strengths of many who influence the STEM program. Regarding the principal:

> And I do feel like [he] does a great job as the principal of holding the expectation. Meeting the individual needs of the student at that moment, maybe that's needing some reprimand or is in trouble. But also still engaging the student body. They love him, you know, and he's created a relationship with most of the students where he can chew 'em pretty good, tell them, this is the way and we're going in this way, and you can get on board or find somewhere else to go. And then when they leave, they're still shaking hands. And, you know, good luck at the baseball game.

The focus on maintaining discipline while keeping an individualized approach to the student body is a point of emphasis by teachers and administrators alike.

JH likened the teachers in the STEM program to being part of a small family with the kids. She indicated in several instances how they fill various roles of being the mother, father, crazy aunt, or an uncle. She also emphasized the importance of building relationships with the students. She specifically pointed out the time spent with the students and that each of the STEM teachers brings something different to the table. When discussing her strengths, she indicated:

> I am fulfilling an unofficial role. Um, and that was just something I decided to do. [It] wasn't necessarily like, we were just talking about it one day, and it actually happened by accident. You know, they had had a really, really rigorous physics test the block before. And then we were going to pound out some annotated bibliography stuff. And I was just looking at their little faces. And I'm like, they don't need this right now. What they need right now is just a moment … so I just said, okay, guys, we're gonna scrap that today. We're not gonna do it, and just tell me what's going on. You know, but I think that's just the counseling background.

JH specifically mentioned some of the stress students in the STEM program face with a full plate of chemistry, physics, and geometry in their first semester in the program as ninth graders. However, she takes pride in these moments where she recognizes the students need to be able to breathe a little bit when they have had a rough academic morning.

Some of these moments of academic counseling involve JH merely reasoning with students when they cannot understand a particular outcome.

> And I can hear [a student in class] talking just about how frustrated they are that their cars aren't working, or this isn't working, or that's not working. They'll be so frustrated that this group of kids over here that they don't think are smart as them in the program like won the mousetrap race, and this kid over here who thinks this whole time in his life that he has been the top of the food chain and cannot figure out how this kid this group of kids beat him. And so he's just, you know, playing everything over in his head and bothered.

These students are very analytical, and it is bothersome for them when they cannot wrap their minds around a situation. So for JH, the opportunity to be the sounding board and offer encouragement while still fulfilling the role of an ELA teacher is rewarding to her.

The faculty, according to JH, have tried to make decisions within the school based on what is best for the students and how to approach students with their best interests at heart.

> We've had lots of conversations as faculty about students as consumers because they really are consumers; they have to have faith in what we're selling. You know, one of the things I think about all the time is that education is changing. And there are lots of avenues for kids to get an education. It's not the same. It's not that this was the only option. You know, when I was growing up, this was the only option you went to high school because you went to your local high school. That was it. If you're going to high school, it's not like that anymore. Kids can pick and choose, especially now; how many more online platforms have come out of this past year, you know, and kids have an option now.

The relationships JH mentioned were crucial to the students' faith in what the teachers and administrators were selling. Therefore, when trying to implement and maintain a progressively designed academic program, the benefit to the student must be transparent.

Building Relationships. Part of that relationship building involves nurturing the students during times of academic struggle. With the nature of a STEM inquiry-based approach, students will find themselves floundering in class periodically. JH described some of those feelings the students tend to have when she said:

> They're gonna let me struggle for a little while. They're not gonna let me fall, but they're gonna let me struggle a little bit, you know, try to figure out what not [to do], because we have to have conversations with them, figuring out what doesn't work. Sometimes it's just as important as figuring out what does work to know that [something] doesn't work. [If] your parking garage has fallen four times, or your bridge is breaking, or your mousetrap car is falling apart, those are learning lessons too.

She continued to describe the importance of these lessons for the students. They almost act as a coming of age for those within the STEM program. These struggles are unavoidable. Instead, they act as a way of allowing the student to further develop intellectually. Over time the struggles lead to development.

> You can see that happen with our kids in the STEM program and their confidence begins to rise, and a lot of them begin to find their niche, like chemistry. It may not be their thing, but biology sure is their thing where, you know, building the mousetrap car may not have been their thing, but they love [it], they excelled in the digital clock building like they begin to find their areas.

Fortunately, there is an endpoint in mind. According to JH, program and personal classroom goals are not merely tied to individual classroom instruction. She indicates, “I feel that one of the things that we're trying to accomplish is to turn our students into adaptive thinkers, and students who can solve problems. These goals are not tied to an ELA class but instead focus on building the student to become a critical analyst and problem solver.

ELA Within STEM. It is interesting to note the ELA's approach within the school's STEM program. ELA works with the students to help them with their communication skills and improve their ability to research and write effectively. These skills work in tandem to maximize the science and mathematics instruction that occurs in the program. While not a specific aspect of the STEM acronym, ELA still holds a vital role, according to JH.

> When you tell people that you're an English teacher in the STEM program, people are like, ‘What, the E stood for engineering.’ But again, I think I've had to take a step back and look at what that means to be an English language arts teacher in a STEM program. We know we're definitely not the norm. So that's why I think, you know, my focus shifted to communication and teaching them to be critical thinkers, critical readers, and learning how to communicate effectively. I tell kids all the time technical writing is the most difficult writing I've ever done in my life. In my life, back when we had a software company, and I was responsible for the … technical manuals on the software. That is some very difficult writing because in your head, like you asked me right now how to bake cupcakes, and I'd be like measure flour measure sugar, you know [because] I've done it so many times, but

when you're writing that out, you have to be very specific. You need to be very clear in your instruction and so you know we do some of that type of writing and that practice writing on telling people how to do things because you are an engineer or whatever it is that you're going to be doing, you're going to tell people how to do things. And so my work, so to speak in this realm, is communication is really what I focus on. Let's clearly communicate things and learn how to succinctly communicate.

JH believes strongly that developing communication skills is vital, especially within the STEM program. She pushes her students to be explicit in their written and expressed thoughts. She understands the impact of communicating clearly and how this can benefit the students in their academics and will benefit them later in the workplace. She also acknowledges the importance of working in the STEM program. The program has allowed her to focus on the student's well-being while tending to academics.

I think being part of the STEM program has helped me do that, you know, like I know emotionally, socially, what I teach. I [know] want to be, and now I'm crafting that academic part of me and the type of teacher I want to be.

JH reflected on her students in the STEM program and quickly acknowledged some of their shortcomings, especially in the reading and writing department. She noted, "Because a lot of our STEM kids, that's their weakness, reading, and writing. Not reading as much, but like the comprehension end of the reading, and the application of analysis, reading for analysis." Even setting aside ELA, JH acknowledged that just because a student is in the STEM program does not mean they excel at everything.

> [We should be] getting the thought out of [our] head that just because a student is in STEM, means that they will excel at everything because they're not, they're not. Nobody does that. We're not all perfect at everything we do as people, we're gonna have our strengths, and we're gonna have our weaknesses.

Goalsetting for Students.

When considering personal goals, JH pondered the idea and discussed developing minds that are both strong and flexible. She profoundly desires her students to develop the ability to think for themselves and become independent in their learning.

> I want to produce critical thinkers, adaptable critical thinkers really… kids who could solve problems. That's really what I want: kids who can synthesize information. They're inundated with knowledge and information and statistics and fake news and whatever. … The ability to sift through that to me is a critical skill that we've got to start getting to, they've got to learn how to be critical consumers of information, and they've got to learn how to be critical thinkers and adaptable.

Her personal goals align closely with the goals of the program in general. The STEM program is not just about doing something different until a student graduates, but instead, it is so much more.

> Okay, we're getting to graduation but what good is that? So that definition of success for me is it kind of holds for the STEM program that we put these kids through this program for four years now they're graduating. Now let's look after the freshmen here and let's talk to them and see if they felt prepared and ready, and like that can be the challenges needed. And I think that's something I've been meaning to talk to [the STEM director] that we need to do maybe now is bring in,

> because our group, our first group that graduated. Next year will be their third year of college. Yeah, so I think it'd be interesting now to bring them back in and talk to them about how they feel this prepared them.

Success for All Students. JH defines her success as a teacher in the STEM program based on the outcomes her students can achieve.

> When my kids are able to leave, and you know they're a little more grounded in their thinking they're able to defend their arguments a little more. They're able to analyze information and take important pieces of information away and feel like I've been successful.

These goals and ideas of success are woven into the fabric of the STEM program. Regardless of the content being taught, teachers push the students to become independent and critical thinkers in the program.

JH also emphasized the type of student in the STEM program. She focused on the idea that it isn't a club for honors kids. Instead, students of all ability levels with a specific mindset to learn in a science and mathematically-enhanced environment can benefit from the unique instructional approach.

> So, you know, what's wrong with the kid being in the STEM program and being a "B" student? What's wrong with that? If they're challenging themselves, if they're rising to the occasion, if they're growing in their academic abilities, in their reasoning abilities, in their responsibility as a student, aren't we doing what we need to be doing?

These students should not solely be labeled by their ability or inability to achieve a specific grade in a course. Instead, watching the growth as they learn to analyze better and solve problems is a much better barometer for effectiveness in a student.

Interestingly, JH admitted there were times when it seemed the teachers might have pushed the students into rigorous academic waters too quickly. For example, the freshman schedule includes challenging physics, chemistry, geometry, honors literature, and engineering courses. Over time, the teachers developed a better understanding of how to push their students without making anything feel unnecessary. JH described the modified approach by the teachers by saying, “We can make it, you know, challenging, but not overwhelming. Instead of **STEM**, it became *STEM* [emphasis added].” She also spoke about high school students getting too much content too quickly. In her words, the students sometimes need to be told, “Whoa, you don’t have to do everything this year. You're a freshman, you know. Let's not do this. Let's pull back out of this class.”

Collaborating With All. JH spoke for a significant amount of time about the need for and importance of collaborating with her peers in the STEM program. In her first acknowledgment of approaching collaboration correctly, she indicated, “...we've all had to step back and be like, ‘Okay, all right. Everybody's content is important. How do we support each other in our content? Like how do we bring out the best aspects of the content together?’” By her admission, she plays the role of a “jack of all trades” in how she works with her colleagues and blends her content and skills with the other course offerings.

> I would look at what I needed to cover, and we will kind of seamlessly try to work the materials in with each other. So, we really do a lot of breaking down to the

> standards and just kind of unpacking all of that and looking at it and, and looking at them side by side and saying, "Okay, when we're reading *The Alchemist* in chemistry, they're just dealing with elemental levels. Well, we can talk about alchemy, we can talk about, you know, just the basic periodic table, how it's structured, how elements interact with each other. That'll work with this reading that we're doing right here." So, we kind of work that in together.

The time spent collaborating during planning sessions was significant. The teachers had adapted to being open to everyone's input in these sessions at the beginning and throughout the year. For example, JH wanted to see what topics were being covered in the chemistry class she was co-teaching and chose literature that best suited those topics.

When I asked how she approached collaborating with the other teachers in the STEM program, JH spoke about having the ability to remain adaptable and checking her ego at the door.

> You have to be willing to set aside your own personal interests for the interests of the kids. And I think you have to have the right personalities together. I don't think … that every teacher that we have, and every teacher in this building, would work well collaboratively. I think you have to have the mindset of, I'm willing to try something new, and I'm willing to fail at it. You know, I'm willing to just struggle.

The willingness to struggle is particularly interesting. JH also admitted that teachers are much more comfortable in their classrooms with their positional power over students and the content being taught. Trying a new approach involves accepting risk, a proposal many teachers do not welcome. JH admits that accepting a certain amount of vulnerability in the classroom is almost necessary for her to be as successful as she is.

JH postulates a possible outcome of teachers collaborating in real-time during class involving the students present to be a part of that process. This collaboration consists of the structure of the courses in the STEM program, allowing teachers to co-teach their content side-by-side. The students become beneficiaries as they see their teachers working together, collaborating in real-time, seamlessly.

> They see that interchange … they're watching adults model behaviors and relationships that they are going to have to model soon. I mean, I dare say that a kid that graduates today, you know, almost any of them are going to be working in some type of collaborative environment. The world [has] just changed.

This acknowledgment of society's direction within the school context provides a sense of forward thinking. Continuing that thought, she also noted:

> And just to talk about the importance of collaborating to build something that's never been built before, you know, that goes somewhere that no one's ever gone before. Just those kinds of things I think is an important skill I think all kids need to learn.

JH treats the notion of the direction of the STEM program as a metaphor for society. As she frequently mentions during our conversations, many of the jobs that will be needed do not exist. However, people must be trained. Within the STEM program, collaboration occurs to develop a program built without a model or blueprint to consider. Instead, collaboration and trust reign supreme between the teachers involved.

JH also understands her place regarding her strengths and weaknesses of content knowledge. Her skills within ELA are entirely acceptable for the STEM-infused classroom. Although she co-teaches with the chemistry teacher in the STEM program, she regularly interacts with others with substantial knowledge in the sciences, something JH is not as comfortable with. She makes up for what he lacks in content knowledge in other ways.

> I don't have that content knowledge like [the biology or chemistry teacher] when we're doing labs, but I can walk around and say, 'Why are you doing that, explain that to me,' and it gave them [the students] an opportunity, I think, to really process and think through the labs, because you know there's something that happens when the student becomes a teacher and those moments where they've got to understand what they're doing enough to explain it to somebody else. And so I just kind of became that person that floats around the room to ask questions.

JH takes advantage of her lack of understanding in chemistry by focusing on what she can do. She can ask questions and probe the students' knowledge in her unique, ELA-driven way.

> I find that sweet spot of facilitating the learning, not doing it for them and not letting them just completely, you know, be caught in the weeds, and what you're describing, that's not really something that can be explained or taught, it has to be more experienced.

JH has even indicated that these learned skills of becoming more of a facilitator of learning, that is, presenting more of an open-ended classroom environment and structure and instead helping students navigate the desired tasks or workload, have even crept into her other classes. Her reasoning: she has seen the approach's effectiveness and believes in it.

I asked JH to give me a specific example of a project that her students work on that blends ELA and chemistry. She spoke about a joint project that combines Shakespeare with stoichiometry.

> Julius Caesar, let's talk about him. He's rigid. He wants to be in control. We name all of these things that the characters possess. Brutus is naive. He's easily manipulated. He's all these different things. Cassius, he's corrosive. He, you know, changes things when he's around [Brutus]. He agitates situations. So, we started talking about all of that. And as we're talking about that, and as we're talking about their interactions with each other, so what happens when Cassius starts interacting with Brutus? And they're like, "Well, he begins to change Brutus, and he begins to manipulate him and, and he begins to see things differently." Okay, so we start talking about all of that as we're reading the play. While on the other end of that, [the chemistry teacher] is coming alongside me and saying, "Okay, tell me about these elements. We've been studying what's an element that's easily malleable? What's an element that agitates other elements?" And so, we start kind of piecing that together, side by side. And all the while she's talking about elements, their interactions, you know, they're solving the equations doing all that at the same time that I'm talking about these interactions between characters. And little by little, the students begin to see if these characters were elements, what kind of elements would they be? And why?

I could tell that JH held a keen sense of accomplishment when working with the students on this project. She felt the ELA content gave her a unique angle into the chemistry concepts in class. She used this approach to speak with them, pose questions, and check them for learning. The opportunity to watch them learn two different concepts in perfect harmony was profoundly fulfilling for her.

Personal Growth. JH admitted what the STEM program has done for her as an educator in the classroom. After spending the better part of three years in the STEM program as an ELA teacher, she identifies specific ways her work at the school has improved.

> The STEM program, I think, put me in a position this year where I was a little more used to, "Okay, let's figure this out," like it's a little different. We need to figure it out. And when you talk, when you first tell people you're teaching Julius Caesar with stoichiometry, they look at you like you're crazy. And I'm like, oh, it did work. We'll figure it out. We'll figure it out.

The willingness to accept the uncertainty of trying a new instructional approach is apparent in how she constantly speaks, is open with her peers, and allows them to shape her classroom approach. JH spoke multiple times of how trying new things has helped her reduce anxiety when change enters her classroom. She continued that thought when saying:

> So, I think I've become much better at mediating situations and feel very just much calmer, and I'm telling you right now it is. I know it's 100% from working with [the chemistry teacher] and [the biology teacher] and down here and just

> learning that okay, it may not have gone the way we wanted, but we'll figure it out. It'll be okay. It'll be okay. We'll figure it out.

The mantra of "figuring it out" spoke volumes. In the STEM program, figuring it out means remaining flexible, analyzing the landscape as it comes along, and adjusting as needed. Project implementation did not always go smoothly for them, but they learned along the way, and each new project was executed with more remarkable finesse. The collaborative approach not only helps in designing lessons but also helps keep teachers in the STEM program upbeat and feeling in control.

Flexibility and Reflective Thoughts. Not only does JH feel strong about her place and role within the STEM program, but she also understands there is a constant state of personal reflection on how she approaches the learning process in the classroom that must take place when considering pedagogical adjustments. While she wants the students to become the adaptive thinkers she mentions on multiple occasions, there must still be a specific structure in how they are guided to develop these critical thinking skills. This reflection and instructional flexibility are reminders that she is constantly considering the larger picture of the STEM program and what the goals of the program are about. For example, there will be times when her students finish their work in her class and want to use the additional time to further their project work in another STEM course.

> We've got kids, they'll be up in my class, and let's say they finish the work for the day, and they're like, "I haven't finished my digital clock. Can I go down and work on it?" I'll call [the geometry teacher] and he's like, 'Well, I won't be in the room. I'm right next door, though." But yeah, we can trust those kids, and they come down, and they work on their clock, and everything's fine.

JH understands that when she allows her STEM students to maximize their time in school on STEM-related projects, they continue to generate more buy-in to their work. She can foster and support this by being flexible with her class time, as opposed to a teacher holding students in their classroom to avoid losing out on their instructional time. JH believes responses to the kids build those relationships as well. Throughout our conversations, she indicated that “kids recognize genuineness, and they recognize when you’re trying to fool them.”

Even after courses are taught and successful instructional patterns are developed, JH still believes processes can be improved. She indicated the STEM teachers as a group are always considering whether a course or unit of instruction is placed to maximize student learning or not. If not, they seek to determine what changes could be made to positively impact student learning. I asked during our conversations if she found anything within the coursework she teaches that could be modified to better match what the program expected of the students.

> We could look at some of the composition classes and see if maybe that's a better fit, where we're really looking at writing, you know. I would like to be more integrated into the lab writing process and use that as a basis to teach grammar and certain things.

Her immediate reaction suggesting possible changes to her instruction suggested she is confident in her ability to do what she has done in the past but completely willing to adjust to meet the needs of the students. It also shows that this pattern of behavior is standard within the program and she is comfortable with instructional change.

KM

Background and Personal Influences. KM holds the role of CTAE director at the high school. Multiple CTAE pathways at the high school are directly integrated into the STEM program. With his task overseeing the development of hands-on instruction in pathway-specific courses, his experience in such matters is of prime importance due to the interconnected nature of STEM and CTAE. He described himself as a nontraditional entrant into education, meaning his original degree and career choice were outside of education.

> I'm definitely coming to it [education] in a nontraditional way, which is from a STEM perspective and on the CTAE side of things, [how] most of our teachers come in. So that has actually benefited me being able to mentor some of these guys that are coming in, guys and gals coming in [from] industry. I've noticed that they don't have the teaching expertise in that background and so [I] kind of mentor them along the way and help them out.

This experience from the industry allows him to help teachers within his program fine-tune their teaching craft. CTAE is about relevance to the workplace. His knowledge about applying the knowledge taught in these CTAE courses allows him to correctly shape the direction of the CTAE department and positively impact students in the STEM program.

KM spoke at length about his interests and strengths as a student in school. He found interest in the application of science content in school.

> I enjoy some of the sciences, I would say, more than others. I was a strong writer, but I [enjoyed the] Career Tech part [of school], and I have kind of a broad

> spectrum there. I took some construction courses. I took some automotive courses. I took business courses. I took computer programming. So, I took a lot of those types of courses, and I enjoyed the hands-on aspect anytime I could do that. So, you know once I was introduced to STEM when I came to this school, that very much intrigued me as far as the program and the blending of academics and CTAE and the hands-on learning, project-based learning, all that kind of stuff. But as far as me personally I guess that's what intrigues me to CTAE and all that because that's what I was intrigued by when I was in school.

His love for hands-on extends farther than just the mere coursework. In his spare time, KM is a crafter, and a creator, constantly seeking out small projects around the house. “I like creating … not necessarily like an art sense, but just building stuff. I'm constantly doing stuff around my house [such as] remodeling.”

As a student in school, KM also developed an appreciation for computer programming.

> I took some computer programming courses. Well, back then, computer programming was nothing that it is now. I mean, we were making a little ball roll across the screen. In the 90s, we weren't creating video games like they're doing in our programming class, but that still intrigued me. I guess the visualizing, an accomplishment of, you're either building something or making this ball roll across the screen, and you've won because you've got to do what it was supposed to do. I was really into … math. The math that clicked more with me was geometry, the things that I could visualize using, like in construction … so those were the things that intrigued me.

His gravitation toward the role of CTAE director seems natural. KM feels a unique bond toward instruction that involves a hands-on approach. His love of vocational instruction guides him in making hands-on teaching the best it can be for the students at the school.

> I liked anything hands-on, anything that I could design. Now here we have engineering students that I don't think we have maximized their experience yet. … I think some of those engineering kids don't get to apply it, and I think we can really build and expand the engineering funnel. If you love engineering, you love just the technical engineering. Do you like drawing? Do you like electrical engineering? What is it about engineering that you'd like in the modern world? … And we have the ability to do that. I mean it's all hand in hand, and so from an engineering aspect, I think a goal for us is to really expand.

KM understands that each student is unique in their learning, and he wants to provide an outlet for all students to have a thriving environment in which to learn.

> I know not every student might not learn … that same way. You know, some students might read something and learn it better than using their hands, but I just feel like the application is key to learning and it connects to all styles of learning.

CTAE Education and STEM.

As the CTAE director, KM appreciates the current integration of engineering and healthcare courses that have already been implemented with his CTAE program and the STEM program at the high school.

> My connections with STEM as a CTAE director are pretty direct. Currently, STEM is involved with our engineering program and our healthcare program and

we're looking to expand that even more. … A lot of the STEM students are involved in [many] of our other programs like computer science, entrepreneurship, and agriculture. And so anyway we're looking at spreading that STEM concept throughout all of our CTAE areas where we're blending academics and CTAE coursework.

KM understands the natural connection between CTAE and STEM education. Both educational entities focus on making content relevant in real-world contexts or applications. As a result, the STEM program at the school has become a template for modifying the current experience for CTAE students.

I was just having a conversation with the entrepreneurship teacher yesterday. They just did these good presentations that the students did for some community members, the other day, and we were talking, we were talking about the growth that you see and these kids that are in that program because they have to present and work as a team and all this throughout the year. In their communication and presentation skills from August to May, it's like night and day. That's just one example of just the power of CTAE and the organizations that go to these competitions, and they're having to sit, kind of like me, and you know, in some of those competitions, enter the interview style with somebody they've never met, something that's powerful. I mean they're learning some life skills that will never leave them.

The perspective from the private sector continues to flow through KM's decision-making process through his interactions with community members, business owners, and other community stakeholders. He constantly weighs out the pros and cons regarding the general direction of his CTAE program. What he has concluded is that the STEM program has provided a great model for how to make his CTAE program even better. This improvement arises from finding ways to better integrate content teaching into the CTAE pathway courses to improve relevance in the classroom.

> So just think like that and always look for ways to improve from [a] business standpoint, you know, continuous improvement......It's more of this continual trying to create more opportunities for kids, you know. And so with that, our STEM model and our STEM programming, the STEM students are basically completing their high school level stuff, freshman and sophomore year, for the most part, our other CTAE programs that are not taught [within the] STEM program. Most of those kids are finishing those pathways by the end of their sophomore year, and then they're almost running out of classes that they love. Say they love construction or welding or automotive, or whatever it might be…agriculture, but they run out of classes, and so we're constantly trying to figure out some old course numbers from Georgia that we can build in [to their coursework]. But why not partner with your local tech school, with Georgia Tech, and start providing those kids dual enrollment?

From a technical perspective, the infrastructure in the CTAE program is already present. Grants have been awarded to keep the machinery and technology within these CTAE classrooms on the cutting edge of the modern workplace. In addition, time has been spent planning to strategically expand the CTAE footprint in the school. KM discussed the wealth of modern equipment available to the students depending on their interests.

> Well, we got a manufacturing program, very high tech … to get kids rolling. A lot of parents, when they think manufacturing, [remember] manufacturing from the 1950s, whereas manufacturing these days, these massive, fancy CNC [computer numerical control] machines that you basically are an engineer and a computer programmer to run [and] operate. So, it's the change in the industry and the change in mindset that every single student has to go to a four-year university or they're not going to be successful in life.

KM's challenge is to ensure that his program prepares his students for the modern-day workplace. This connection is where CTAE and STEM intersect for him at the school. Each pathway or program within the CTAE department directly connects to career fields in specific technical areas such as construction, welding, forestry, plant sciences, animal sciences, automotive, and healthcare. In addition, each pathway offers unique instructional opportunities to allow students to specify the direction of the knowledge they want to enhance.

Characteristics of the STEM Program. KM often spoke to the various components of the STEM program, speaking directly of the work ethic of the teachers and the students. He described the teachers as innovative, energetic, caring, and individualized. KM believes these traits are what drive the program toward being successful. He also believes these traits helped the program to push through to where it is presently.

> The culture towards … the STEM program was, I don't want to say it was negative, but it probably wasn't as positive as it is now. It was kind of seen as an elite type, only the top kids could go into it, and the district put all this money into

> it, and so not even in the school building, but the community in general kind of was, had that perspective, I guess. But … the instructors and everybody involved with the STEM program have done a very good job kind of revamping that perception so to speak over the last several years. And it's no longer perceived like that because they've done a great job of spreading the word [that] this program is for everybody. Now, we're adding the College and Career Academy [CCA] kind of aspect to this school. And we're about to take STEM further, so to speak into all of our different CTAE pathways.

The CCA he refers to is an initiative at the school where the blueprint established by the STEM program, involving an interdisciplinary approach to academic and CTAE courses, will be expanded throughout the school and become available to the entire student body.

The initial recruiting for the STEM program may have led to this reputation.

> I think it started with that top tier, the top-tier students. But now I don't know the actual breakdown [of student makeup in the STEM program], but it's a mixture. We've got special education students in STEM, we've got middle-of-the-road students in STEM. We still have those top-tier [students] and … [the STEM director] has told me that it's very neat … to see them all come together and work together in teams and things like that. So yeah, I think the makeup of the students has changed dramatically over the past five years, [from] where it started, and now it's a mixture [of students and abilities], and then that has also increased their numbers tremendously.

Becoming a victim of its success, the STEM program has seen its numbers double in the last few years. Where they would initially take 25-30 students per school year, this last year saw between 60-70 students taken in, a testament to students being attracted to this type of educational option and the program's willingness to work with a variety of students.

KM spoke of a general school characteristic, a desire to try new and exciting things, or a sense of progressiveness that he believes has helped the STEM program become what it is.

> One thing I love about this school is that we're very progressive in [that] there are no bounds if our teachers want to do something. We're gonna bust our butts trying to make it happen. For instance, [the STEM director] this past fall brought up the STEM students really were having a difficult time getting into the computer science program because of scheduling. When certain classes were offered, they weren't able to take them. So, I went to a computer science teacher … and he said, "Well, why don't we just offer it to [the STEM students] as an online, standalone course they just do on their own time, and I'll grade it as they do it.

The faculty at the school seem to pride themselves on their ability to take on a problem and find creative solutions that work in the best interests of everyone involved.

> Maybe just the creativity and how can we get creative and make something happen. I'm very much student-driven, and I want students to succeed. I want to provide them as [many] opportunities while they're in high school as we can. So, we're currently exploring through that Career Academy we want to basically expand the STEM model throughout all of our CTAE programs … the blending of academics, and because all of our CTAE areas are project-based learning. So,

> for instance, in construction, why are we not teaching geometry? Why are students not getting their geometry credit in a construction class?

These questions emphasize how they try to generate more relevance in the classroom.

KM spoke directly about what characteristics make the program run on all cylinders.

> Innovative. Innovative is a good one. Teachers, you know, energetic, caring, I mean, those teachers pour their heart and souls into the STEM program. All of them, I mean, down to the individual. And I think the STEM program here, we're talking about individualized instruction [that] goes above and beyond. I would say I've never seen individualized graduation plans laid out [for] every kid. They know every kid, [what] they want to do, and they put them in dual enrollment, specific to them. … And so, it's amazing, really, the time it probably takes to sit with every student and do that, but how valuable that is. So that's kind of our goal when I say schoolwide that's another aspect of it, like every kid that graduates from this high school, walks across that stage, should know where they're going the next day. … Are they going to tech school? Are they going to a four-year university? Are they going [into the] military? I think that individualization is huge.

He believes in the passion, the innovation the teachers show, and the willingness to meet the individualized needs of students. All these characteristics build to what makes the program so successful.

The teachers push their students to develop job skills such as independent thinking and analysis. They want them ready for the job site or the college classroom on day one post-high school.

> And I think the STEM program through the project-based learning and teamwork and problem solving, critical thinking [works]. All those things are building kids to be employed, be trainable. … I don't know how much you talk to industry folks, but that's their [main concern].

The leadership within the school not only promotes collaboration and problem-solving with the STEM program teachers but also among themselves. Their actions pattern what they expect of the teachers and the students, and it shows through the development and oversight of the program. Administration in the school, such as KM, conveyed a constant sense of self-reflection in their work. He wants the pathway courses in the CTAE department to be highly effective throughout the school, especially when connecting with the academic courses within the STEM program.

> Well, and on that collaborative planning side, I think strong leadership is needed, and not necessarily to sit there and facilitate every single second of the meeting, but to make sure that the right people are at the table for successful collaboration and collaboration in order to move that program where you need to go. … You're not facilitating the program so to speak, on the day-to-day operations of the actual program, but you are facilitating the kind of umbrella, so to speak, that encompasses all of that stuff when it comes to collaborative planning, the moving pieces.

The complex nature of the CTAE program that KM describes only works when every administrator and every teacher approaches the program from the perspective of doing what is best to make the program thrive. Total buy-in leads to success.

KM continued discussing the nature of the work the teachers in the program endure to realize their successes.

> They work their tails off to get to that. That's how they accomplish that goal, and I can tell you that from master scheduling [of courses] and doing all that side of that thing, that's a challenge. To sit there and one-on-one with each kid and talk about future goals takes a lot of time. I guess I would say their goal is to provide as [many] opportunities while they're in high school to get them to whatever level they're going to be or whatever their goals are. That's kind of their goal, but to accomplish it, man. It's hard work, you know, and I think those goals [probably change] over time. I'm sure when the STEM program started, those goals were like, "Okay, the first couple years, let's just get our curriculum down, you know," and then they had that pretty good. [Then] they go back and adjust things just like anybody would but then the goals kind of changed. Now I really feel like that individualized graduation plan for every student type thing is kind of their main thing.

The program reflects itself in the type of student created due to the coursework. As a result, they stand above the typical student in other academic environments, according to KM.

> And that high level of achievement. I mean, yeah, like I said that kids that come out of the STEM program, they start taking some of these other CTAE [courses]

> like computer science. I mean they're well above just your normal student coming in there and starting that program. And they succeed at high levels in our entrepreneurship program. It's not just writing a book. Here's how you write a business plan. It's kind of like a “Shark Tank” type thing where they look at everyday problems and they come up with solutions to those problems in the form of a product or service and then they develop that product. They work in teams; they work with the community. They've got a community industry leader that's a mentor to them all year. At the end of the year, they pitch it for money, their idea for money to start their business. The STEM students that are [involved] in that, it's a huge boost to the program.

KM spoke as if the STEM program helps other programs in the school and allows the STEM students to branch out and showcase their skills in other areas.

Blending Disciplines. KM appreciates the opportunities that organically exist within the school to blend disciplines. Creating a learning environment where students cannot find the line separating content creates a phenomenal context for the students to be placed within. One example involved an Agriculture teacher teaching the physical constitution of a Boston Butt cut of pork and what happens chemically when the meat is cooked.

> And then they also brought in one of our ag teachers and they cooked a Boston butt [cut of pork], smoked, and they did the science behind Boston butts and the breakdown of the meat and when it hits that stall period. What's happening? When you blend the disciplines it's fascinating, [the] kids, they're making those connections that they'll never forget.

> A second example involved a welding class being partnered with a calculus class. Our welding class partnered with calculus and … those kids went into a big classroom apparently and worked some high-level math that they were going to then use in the welding lab. Well, our welding kids were struggling with the high-level math until they got into the welding lab, and these high-level math kids that never stepped foot in that welding lab were the ones being led by the application process. It makes sense.

These two examples provide a snapshot of teachers reaching across disciplines and collaborating to help their students. In the end, the students benefit from teachers willing to try something new to better their classroom experience for the student.

His overall vision within the school is for a blended approach across content areas to become more common practice. KM acknowledged that each CTAE pathway has much to offer academic teachers within the school. In addition, STEM students also have multiple opportunities to broaden their knowledge base.

> We're going to take that [the blending of CTAE courses into academics] kind of schoolwide throughout all of our CTAE programs. And we've already started spreading [into] … agriculture, they've done some things with them. They've started spreading into our computer science, big time. Entrepreneurship program, healthcare, but we're going to take it out to our trade programs and start dabbling a little bit with STEM ideas in the interdisciplinary stuff with construction, automotive, welding, [and] manufacturing.

KM understands that some areas have an easier time when trying to blend content areas to benefit student learning.

> But agriculture, healthcare, computer science, and entrepreneurship, … they've already started the kind of STEM blending a little bit. Not full on yet, but they've already kind of been dipping their toes so to speak, and then it makes sense because those are applied sciences. And so, I think those programs [are] easier to develop, and because it's kind of those applied sciences, I think the skilled trades, it'll take a little more work.

What KM finds so exciting about how academic disciplines are blended is how the concept is beginning to spread throughout the school.

> But as far as where we're going as a school, it's exciting, man. … I guess the most exciting thing is the support from the Board of Education, [the] superintendent down. [It] starts at the top, you got to have that support, you got to have folks that believe in what we're doing, and they do 100%. … We meet pretty regularly and discuss different things related to the curriculum or whatever direction we're moving, and so it is exciting. And I'm, I'm just pumped to see, you know, come back in five years and let's see. Because I'm excited to kind of progress, and we're, we're not at the beginning stages with our STEM program by [any] means. We're [a] STEM-certified school, but to do what we're talking about doing, I haven't [seen it]. And I'm not saying it's not been done, but I haven't seen it anywhere to the degree that we're talking about.

What are they talking about doing? The school's leadership has set a goal to turn the school into a College and Career Academy, using the STEM program as a blueprint to weave and blend academic disciplines with CTAE offerings for the benefit of content relevance for the students. A College and Career Academy is defined as blending the requisite academics needed in high school that correlate with specific pathway choices into the CTAE courses. An example KM mentions is having geometry embedded into a construction class. This pairing is meaningful because it allows the students to grasp the content while experiencing the relevance firsthand.

Making Content Relevant. Generating buy-in from community stakeholders was a critical checkpoint for KM when discussions began to organize around the College and Career Academy (CCA) development.

> I did a presentation when we were going through this career academy grant to about 100 of our community folks, and I showed pictures of classrooms from the 1920s. Then I put a classroom up from the 1950s and 1960s. Then I put a classroom up from the 1980s, 1990s, [and then a] current classroom.

His point was to highlight some of the similarities in the structure of the modern classroom to those of many decades ago.

> And then I said, "Well, how much change has happened in the workforce and industry in the last 100 years?" … Where are we missing the boat in education? Why are we still sitting in the classroom, in straight rows, listening to a teacher teach us theory when everything in the world is about problem-solving, critical thinking, all these things…

In his mind, KM knew something had to give. He mentioned throughout our interviews that the time was right to attempt a sizeable institutional change, like developing a CCA.

Making significant institutional change happen requires passion. Throughout our conversations, KM showed a deep passion for the CTAE curriculum he is responsible for and the excellent opportunity to extend this content into selected academic courses.

Initially, I wanted to know the angle they would be using to push this approach with ultimate acceptance from students and the community. However, according to KM, it was all about money.

> If you learned this you might make two to three more dollars if you're working on a construction site, two or three more dollars an hour. It might separate you from being a gopher to run a crew if you understand these concepts. … And our construction teacher teaches it that way. Currently, [he] tells kids if you can lay out stringer stairs, or if you can lay out rafters for a roof, and cutting angles and all that layout by hand, that's [going to] separate you when you get out on a job site from being an $8 an hour ago for all to start at a $20 an hour, like [a] foreman, you know what I'm saying. That's right, just the ties [to the academic content] and in the world of maintenance the world around us and the application of all these math and science and language arts, I mean, that gets into communication, and we all have to communicate and communicate effectively to be successful.

KM believes in giving students in the school every competitive advantage when they enter the real world and begin working and supporting themselves and their families. He wants them to leave with a base of knowledge that makes them a more effective worker in whatever field they choose.

When KM came aboard as the CTAE director at the school, it took time to learn about the initiatives being driven at the school. First, he became familiar with the STEM program. However, he also saw the natural connection between what the STEM program was doing and what the school administration hoped to accomplish with the CCA.

> And so, through my first years of being CTAE director, I learned a whole lot about STEM and other programs too. But then I learned about the College and Career Academy stuff and so I started talking to it about our about it with our principal and superintendent. … That's when the connection came with the whole [connection with both programs] because the College and Career Academy philosophy is interdisciplinary learning, project-based learning, all that. And so, as we kind of dove into that stuff, it dawned on me: we've got that model going on right here in our STEM program. We just need to expand on that and we're not recreating the wheel here. They've been doing it for six [or] seven years.

Was the STEM program the "driving force" behind the development of the CCA? No, but the blueprint was there. Moreover, it allowed the development of the CCA to come much more organically due to the success and influence already present at the school.

KM continues discussing his motivation to bring real-world application into the classroom. He indicates, "But yeah, I mean, that's 100% motivation. To me, the application [of knowledge] is key to the connection [in the classroom], and to dive in the depth of knowledge, the deeper understanding of theory, and how to apply [it]." As mentioned before, showing students the importance of having the knowledge and watching that translate into a better livelihood is paramount.

> You bring that math class to construction and show them that, "Hey, if you understand how to do these things and how to lay out these roof trusses or whatever it might be, you're gonna make probably a whole lot more money than somebody [who doesn't] understand those connections" and is just the grunt on

> the job site, carrying wooden garbage off because they don't understand how to lay that out and do it.

KM also acknowledged that his plans involve extensive conversations with the STEM director to integrate each program within the up-and-coming CCA.

> [The STEM director] and I've talked about it a good bit and we're gonna dive into it really heavily next year. Looking at each program and looking at the standards for each CTAE course and how we can blend those academic standards in, and she's the bang expert on that because she's done it now for six years, and they've got a rockin' program with engineering and healthcare, but now it's like, "Okay, well let's start rockin' it with some of these other things.

KM recognizes that the challenge at hand is "actually doing it." Many plans can be made, but there must be follow-through. The principal at the school acknowledged that problems arise due to scheduling within a smaller school environment, finding enough personnel, finding the right personnel, and making sure there are the content teachers needed to go into these CTAE courses and teach. The list is enormous. He mentions that the school planned to begin a conversation regarding how to involve local industry partners better when teaching their students. "Part of our goal next year is to bring in industry folks that are connected to these pathways, and look at the state standards, and dissect." KM intends for this to occur within CTAE and academic courses because "there's a lot of fluff out there." The fluff he refers to regards time and efforts spent on concepts or skills that are not the best use of time. While this could be subjective, his deference to industry partners to verify their areas of focus brings a relevant component to their instructional directives.

Why the push toward giving industry partners a voice? These local industries will either modernize or perish, as we discussed during our time together. A significant change within industries such as manufacturing and machining has already begun with the implementation of robotics and automation and the effect on manufacturing. KM described a tour of a local industrial partner and what he saw.

> It's all robotics. It's automated. So, we go through there and start immediately identifying the academics that are going on as we walk through. They're making this part, and it's got to be dipped in this chemical, and they're talking about the chemistry that goes on … it's a metal piece, and they [showed] what it does to that part to make it stronger and solidifies. And that's, I mean, it's 100% chemistry and engineering that goes on. It's engineers that run those machines that manufacture now, it's not somebody standing there, turning a part by hand anymore. There is a little bit of that still. We've got one manufacturer that does a lot of custom pieces, so they do have some of that, but you have kids that 100% love working with their hands and designing and building things. I mean that's 100% up their alley.

Students are quickly becoming aware of the need for next-generation skills in the workplace, especially as they begin seeing and hearing about it in the local community. And there is the motivation, the drive to provide something relevant for the modern student. KM believes the modern student needs a modern education to survive in the modern world.

Defining Success in the Program. I asked KM to define what success looks like in the STEM program, and he approached it from two perspectives. He looked at it from a larger perspective, considering the impact on the community around the school.

> It's a bigger thing in my mind, when you say success, our STEM program, it's a bigger conversation because, ultimately, you're impacting the community, the region. If you want to say success, what is success? Well, that's the end goal. Success is providing that future workforce throughout this region and breaking [down the] generational poverty [barrier].

KM provided a singular, unique story that encapsulated the success the STEM program has brought not only to the students within but also to the community around the school.

> Two years ago, [we had a] STEM student. She graduated here with a CNA. And she was so advanced through dual enrollment … that she immediately got accepted into the nursing program at UNC [University of North Carolina]. So fast forward two years, and she's graduating with her nursing degree. And she's working full-time at a hospital as a CNA, you know, making a salary while she's in college, pursuing [her degree]. And it only took her two years to get her nursing degree.

KM considered this former student a model of what the STEM program can produce, especially with the direct relationship these students have with the CNA pathway within CTAE. These students complete the first two courses as a part of the STEM program in their second year while taking biology. He added, “I mean, you take it to the next level, she's moving back home, going to work at [the local hospital] as a nurse, as a successful member of our community, our society.” This aspect of the program, explicitly preparing students with clear educational goals, is a point of pride for teachers within the school.

KM expounded beyond the individual student story when discussing success within the program.

> I think the best way [to define success] is the example I gave of the girl. Yeah, that's success. Success to me is not deciding [that] we want to provide opportunities. Success to me is doing it. Can we get to a point where every single student walks across that stage [at graduation]? We've given [them] all the opportunities they can [get]. They are ahead and they're on their path, on their journey, and they know exactly what their next step is. I think when we get to that point, we can say we've been successful. I think our STEM program is awesome. I think all of our CTAE programs are awesome. And all of our instructors are awesome. The whole thing's great, but we're not there yet, you know, and that example that I gave you, the girl that graduated at 20 with a nursing degree. Why can't we do that for everybody? So, in my mind, that’s success not only for our STEM program but that's success as a school.

Words of Wisdom. I asked KM for words of wisdom from his perspective on building a successful STEM program. Without hesitation, he went straight to the point. Bring in local industry to demonstrate how content can be applied. Let industry professionals show students why their learning content is meaningful and can translate into a good-paying job one day.

> Make it real. … Bring in the people that are connected to those programs. If it's agriculture, bring in agriculture folks and bring in the experts that work in the field every single day. Dive into the standards. … What do we need to learn? If you're talking about project-based learning, do it [the right way], and don't throw in a little fluff project [with less inherent academic or contextual value]. … Venture out, be creative, and just make it as real as you can make it.

He further emphasized the importance of going through a legitimate, thought-inducing process teeming with community-driven relevance. This legitimate process involves helping students understand how the material they learn in class is relevant to specific jobs or industries.

> No matter what program it is, it can be very real, hands-on, like you're producing something that is a benefit. So, I think that's the biggest thing you [get], those connections. I think connections with your regional industries are highly, highly important, and having those partners on board and understanding what you're doing. Having those goals and understanding working with them to develop your goals for your program is important. And so just, but I think the more real, you can make it for kids, the better. I think everybody in the school setting, you're doing projects and things like that, it's good you're learning the concepts. I think when kids can see they're building something or they're planting a field, and they can see those crops grow and serve them in their cafeteria and those [things] impact kids, and [they] don't forget.

I also asked for potential pitfalls and problems that could arise when implementing a program like the one they have at their school. KM described the importance of keeping a positive mindset and remaining persistent in accomplishing goals as a school.

> You're going to have times where you try something [that doesn’t] work, but I would say just don't get discouraged because you can try something else. It's all a big experiment, right? Isn't that [the point]? …Don't be afraid to fail, because

> there will be some things that your teachers try [that] might not work exactly [like] you thought [they] were [going to].

The final thoughts KM provided included getting people involved and moving away from checking boxes, that is, teachers completing their work to simply get it done. Instead, make sure the teachers working with these students are dedicated and willing to experiment with their craft so they can ultimately impact students in the best way possible. This dedication involves letting go of many traditional instructional practices to give students more freedom and power over their learning. Teachers can let their students become owners of their learning when challenged to think critically or create or solve problems. These changes do not always come quickly or easily.

> There are always going to be some hurdles. There are always going to be some teachers that don't want to dive in. That's fine. You will in a couple of years, when you see it working, you'll be like, "Well, how do I get involved in that?" I don't know if that's a pitfall, but I guess just an obstacle to maneuver around, just being creative and striving for the best opportunities you can give to kids. Understand that learning is that application and problem solving, critical thinking, all those things. You know all those buzzwords that we hear all time but taking it from a buzzword to implementation is two different things and taking the program from a checkbox (Yeah, we have this awesome program. Come see it. It's a shining star in our school.) to impacting lives. [They're] two totally different things.

Education is filled with new approaches, programs, and acronyms intended to simplify or empower the process in the classroom. In some cases, similar strategies simply take on new names with slightly altered meanings. KM believes the STEM program at the school is more than a buzzword or educational fad. He believes in the importance of proper implementation and impacting the lives of the students involved.

DW

DW speaks throughout our interviews with a sense of pride in the school and what the school has been able to accomplish during his time as the principal. He believes in the mission of the school and the school system. He believes they are acting as pioneers within education to become increasingly impactful in the students' lives at the school. As a result, DW drives a plan at the school that promotes the completion of these objectives. He believes strongly in everyone being on board with the process: teachers, students, and parents.

School Climate. When asked about the overall school climate, DW was reflective in his thoughts but quick to answer.

> I would say that the overall student body is probably one of the most well-behaved. They're happy. They're competitive. We do a lot for our kids. When it comes to getting them involved in different programs, it's almost like there's too much for the school, the school size. We do a lot of special things. A lot of people have called us the Pinterest school. A lot of the things that we do are fun, you know, and the kids tend to like it. They're growing maturity-wise and stuff like that. But overall, I mean, I think that the culture looks [great]. We are always pushing to get better.

DW exudes a sense of accomplishment while acknowledging that the target of where to get is constantly moving, and they must continue to find ways to improve, to become more effective.

One of the critical aspects that DW focused on involved getting what he referred to as “culture builders and climate people” in the building. He spoke of transparency that starts at the interview stage. He wants to ensure that teacher or administrative hires are done with the school's ideals. DW wants people who will help continue to push the school's vision. He readily admits that getting the school to where it is now has been an up-and-down battle.

> I'm not saying we're there. We're definitely past a tipping point. I think we fought a hard battle to get to a tipping point. And of all the people we hired, I mean, they're all super big-time culture builders and climate people. They're good teachers, too, but they're big on culture. … Let's talk about culture and building culture. And how do you build it from the middle school? [I’m] really excited because my assistant principal is now going to be the principal at the middle school. And she understands and has a good relationship with [the CTAE director]. She's owned businesses, she knows and fought the battles for a culture that I think what we figured out is it's just starting earlier. And so, we're [currently] in a react[ive] mode instead of a proactive mode. And so that's going to be good for her to get on there.

DW believes that change occurs over time and wants to exert a plan into place longitudinally. He feels the middle school can play an integral role in the further development of the vision and expectations of the high school through the proactive approach he would like to see put into place.

DW is proud of how visitors react when speaking with the students. He specified, “When people come here, they're like, ‘Your kids are unbelievable, and they are respectful.'" He believes the school culture battle starts at the front door. He would stand at the door with other teachers and greet each student with a "Good morning. How are you?" And the students have learned to engage in this discourse. "Fine, how are you?" they will eventually respond. DW said they have been working on building climate in this manner for almost a decade, and he believes this simple approach has helped reduce low-level disciplinary issues just through the building of relationships. DW concluded by saying, "This school is not the same place as when I first started … You know, I can look at people now. And we're just like, 'We don't do this here.'" He teaches through example to look people in the eye when talking to them, say what you mean, and consistently follow through with expectations.

The consistency that DW strives for is essential on so many levels. Fairness, transparency, and clear expectations for all tie into maintaining the school's climate where he wants to keep it.

> I think they appreciate seeing everyone held to accountability, whether they're the star quarterback or whatever. It took a long time, though, to get through that. And sometimes there are things that happen that we can handle things consistently at the school level, but when law [enforcement] gets involved or district attorneys get involved, or they go to tribunal, decisions are made, and concessions are made in the area of gray. That may look like certain people who've got different punishments, but not from the school level. Right? The school's decision was the same every single time. We just don't make any decisions in the gray.

He describes the importance of the school maintaining decision-making in black-and-white perspectives. The school is not responsible for making decisions in the gray. DW understands that is what outside support is there for. By maintaining objectivity, the all-important consistency can be maintained.

An example of maintaining this consistency involved fighting the wave of vaping that became pervasive throughout public education in recent years. The whole point, DW indicated, is to provide a safe, educational environment for students who want to participate in the process and do things the right way.

> Our main issues (that a lot of schools have discipline-wise) are pushed off campus because we just ride this extremely consistent hard line with things we've addressed and fought battles on, culture-wise with vapes and drugs and sexting and things like that. I made national news because we didn't put up with it. We put 100 kids in alternative school for vaping in the last three years. Now they come back, and they're fine. That means that they know it's a safe [environment]. They know the expectations here [are] very high. … So, it's a balance of high expectations, high accountability, and I think that the kids step up with that. We offer, like I said, a lot of things in this school … we've got our STEM certification, we've got our CCA [College and Career Academy], we've taken a lot of pride in our fine arts, we take a lot of pride in athletics, we take a lot of pride in academics, and we push to be one of the best. Because of that, we’ve had a lot of people want to move here, and our enrollment’s gone up quite a bit. We've enrolled 10% of our population as new, I mean, 81 or 87 kids, that's more, it's more than 10% have moved in.

What is so impactful is despite the presence of disciplinary issues, DW doesn’t dwell on them. Instead, he deals with them and moves on. He understands he is there for education, not discipline. He deals with difficult situations when they arise but then moves on. After the punishment is served, the students are welcomed back, and typically, they are fine afterward.

> Yeah, there's vaping, you know, and everything, but it's much lower than most places. They'll get caught, and that's okay. I mean, that's part of it. And they usually need some help, you know, and that's why we've got a super alternative school. And a lot of those kids don't want to leave there because they fit that model of [instruction], and they need the structure, you know. They like it. So, anyway, yeah, our culture's good, right now especially.

Holding the expectations allows the school to maintain the established culture. As hard as they have worked to establish various programs and opportunities for students to participate, they want to ensure the fidelity of the school experience remains as pure as possible. As such, the students understand that removal from the school environment means not taking part in those programs and activities.

> But when you sit and have those conversations [about] band, chorus, theater, football, baseball, basketball, softball, volleyball, they'll go nuts when they realize they can't do that stuff. STEM. Man, oh man, I've had, "What am I gonna do?" Because you can't do the hands-on classes. You can't do [them] with fidelity. … But again, coming back to the consistency side is super important.

DW consistently emphasized the importance of maintaining the diligently worked culture for several years. He believes that no individual is above the greater good of what the school is trying to accomplish. Through this vision and directive, he believes culture has been established that provides a positive and supportive environment for students to thrive in.

Developing the STEM Program. Hindsight is always 20/20. Anytime a new directive is implemented, some moments can be reconsidered and replayed in his mind. DW affirms this is the case as the development of the STEM program took place. He indicated, “It started as an elitist [group], like only the top, top, top [students], like application based. The top 10%.” DW quickly describes a shift in the approach to recruiting and informing kids about the opportunities within the program. “I think we quickly learned, and we've grown to be more inclusive. I think the biggest mistake is that it was rolled out as exclusive. It was the very first year.” He further elaborated on this idea by indicating,

> I'll tell you it's gotten more inclusive, and I like that because it's just better for the whole school. Right? Success for all, [that’s] what we're about. I mean, you’ve got to protect that. If you don't, it'll never really be good for an exclusive elite group of kids, and you get the wrong board member, the wrong parent out in the community that's like, “They're just doing all this just for the VIP kid,” and then it could shut down and go away quickly. [The] optics are bad.

At this point, the program houses students of giftedness, average academic abilities, and students with learning deficiencies. The program's model shifted to serving students with the passion and desire to work the way STEM education is designed.

The turning point occurred when students within the program were used to begin the recruitment process for future students at the middle school.

> They're smart with the way that they recruit more and more kids in because they use certain people that a lot of eighth grade [students] looked up to, like softball players. … They make videos, and they are sent over to talk to these [prospective students]. You know kids. I mean, they just go in droves … you know, it's grown to where it's not that, but it was, it started [as exclusive].

The trickle-down effect began from this point, DW explains. Students from various backgrounds and ability levels began to perceive the program as something in which they could thrive. DW also believes the people working within the program played an important role in furthering the school's mission of implementing STEM education. He believes that "because of the people that we had involved in it, I think people began to trust these people and know they're going to have their best interest at heart." Due to the changes in how the program was described and built and word getting out about the teachers in the program and what they do for the students, enrollment began to rise. Instead of having 20-30 students in a single cohort, the program was forced to reconsider structuring and expand to handling two groups per year of around 60 students each year. As DW explained, once the students in the program were allowed to have a voice in support of what they have done academically, growth was fast at that point. Also, the differentiation for multiple ability levels made a tremendous difference in the external optics of what the program provided for students and for whom it was delivered. STEM for all was a ticket for success and growth.

Characteristics of the Program. Asking a principal about the characteristics of a program within the school is different from asking a teacher within the same program. While the teachers can speak to a microscopic view of the day-to-day within the classroom, an administrator will see a different perspective. Instead, the outside view looking in is more prominent. Throughout our interviews, DW described the program as "pioneering, engaging, empowering, inclusive, rigorous, and accelerated." His reasoning? "That's the way that they run it." From the outside looking in, the teachers have built and fostered a program that leads the way, engages the students consistently, and empowers them to become successful at the next level.

When asked to elaborate on his perception of the characteristics of the program, DW went in several directions.

> I just think again, it comes to that early adopter thing. When you come down to [it], I've been in a position since the beginning of this with other people that are not tying our hands. It's a team approach that I feel like we've made it together, and I think we were able to have the freedom to be able to do these things and just make something as a blank slate and write it however we want to. And I do think that we've made something that's neat, and we're about to go spread it through a whole school with the College and Career Academy grant that we just got when we're starting building construction in August this year, and we're pretty excited.

Initially, the point of being an early adopter speaks to the progressive lens the teachers and administrators use to see themselves. They revel in pioneering through uncharted waters to achieve something with their students that hasn't been done before. The notion that the program's success will be further shared throughout the school through the up-and-coming College and Career Academy is evidence of its success.

The teachers are dialed into the needs of the students. DW indicated, "[The STEM director] meets with all students regularly. And she's pretty straight with them. She knows, and she's worked with them for four years." She sits down and discusses their schedule, their wants, and needs, and provides assistance when dealing with college applications or scholarship opportunities. In addition, she can offer a specialized touch due to the unique relationship she builds with each student in the program. DW further elaborated that all the teachers in the program are big on establishing a culture with the students. He describes the culture of success the program has built up has led to students with numerous disciplinary issues in the past simply existing and thriving in the program. In his words, the discipline issues "just disappear."

Another characteristic that DW brings out is the ability of the teachers within the program to constantly self-assess their work instead of being satisfied with the status quo. Initially, the program was geared around accelerating every aspect of the traditional academic high school experience into the first two years. He admits, "We raced out like Wile E. Coyote." There was a sense of sprinting out as rigorously as possible. Then after considering every aspect of what they wanted to accomplish, they began to walk back some of those earlier points of emphasis on the speed of completing the high school portion of the program to ensure the depth of learning was taking place with proper course sequencing.

> I think it was the speed of sequencing of classes. I think we've learned that, though. We've tweaked over the years and made some things [better]. I think we're still tweaking. I've seen holes. They've seen holes. It could be staff. It could be when you're getting people that are engineering teachers that are also math teachers, they may not be able to prepare them [for] the math and for the SAT. So [the students are] learning the application side [instead]. Maybe the math skills

> aren't there at a certain age, maybe sophomore [year], junior [year], after they take that next class with a different teacher. And they get statistics, and … they need trigonometry, then they just explode from there. I feel like our SAT scores … really improved. I think our college success level has improved.

The constant sense of self-assessing progress within the program and how effective the program is on student growth is evident. “It just doesn't have to be 110,000 miles per hour, you know, all the time. … I don't think they want that.” DW realizes that each student is treated independently to reach their goals, which leads to managing a “bunch of moving pieces.” He understands that students' movement through the program must be balanced if flexibility is critically valued. As a result, the pace has gradually slowed from what it originally was to achieve that goal. “You want to give them freedom and trust them.

DW trusts his teachers by allowing them to be professionals and make many day-to-day decisions.

> I don't tell them how to teach their [content]. They do a good job. I have questions, sometimes, about … course integrity. [You have] got to balance. … The engineering applications and advanced algebra [class is] together, and they never go in the lab. Does that [sound] right? Oh, no, I don't think so. … But we'll look at that again. But I don't really [micromanage] because they do such a good job. And I trust them. … I've got a math department head who rocks. I've got a science teacher who's also a professor at Young Harris [College]. … She's got it all. One of the best teachers around. And then you got [the STEM director] who rocks. We’ve got [our counselor] who rocks and she's a super advocate [for the

> program]. I mean, it's just that they'll never say no. They're always looking for ways to fix kids, you know, help kids. And so, you got to pump the brakes on that sometimes and give them procedural stuff.

The staff DW has in place works tirelessly to help students. Their talents are diversified, and they can push the academic boundaries through rigor in their classrooms. The students are the priority for these teachers. Because of this, DW can, for the most part, let them go and be themselves with minimal guidance.

The 30,000-Foot View. Being in a position of authority over an entire school requires vision. Vision is needed to manage current objectives, direct expectations to personnel, and ensure planning occurs to ensure the organization functions as intended. As DW mentioned throughout our time together, there are so many "moving parts" within the school, and everything must work together.

Viewing Personnel Expectations. DW wants his teachers to play to their strengths. He understands the teaching aspect from an extended amount of time in the social studies and coaching environment. And because of his experience in the classroom, he is supportive of his teachers and their work.

> I mean, I'll go to bat for them, but I think that's just what you're there for: support. And coming from a teaching background, I think it's important. I think that a teaching background, not forgetting what it's like to be an educator, and setting things up, like the schedule or the bell schedule or the requirements and duties, and responsibilities free them up to do their job. I think that's the most important thing we don't require them to [do] hall duties or parking lot days or lunchroom duties. We try to [give] them common planning [so] they have time to meet.

His expectations of the STEM teachers are considerable from a curricular perspective, so the strain in other areas is purposefully reduced for balance.

Many of the faculty members within the school are also capable of wearing various hats, depending on the need or situation. For example, he has a media specialist with previous administrative experience, a new administrator with a specialty in special education, and a STEM director who fulfills a specifically unique role with students in the STEM program. Each of these individuals works toward the betterment of the school. Regarding the STEM program, DW manages the STEM director through trust and communication.

> You’ve got to let them be experts and you don't want to micromanage them. You want to have good trust [with] them and [I] trust her totally to make the right decision for kids. Well, more than I would trust some of the other entities if that makes sense because she's proven time and time again to make the right decision.

Even when DW senses things need to change and he needs to be more assertive, he is quick to mention there is a right way and a wrong way to make effective change. “I'll tell you, that's another danger. You’ve got to be careful changing too much too fast.” He referenced making a scheduling change in the eighth grade to impact student scheduling at the high school level. He then mentioned that he felt they were in a bind scheduling-wise because of the larger-scale changes made in the past two years.

When managing personnel, DW also asserted that individuals often have difficulty seeing beyond what immediately impacts them.

> Another way to look at it is this: if you're looking down the barrel of a gun, and [the STEM director’s] got [her eye] on the sight, and she's on the sight, on the

> sight, on the sight. You've got to get them to take their eyes off that sight just for a second and go back and look at the range.

The result, he later points out, is that all the other subjects, such as fine arts or agriculture, must be considered when making critical decisions. It helps DW to make these kinds of decisions by getting away from a master schedule and instead getting into the classrooms and seeing the day-to-day interactions and instruction. “It's neat. It's neat to see it in motion. And it's neat to see it all work, and I'm not saying it's perfect.” Even the principal acknowledges that there is always room for improvement with everyone in the building.

Viewing Scheduling. Scheduling was a topic that constantly flowed in and out of the conversation. Students must have course sequences that are logical and considerate of the educational landscape. When the landscape changes, scheduling needs to be revisited. While DW feels the program is a success in so many ways, some areas can be tweaked for the benefit of the students. For example, with how courses are integrated into the program for dual credit, DW feels a more fluid exposure to multiple teachers during those times would be more beneficial. For example, when engineering or healthcare courses are being taken alongside physics or biology, the students should receive equal exposure from each discipline's teachers. Nevertheless, DW is satisfied with how the courses flow throughout the ninth and tenth-grade years for the STEM students. An exception he mentions is there could be more flexibility for electives in the first two years so that students are not trying to cram in too many elective courses their senior year. Small changes could be implemented to allow for course flow and content blending, but nothing significant to overhaul.

However, a primary focus for DW involves the latter portion of course sequences in the eleventh and twelfth grades. Specifically, he is concerned with the students having plenty of the theory taught them without enough application in the laboratory setting. He feels there should be ample opportunity to provide that outlet for the students in the STEM program.

> So that's where we got to fix the junior and senior years. I mean, we've had some kids with engineering that have left and [gotten] jobs instantly. Right now. I mean, they've graduated. Good jobs. But at the same time, you know, a lot of those kids want to go into Georgia Tech … but there's that gap between application, like CNC application, drafting computers, and they just don't have the lab [experience]. Now the lab can go back up there.

DW thinks a simple solution could be found through earlier discussions regarding slowing the program's pace down and not accelerating into non-stop dual enrollment for the students after the tenth grade.

Here again, another problem arises in dual enrollment. The state changed the maximum number of hours available to be earned at the high school level. This change severely limits the current flow of the program and leaves STEM students with literally nothing to take later in their high school careers. Too much, too fast. As a result, some students have heavy doses of electives during their senior year.

> They'll break up on Fine Arts their senior year. I mean, they're like, half the day up there both semesters. Great, good for them. I mean, what was the purpose of all that? But at the same time, I’ve got kids [that] are [complaining] because they can't take Fine Arts as freshmen. But they take it four times their senior year.

> Balance [the schedule] out. And again, there's room to do that with the dual enrollment, checks, and balances now, you know, the junior/senior year, I think, something that needs to be fixed.

These electives could be spread out throughout the high school experience, provided changes to pacing were enacted. DW is quick to point out that the overall model of the STEM program is phenomenal. There just seem to be situational hindrances that arise and need to be dealt with. Truthfully, they cannot always be prepared until problems occur. Solutions can be found from 30,000 feet above.

Viewing STEM and the CCA. By his admission, DW repeatedly emphasizes the STEM program has been highly successful up to this point. So much so that the program has become the blueprint for something much more significant at the school: the up-and-coming CCA. His words indicate that “the STEM program is about to be shifting underneath the umbrella” of the CCA. From his perspective, the greatest challenge or obstacle to such a momentous shift has the right people to push forward. But, DW indicated, “nothing will change for them because their model is going to be the model. They're the model for the other academies to follow.” He elaborated that these academies would focus on applied sciences and skilled trades.

DW believes a hyper-focused approach to academics is the next major initiative at his school because, from his perspective, “I'm seeing the middle shrink anyways. The middle is almost gone. I mean, I could probably get the middle down to one, maybe two classes per grade level, maybe 60 total kids.” He defines the middle as students who aren’t gravitating toward a specific applied interest and instead just move through classes to graduate.

DW believes in the STEM program's format and wants it to spread throughout the school.

> With the CCA coming in, again, their model of instruction is what we want to follow in that. But the sequencing and involvement and all that stuff. I mean, there's [going to] be some change. There's got to be some change. … It's not [going to] be STEM and then healthcare. Right? And then you've got engineering. I mean, STEM kind of covers a lot of different areas.

His point seems in line with his plans for the school. The STEM program acted as a groundbreaker and paved the way for the rest of the school to benefit. Success for all. STEM for all.

Viewing STEM Integration Throughout the School. The success the STEM program has enjoyed over the last few years has positively impacted the school in various ways. DW expressed satisfaction with the school being able to add courses that focus on computer science, coding, and cybersecurity. But, again, he returns to the importance of culture and upper-level support to accomplish goals. The superintendent of the system when the program started was highly supportive and helped build the foundation for what the program now has become. However, as the program developed and further integrated throughout the school, upper-level leadership went through periods of support or lack of support for these initiatives. During the more difficult times, DW indicated, "we had to find a sustainable model. … I mean, it was hard because we had a guy that was not about it." Fortunately for the program and school, board members had seen the early successes and were supporters of the STEM program. As DW elaborated, "and now it's fine. We have this current superintendent who supports [the STEM program]."

A specific example of STEM enhancing current programs involves a “Shark Tank” type offering where the students develop an offering or product and generate advertising. According to DW, they spend the entire school year on this long-term project, which strongly resembles the format of the PBL approach. As a result, STEM students have begun to thrive in this learning environment.

> They work with really good entrepreneurs in the local [area] that are either millionaires or tycoon business owners. They're definitely MBAs [Masters in Business Administration]. I mean, they know what they're talking about. And then they get grilled. And when I say grill, I don't mean like just polite … they get hammered down [about] their product. And they go into and talk in a language that unless you were a second or third-year business or marketing student, [you wouldn’t understand]. I mean, you you're like, “What are they talking about?” They're using languages, estimates. Things that most people don't understand. Certainly some. Always think about, like, man, I can't wait to see those kids when they're seniors. … Well, they're speaking [as professionals]. And I'm telling you, it's a defense like a “Shark Tank” defense. I mean, they're just tearing them up. I like it for many, many levels. Our freshmen STEM kids work a lot on things like that. And when they're seniors, they're usually transcendent at that point, like super, super organized. I've seen very few [STEM students] fall apart.

The training and experiences the STEM students have lived throughout their classes have allowed them to flourish in environments that would typically be much more challenging for the average student. By learning to work independent of the teacher and collaboratively with peers, the STEM students have developed a mindset and approach to learning that helps them solves problems in these types of scenarios. DW sees this as unmistakable evidence that the program works and is building success for other programs and efforts within the school.

Smoking the Bees. Another key theme that continually resonated during our conversations involved dealing with many different groups of people while trying to focus on the school's goals. DW referred to having “difficult conversations,” “tough conversations,” or “crucial conversations” at various times as a part of his job. While these conversations will always be standard for an administrator in a school, it can be pertinent to remain mindful of how and why the conversations occur around the school's STEM program. DW referred to his treatment of these situations as “smoking the bees.”

> Okay, smoking the bees is when you’ve got to have a crucial conversation in a certain way, and where they leave, and they're not mad, but they didn't get what they wanted. And they're like, “[I] didn't get what I want, but I feel good about it.” And if you don't do it the right way, if you open the beehive before you smoke the beehive and just go right in and open it, they're going to be all over you.

He focuses on ensuring that a difficult situation is approached so that the best possible outcome can be found. For example, dealing with anger, friction, and resentment can be extremely difficult with parents. Hence, DW always wants to try and approach each potential conversation in a cautious but firm manner. He then continues:

> You know you’ve got to have a certain conversation in a certain way, but it's got to be direct. If you mince words, or if you repeat yourself three times in the same conversation, sometimes in crucial critical conversations so now that you want to be, you because you can dance around it because you're scared, some people do

> that when trying to smoke the bees. And that's a mistake because then there's miscommunication, and the people will say, "You didn't tell me that I was getting written up. He just told me that I'm getting [punished]." Then that's got to be communicated [again].

DW also discussed how intentional he is in protecting the STEM teachers from the occasional parent. "[Some parents] get very upset and overbearing. What I will do is protect [the STEM director]. He believes she sometimes receives an unfair level of criticism being the face of the program when a parent feels their child is slighted in some way. He also does the same for the other teachers in the program. If they come to him with "an overbearing parent, … I'll handle it, and they won't be like that because I think they've been so good [for the students]."

These crucial conversations happen within the STEM program as well. Sometimes, these conversations revolve around making every aspect of the program work within the structures and routines of the rest of the school and making the needed adjustments accordingly.

> So, those are the tough conversations. How do we fix this? We work together with the math department head, the STEM [director]. Another crucial conversation would be the dual enrollment person with the STEM person [and] the counselor. … So, then you got to get them all in there and explain the consequences for everybody, and then you've got to draw a line in the sand of like, "I'm sitting here. I don't care what you do, but don't [complicate] third period. Not saying they can't ever talk [about scheduling] something third period, but don't force [a change]. I always think of those cohorts like new cranberry sauce. Just dump it

> out of a can. Don't make the whole can do it. You're just literally taking all these options out for all these kids.

DW continued to bring up the 30,000-foot view. The whole picture must be considered when every entity within the school could be positively or negatively impacted. The third period reference revolves around maintaining specific elective or fine arts options in third period and not having a conflict with academic needs. These conversations are necessary to keep the school moving forward. As he continued to explain, everyone will not always get their way. The balancing act involves all sorts of courses: fine arts, theater, chemistry, anatomy, and even AP courses.

Trying to make everything work is sometimes not feasible. Instead, communication is key to ensuring that most people are positively impacted.

> I've got [the STEM director], and I say, "How many of these kids need the second level of human [anatomy] or the second level of chemistry? If they get the AP chemistry credit and a chem one credit, why do they need the second?" And [then] she explained it to me and [I] understood. I think knowing the why is super important, like explaining the why to people and also understanding the why. And then we have debates on why kids need the second level [of chemistry or human anatomy], and you got to realize with 30 credit hours of dual enrollment max [allowed]. … So, you better make sure that the human [anatomy] is going to transfer to Georgia, [if] they're [going to] go to Georgia, it adds up in a hurry.

Even using this singular example, DW illustrates the types of interactions that routinely take place. He quickly admits, however, that these conversations are essential, extremely constructive, and vital to ensure the positive impacts the teachers seek for the students in the STEM program.

> Yeah, so I mean, those are your real conversations. Yeah, I mean that's [it], and they're not [perfect], but we have good ones. And we all want what's best for kids, but you've got to play that balance of [scheduling] fine arts, the [STEM director] doing all the coordinating, the counselor is looking to advocate for the best of the kids, or math teacher who represents Young Harris [College] and is also your math department head. You've got to know how to work all those and I guess they don't have to understand. You want them to all understand why things are going to be [a certain way], but not everybody can get what they want.

The key is balance. DW wants a balance between every group in the school and understands that sometimes people will not get what they want for their department or their students.

DW admits there is plenty of laughter and camaraderie amongst those within the school, even while these conversations occur. However, he believes these emotional connections help keep everything in perspective. These conversations happen so everyone walking in, the "bees," feel they have gotten what they need, or the teachers understand why they did not get what they wanted and can walk away feeling okay about it.

Defining Success in the Program. DW defines success from a macroscopic point of view. He wants the STEM program to develop exceptional students able to use both their minds and their hands in an equal capacity.

> I think that the STEM program should breed more MIT [Massachusetts Institute of Technology] kids, not [that they're] going to go to MIT. The reason why it's so hard to get into MIT is because you have to be smart and good with your hands. Like you have to be smart and technical, you have to be a genius welder. Not necessarily a welder, but you're a welder, plus [you] know how to do AP [Calculus]. You have to be the kid that can do both. … They are rare, so we're trying to build more kids like that … just smart, hands-on, and reliable.

He continued his thoughts with relevant examples of how the combination of hands-on work and intellect merge in the workplace. He tries to communicate to the students how unique and how important they can be for the future workplace with these skills in tandem.

> I think some of the best kids that we've had, some of the best kids that we've had, I tell them straight to their face to them, "There are very few people like you that they can get up there and they can do a MIG weld, or they can work on a car and pass AP [Calculus]." … Some people are brilliant at both. That's hard to develop. To me, true success is developing more kids like that that have good employability skills, but show up on time, and pass a drug test. [They respond with], "Yes sir, yes ma'am." They're smart and they learn how to work with a team and problem-solve. That's what I think would be [an] employer's dream.

His point resonates with the goals of the STEM program and how he wants students to be impacted when completing the coursework. DW hopes students become "lifelong learners" in whatever field they pursue. He wants the students to develop a willingness for "learning within the job," and the program's goals are to create students that fit the mold.

Words of Wisdom. I closed the final interview by asking for words of wisdom for prospective schools trying to develop similar students or establish a program focused on STEM. DW provided a variety of insights to glean from. He initially emphasized the point of "… don't make it exclusive and elite to start. Even though it might seem like the easiest way because you can cohort it, keep in mind the big picture. Look at the range, not down the sight." DW believes in providing opportunities for a broader range of students to generate a positive view of the developing program.

A secondary point of emphasis feeds off the mantra of "look at the range," meaning to consider the entire picture, in this case, the school.

> To get it off the ground taking the whole school into account, knowing that it is important to take into account the effect on other areas. If it starts to grow and take root, you can also be negative [regarding the impact on different areas within the school]. … Eventually, it might be unsustainable if you hit too many landmines.

The landmines DW spoke of included students choosing what they can be involved in. The reality is that students cannot do everything. When considering activities such as football or other sports, as well as musicals or other areas of fine arts, decisions may need to be made. Will a student prioritize one of these areas or STEM? These decisions impact the overall direction of the program and the pace of scheduling.

Regarding the pacing of coursework, DW also mentioned the importance of "not over-accelerating kids" and how it is "super important that a good balance" exists when developing the sequencing of instructional classes that focus on STEM. He elaborated more on this point.

> So, an easy thing that I've learned is, well, you got plenty of room and your junior and senior year … maybe it could just be a hair more balanced. … It's almost like the road runner that runs off. And then you've run around like, "Why did we need to do that?" Yeah, that was stupid. … We don't need to do that; over-acceleration is bad.

An example DW provided involved the initial pacing of math courses for the STEM cohort of students. First, they were accelerated to the point that they took every advanced class offered or possible at the high school level. Then, they ran out of classes to take and had no math class for their senior year. Immediately, he admits there is a problem there. Students do not need to take a year off from math, no matter their abilities.

A final consideration DW provided involves how scheduling can be approached when dealing with a specific cohort of STEM students. Potential landmines he identified included forcing large groups of cohort students "through college classes that won't transfer" and making sure, when determining the core sequencing of the curriculum for these students, not to waste their time. DW again alludes to the hyper-focused mentality of these types of students and their desire to get the most, academically, out of their high school experience. For example, the teacher within the STEM program responsible for teaching human anatomy at the collegiate level will take the students that have a specific desire to go to nursing school. He says, "[The students] want to be nurses, and they know specifically where they want to go to college. They know for a fact that those two [courses], those eight hours will transfer to the school they want to attend." These are students with an understanding of the larger picture and plan accordingly. DW emphasizes maximizing the effect of scheduling to help these students achieve as much as possible.

DW's insight into the current state and direction of the school's STEM program and the changes beginning at the school was timely and to the point. His tone reflected a sense of accomplishment in what the STEM program has accomplished and how it has laid the groundwork for the school's future direction. He believes strongly that the progressive nature of the school's approach is cutting edge and will only work to better the educational value the students at the school receive.

MS

MS carries the role of STEM director for the school. She is responsible for not only teaching two classes in the program freshman year but also working to organize the path and direction of the program. Her insight into the day-to-day activities helps to enlighten an outsider as to what they do as a cohesive unit of teachers to better the education of students in the STEM program.

Personal Influences. MS's educational experiences played a significant role in pushing her to become an educator. Initially, she had her mind set on pharmacy school, so she moved toward completing her major in chemistry. A math professor, though, impacted her decision to become an educator.

> He was always one of those professors who wore the same clothes every day. He always wore a blue shirt and khaki pants. He was a Georgia Tech graduate. He held you to the highest accountability possible. But I remember as the semester [progressed] and he [told me], "You're doing the wrong thing." I'm like, No, I'm

> not. I'm a chemistry major. So, he actually got me involved as a tutor at the college for math. So, I started tutoring college students in math, and then he got a lot of the college professors to start hiring me to tutor their kids in math. So, I did that and then I started tutoring them and other subjects and so on and so forth. And he kept telling me you're, "You're missing your call. You're missing your call." But nope, I'm gonna be a pharmacist. I did not want to be a teacher. I was fighting and was not gonna be a teacher. And so, after I had a few high school kids that I started tutoring and things like that, I realized, okay, this is what I'm meant to do.

Shortly after, MS took her first education course and hated it. In her words, "Worst waste of my time ever … because it was theory and all this stuff. This [course] is not gonna help me teach kids at all." Despite the minor setback, she continued to complete college with a chemistry degree and then moved into a provisional teaching certificate to get started teaching right out of college. "I actually graduated early because a job came open in [a nearby system]. They begged me. They're like, 'We need you now. Can you graduate now?' I was only a junior. I graduated in December of my junior year because I was a science major, and I had all my chemistry taken. I just needed those education classes. And so, I took a few extra classes. I doubled up and got it all done. I graduated in December, and I started teaching there in January." The influences from college were instrumental in bringing her to the classroom. She now had the opportunity to impart her love for science and math to students at the high school level.

Planting the Seeds of STEM. Despite achieving STEM program certification in 2017, the program's roots go back much further. MS specifically recalled how far back her desire to implement some of the core tenets of STEM education went.

> I always believed in an integrated curriculum, though. I did my specialist research thesis on interdisciplinary teaching back in 2007, and so I knew that that was the way you were supposed to teach. It was a precursor for STEM. I knew that just teaching subjects by themselves was wrong, and we've been doing it wrong. [Still], I didn't realize what needed to be connected or what you could connect until we've started connecting so many different types of things and realized what can be connected. And as we've learned and integrated and looked at the standards and [filled] in the commonalities, now I can see that, but I didn't realize that until I started doing it.

The crossroads for MS came when she began working with a former state specialist in Georgia for STEM education.

> I never even used a drill until I had to teach my students how to use a drill. So, I have learned a lot as a STEM teacher, just as much as my kids. … I don't know if I could do what I'm asking my students to do, to be honest with you. When I was their age, there's no way I could have done it because I didn't have the support in the background that they have now received, but I mean the problem-solving skills that they have to use with [the] engineering design process that we forced them to do is something that I have learned through building a STEM Academy, not from any kind of formal education. It's just been a learning process, and then

> as I got involved with Gilda and started going to the STEM conferences and started learning what STEM was.

These processes took time. The precious time needed allowed MS to slowly develop her teaching craft in a manner that would become vitally conducive for the students in her classroom later in her career.

MS recalled her first time collaborating with another teacher on a cross-curricular assignment in her classroom, again, as part of the transition into using this model consistently.

> My first co-taught-like project was actually with [the former ELA STEM teacher]. We did a unit together in English and chemistry. We used to do literature circles, and they would read a book that was controversial about biology. It was the year I had to teach biology. They had to pick a controversial topic and read a book about it, like a best seller book, and then we had to apply it to the science concepts, the biology concepts. Then we had like this big ethical debate in class about the types of things that we learned about while reading this book and getting these different perspectives and things like that. So that was the first [time] ever opening my door and realizing [that topics can blend effectively]. Then I started doing it with my math teacher across the hall, and so we'd do something with all three of us together and then we'd expand to a history teacher and so we just began to open our doors. That's when the beauty in the magic started happening.

MS was quick to make clear, "It wasn't just a singular step process. No, I mean you're talking it's been how long? That was probably 18 years now." Nevertheless, at an early point in her career, she was willing to try a teaching method far from the conventional approach.

One memorable event that helped shape MS into a proponent of STEM education was her time and work on an interdisciplinary grant that utilized the arts as well.

> As a brand new, young teacher in my third year of teaching, we got this big grant called Character Through the Arts. It's STEAM now, but it wasn't called that [back then]. It was this huge grant. I mean, it was like $25,000 a year, and we got money to take [students] on field trips and buy supplies, and we wrote units, and every unit that you wrote, they would publish it, and then they would give you a check for it. It was phenomenal, and I was the director of that grant. I helped write it, and I got it, and then I helped distribute all the funds and coordinate it all. And that was as a 25-year-old, fresh out of college, so I kind of got thrown into things really quickly, but I was able to do it.

Reflecting on that event and its impact, MS continued discussing how fateful it seemed to meet such influential people within the Georgia Department of Education regarding STEM initiatives. One of the summer teaching opportunities she participated in led to her meeting her current principal for the first time and developing a professional relationship with him. "It's just amazing. My life has been just one door after another after another, and you never realize it until the end of your life because you never think about it when it's happening."

Moving Past the Fear of Failure. MS often spoke about the monumental shift needed in the classroom to change from a traditional approach to teaching to a more student-centered approach. She emphasized the struggle comes from the resistance teachers tend to show in doing something unfamiliar when they still understand the expectations regarding covering standards and achieving standardized test scores, when applicable.

> A lot of teachers are really afraid of failure, and they're afraid of their kids not learning the standards by doing it the same old way, and they're afraid of opening their doors and using time more freely as opposed to [a] very structured [approach]. It's hard. It does take special people to teach STEM because you have to let go of a lot of control. As a STEM teacher, I have to be willing to listen to what [various STEM teachers] have to say. And we have to put our ideas together. It's not just one of us. We're always a team, and sometimes you're like, "I don't know if that's right." But if the team agrees, we do what the team says, and we always try to do what's best for the kids.

One positive light MS shines on the struggle to move away from a structured approach is the opportunity to lean on your other teachers for support. The emphasis on collaboration for the sake of the students is apparent.

MS continually pointed out how vital it is to reshape the teacher's mindset to become more flexible in timing and be open to change.

> Last week, [students were] working on their mousetrap car. If you come in and look, you're like, "Well, what standard are they using right now?" Well, right now, they're just using the engineering design process because, you know what, that takes a long time. That's the standard they're teaching. We will get to everything else later, but right now, that's all they're doing and to be willing to let that happen in the way it needs to happen is a very hard thing to do sometimes

> because you think, "Oh my gosh, I need to be done in two weeks" or "Are we going to be finished with this project by this date?" Well, sometimes those dates have to be changed, and sometimes you just have to let it go, and that's hard as a teacher.

She echoes the importance of maintaining flexibility in the planning and execution of teaching lessons. "I've got to uproot my schedule, my pace, [and] my plan."

A secondary concern that MS brought to light was a fear many teachers share throughout their careers. Students will ask, "When am I going to use this in real life?" The classic struggle of application of knowledge.

> I think learning how to apply knowledge is a huge thing because if you went through school as I did, you didn't learn how to apply the knowledge. You just got the knowledge. We didn't know what we were learning it for. "We just told you to learn it." And so now you have to go back, and you know it's hard to go and talk to these people in these businesses and be like, "I don't know why this is useful. Can you help me? Tell me why this is useful." You feel dumb because you don't know, but they're like, “Oh well, this is how you can use it." You're like, "Okay, that makes sense because I've not been in their world." Being willing to admit that you don't know everything [is crucial] because I think teachers have this fake persona that we're supposed to know everything, always be right, and we don't. And we are not always right, especially nowadays.

Teachers always feel a bit of a power struggle in their classrooms and may feel concerned if their lack of practical knowledge can lead to the erosion of some of their power. Giving up some of that power to create a more open classroom environment led MS to change her role for the students.

> I'm having to relearn how to teach in a different situation, you know. You do have to become a facilitator of knowledge as opposed to a giver of knowledge because they already have the knowledge, but they don't know how to use it. So, your new job is to teach them how to use the knowledge and apply it. That's why I love hands-on things because [the students] can't just Google hands-on things. They can't just say, "Oh, if I put five grams of this and add it with this it's gonna give me this." They can't just Google that. They have to actually see it happen or do it or build it or create it, so that's kind of my new [approach]. I've changed a lot in 21 years.

Self-described change is only possible through the development of professional maturity, and MS has reached that point in her career.

STEM Program Culture. I asked MS to detail the STEM program's culture as she perceives it. She began with a brief description of the larger picture, the school.

> I think that also plays into a part of, you know, it is a very small, it's a smaller system. While we're not as small as some other counties, you know, we're still small enough that everybody knows everybody, you know. And another [thing] that also plays out too is if someone messes up, everybody knows you mess up, and when you're successful, everybody knows you're successful, so that is a nice and bad part of the environment.

The nature of the small school system creates an intimate environment to teach in, so building relationships is a tangible outcome to achieve.

When she moved into discussing the students in the STEM program, MS was thorough in her thoughts.

> So, the STEM students have become, they're kind of a school within a school. They become their own family and pretty much their own school, you know. They have their own set of standards and their own set of curricula that they follow—a different way of learning than everybody else. A lot of times, some of the other kids get very jealous of what we do in the STEM Academy, which I think has accounted for our growth because while it is a rigorous program, they're also very rewarded. We try to take them out as much as we can into the community to see things. They go on a lot of field trips, we're always out in the hall building projects, racing things, doing things. I mean, so everyone gets to see what they do. And so, with that aspect, they kind of feel like they're their group, and they really collaborate and grow together as a family. I remember our very first graduating class. I mean, they had a group graduation party with their parents and their family and their friends, they all got together and had one big celebration at the end. They become their own friends and their own family and their own group. So, it's really neat to see how they grow and connect really close together toward the end.

The development of close-knit friendships within the program is a unique reflection of the community in which they live.

Concerning the culture in the STEM classrooms, MS again echoed a position of teamwork and collaboration, doing what is in the best interest of the students in the program.

Something that we worked hard to accomplish is we try not to draw content lines if that makes sense. So, the culture in my classroom is going to be the same as the culture in the math classroom, and the way we accomplish that is we're always together. Even though they may be learning math in a math classroom, I'm probably in there with them. At the same time, we'll put some chemistry or physics or something in there with it at the same time. So, there's always collaboration. Last year when we taught, we taught all the classes in this room. So, while the teacher who taught math may be doing a math lesson, they're still in the STEM room. They're still in the STEM environment. … And so this year, while we expanded, we made this whole floor their home, as opposed to one room. So, while they may be in a different location, they still have the same expectations and kind of the same culture, no matter what person they're sitting under.

There was a familial approach in how MS described the interactions from teacher to student as well as teacher to teacher.

Not only do teachers sometimes spend time teaching in each other's rooms, but the scheduling and flexibility that exists in the coursework is also something to be considered. MS indicated that even how the scheduling is completed and executed is a component of the culture within the program and how the teachers want to impact the students collaboratively and effectively.

So, they're kind of designated periods, as you could say. First block is designated on our PowerSchool as physics, geometry, and engineering. Second block is designated as chemistry, world literature, and engineering. So that's how it's kind of designated on our PowerSchool setup. However, because we all do work so closely together, first block sometimes runs into second block, and second block sometimes starts during first block. So, there's not a line drawn as to [whether] this is our math period. We approach everything, and we build our curriculum based around projects, and the standards are taught through the engineering lens in each of the classes. So, everything we do, we apply engineering because that's the lens that we use for our certification, engineering through all our content. For example, right now, in English, they [are] reading [the novel] *Night*. And so, they read *Night,* and they would read [the novel] *Wave* also … the content is so heavy [in science content] and so applicable to the kids. It's about a classroom experiment that someone did, it's a true story, and the kids get very excited about it. They're like, "What were these people thinking?" They also read *Night,* and they're keen; they can connect some of these concepts. And then we also read a lot of work from Einstein. We read his speech that he wrote to the Italian National Society of science back in 1950. And we read his letters to Rosevelt. In world history class, they're studying the history of World War 2. We tried to time everything, [and] we hit it at the same time. And then we start in chemistry, of course, we're talking about nuclear chemistry, physics, we're talking about the quantum mechanics behind it, all those different things with the atom bomb, and we're doing it simultaneously all at the same time. We even have reading discussions in my classroom, even though I'm not an English teacher. We still have those discussions, and she has discussions about the atomic bomb. Even though she's not in my classroom, we tried to make sure we're all comfortable

> with enough of everybody's area that we can jump in and team teach everything, whatever we need to do. And usually, we are trying to all be in the same area, so we kind of float around to all the classrooms. So, the kids are always seeing all of us at the same time.

The teachers attempt to completely embrace these students in an interdisciplinary world of academia while in the classroom. They want the students to understand how all these areas are explicitly connected. To accomplish this, they remain flexible and constantly communicate with one another.

I asked MS to provide adjectives that properly described the STEM program. She replied with "fun, challenging, collaborative, student-centered." Her words seem to describe both teachers and students in the program. However, MS did make sure to point out that there must still be times for traditional instruction.

> We still have those times [of traditional instruction] because you know that kids need to learn how to take notes. So, we still have some traditional aspects, more so in the fall semester, and [in the] spring, you hardly ever see us at the board. We usually introduce things, introduce topics, and then boom, they're off to work, they're off to the races. So, it comes, you know, it starts out a little more teacher-centered, and you teach them how to work together, you teach them those group skills and how to collaborate with each other, how to be team leaders, how to be team followers, how to be team players. And you know, as you get on towards the end of the year, you reach a point where (and now we always love this time of year) we can sit down, and we can relax. Now we can let them run with it. So, we're trying to make them [become] the owner of their knowledge and learning.

MS indicated at a particular point in our time together that she probably spends between 20-25% of the time in a traditional instructional approach in her classroom.

Focusing on the Journey, Not the Destination. Continuing the emphasis on teaching from a student-centered mindset, MS provided ample detail about how important this is for student learning and the differentiation needed in the STEM program curriculum. In so many instances, students become trapped in just wanting to "know what is on the test" so they can regurgitate the information and move on. With STEM instructional approaches, MS is looking for something much more meaningful. She wants students to truly internalize their experiences, not just the explicit content that is taught.

> So, when I teach, or when I used to teach just standalone [content] like honors chemistry classes, I was just pumping through the material I was teaching. I was still giving my best, we were still doing hands-on labs, but I struggled with being able to get into their long-term memory. They would learn the content, take a test, forget it, learn the content, take a test, forget it. But in STEM, we don't focus so much on testing. We focus so much on projects in elongating the need to know that knowledge that goes into their long-term memory. So, if they get to the end of the year, they're still able to remember what they did in August and September. Sometimes they have to remember a lot, learn that content with this project, and then they remember what it is, but they have multiple connections in their brain, and we've kind of networked their brains into a concept map.

The imagery of the students' brains becoming a concept map stands out. The program is built around students connecting with what they learn and how it applies to real-life scenarios.

MS continued providing example after example of how they focus on the experience while in the classroom, enhancing the journey as much as possible in the time they have.

> I'll just start with the hospital. You know what they do at the hospital. We know what their jobs are just by talking with the administrator over at the hospital and just brainstorming. How can we bring in and connect doctors with kids? How can we do this together? And then they come up with these ideas of, "You know, we can do field trips. We can have the doctors come there. We can build our units together. We can focus on different careers." It was basically just opening up a conversation. It wasn't a lightning bolt. It took multiple conversations for us to figure everything out. It was just opening the doors and starting conversations because you don't think, "How can a doctor help me teach biology in my classroom?" That's absurd, but in real life, it's not absurd. It makes sense. It makes perfect sense.

Biology was not the only course to receive the application treatment. The physics class also had its fair share of experiences.

> And the same thing [happened] with physics. We [coordinated with] a company that builds metal parts. She trains the people that are on the job, but she has engineers who draw up the parts before they send it to the machines. Companies say, "Hey, we need this." They have a certain measurement, they draw it up, they send it out, it gets printed, and they ship it off. You know, those kinds of production things. And so, talking with her, you know, we wanted to set up internship opportunities. That was my goal. But it evolved into her engineers

> coming into my classroom and teaching them how to read blueprints. Um, so, you know, just different things like that. … They just came in, brought a whole bunch of blueprints, and we used some calipers and measured blueprints and taught the kids what it looks like, those types of things. She said, "You know, a lot of people have never seen that before." That was a help for her if we are going to send kids to possibly work for her in the future. She wants them to be better prepared—those types of things.

The application within the physics class was exceptionally well thought out. Another opportunity involved a company responsible for designing and building prefabricated buildings and spaces.

> Another company that is a great partner with us is Panel Built. They invited us to come in and spend a day with them so they could show us all the different jobs they have and what different people do. Their engineers spent a few hours showing our kids what a typical day looks like for them, what they do, how they do it, and the software they use. I mean just little things like that, which meant the world to the kids. I mean, because they had no idea that the company was even there. … They build prefab buildings, like the guard shack at our school, they build things like that. Yeah, or like in warehouses, if you have offices and stuff, they build those offices, and they prewire them and everything. They're just set up like little houses. It's prefab, [it’s] made together. You just take it. Boom. Set it up, and it's done. So, it's pretty cool the stuff that they do there.

Each example highlights a fundamental point the STEM program brings to the school: application of knowledge is vital. Throughout these classes, the teachers value experiences for the students along the way that will amplify the content they teach in their classrooms.

Part of the journey MS desires for her students while in the STEM program involves course diversity. Before the STEM program started, there were some deficiencies at the school that she felt needed to be addressed. The development and implementation of the STEM program allowed for the facilitation of these improvements.

> When we started [the STEM program], there were [minimal] AP courses offered at the high school. There were zero dual enrollment courses being taught in our high school. So, when we started developing this, we were not only building our STEM Academy, we were simultaneously increasing the rigor and the opportunities for the students at our high school. There were no science [options], there was one math AP class, and there was one English AP class [offered]. … So, as we were building this, we were trying to come up with ways not only to accelerate and challenge students but to be able to apply their opportunities. So, as we were opening those doors for AP science classes, I was able to connect with Young Harris College. I knew a lot of people who were in charge over there. I knew the department head over there. And so, we got to talking, and we got to brainstorming … And so, then we talked with the person who was over their early college that they were beginning to develop. It all kind of happened at the same time. They were beginning to develop an early college at Young Harris [College] and building their dual enrollment opportunities, and then North Georgia Tech jumped on board and was like, "We want to do this also." So, they helped add in some history components. Young Harris [College] helped add in more math, such

as calculus, statistics, and then even below calculus. We also offer college algebra [and] college precalculus for the kids who aren't ready just to jump into calculus to help build all those dual enrollment courses up. … the chemistry classes and the biology classes. We do those with our AP courses so that we match those curricula. The teachers work together. We build everything simultaneously. So, the kids are getting the best of both worlds. But that was directly because of us researching and building our STEM Academy at the high school.

MS indicated multiple times the emphasis they placed on making the courses the students were taking meaningful for them. As a result, the teachers put their heads together to determine what sequence of classes would be the optimal approach for students in the STEM program. This planning led to the development of additional college course offerings at the high school, ultimately impacting the entire student population.

Reflecting on their decision-making as a group while we talked, MS spoke to a sense of pride and accomplishment they feel as a result of the myriad of changes that have taken place from a curricular perspective at the school and what these new course offerings mean for the students that take them.

> Well, it just validates that what we're doing is right and what we're doing is the way you're supposed to teach. That's how kids are supposed to learn. Kids aren't supposed to be in little silos and learn individually. It just helps you realize that they're able to hold on and grasp the material that is very difficult. But because it was connected, it stuck. And when you disconnect the material, it doesn't stick in their minds, which brings me very frustrated to the point of why doesn't everybody do STEM. So, you have both feelings, I feel very proud of my STEM

> kids, but I'm also very frustrated as to why did those kids not want to do STEM? Why didn't they want to push themselves? Because now they're working harder, and I think they see that a lot of them will tell me their junior year if they take me, they'll be like, "I was so dumb not to do STEM because I can see how these other kids learned this, and they think they learned more." And I said, "They just learned it differently. So, it stuck."

Again, MS emphasizes the importance of the journey through the courses offered at the high school and not the destination. Whether students are in the STEM program or not, they end up with a high school diploma and opportunities at the next level. MS reaffirms that the STEM students are better prepared for the next step, and the content is better embedded in their minds, all because the journey they embarked on through high school was more impactful to them.

View of the Classroom. The beginning and end of the school year are vastly different entities in MS's classroom.

> In the beginning, I am more teacher-centered. I show [the students] my expectations, and I show them how things are gonna go. The first couple of months, they're learning how to use all the equipment and things that we're going to be using throughout the rest of the year. I'm going through all the safety protocols of everything, you know, practices, best practices in the science world, and using the scientific method, but instead of the scientific method, we use the engineering design process, which is pretty much the exact same. They mirror each other beautifully. And so that's at the beginning of the year, and then it's baby steps.

She then proceeded to outline how she tries to develop their minds to think collaboratively and critically. Sometimes the project goals will be competitive. The best group will win or earn the highest grade. Other times, there are specific benchmarks that, if achieved, yield a high grade.

> So, the first project we do, we assign their groups, we assign their roles, and we explain to them what they need to do in those roles, and each kid has their responsibilities within the group. [For] the next project, we kind of back off a little bit. We say, "Okay, we'll still assign their group, but you can choose the roles that you want to do, or we have them apply for the roles they want to be. We always have a project leader, and it depends on the size of the class or the size of the group. In a group of four, you'd have a project leader. You have a materials leader, so that person is in charge of the materials. You have a writer, and then you have the mechanic. So, the mechanics may, you know, they're the ones in charge of making sure everything was good and then one person in charge of making sure everything's written correctly on the research and so on and so forth. One person is in charge of making sure all the materials are there. … And then one person is making sure everything is good, the leader. Everyone is still writing, but the writer is in charge of editing and making sure everybody does their part.

The classroom concept may be open-ended and student-centered, but the structure remains. Students each have their expectations within their groups. They are given protocols to follow and slowly gain more freedom as they learn to work within the confines they are given.

MS gave me a detailed breakdown of time spent in her classroom. Granted that traditional instruction and science labs still exist, the focus is still on project-based learning. The goal is to complete one major project per month in her class.

> I would say maybe 20% is traditional instruction. And then I would say probably 10 to 15 to 20% is traditional labs because they need to do the traditional labs, or they're following the directions of doing things that way. And then the other 60% are doing the projects. That's how I would probably break it up. But given the time it takes, it also depends on the year. Some years, I have to have more time with additional instructions. Some groups have to spend more time with traditional [instruction], depending on their learning styles, so it varies from year to year. You know we have to learn what the kids need every single year.

Even in the face of open-ended, project-based instruction, MS still watches for cues showing how the students learn and modifies her approach as needed.

MS touched on one of the beautiful aspects of a project-based classroom and the goals of the STEM program to begin modeling real-life scenarios in conflict resolution and collaboration. The students have the opportunity during their project time to "make sure everything's working properly, and if there's a dispute or an argument, that person gets to decide what happens." That person ends up being the student assigned a specific role. "Okay, so like, when you have multiple different designs, that person gets to choose, even though it's a group, if there's an argument, and they can't come to an agreement. Ultimately, they get the choice." This approach means the classroom environment "is mirroring the real world. That's what we try to do." Progressively, MS has reduced her influence on each group and their decision-making. In her words, "Maybe by project three, our goal is we don't assign those roles. We let them do it themselves, and then they're just responsible for figuring out how all that works. And then by the end, like I said, boom, here's the project, go for it."

An example of this project-based work involved groups of students designing a catapult made from PVC pipe.

> With our catapult project, we cover the geometry standards. We cover right triangle trigonometry, sine, cosine, tangent, and the Pythagorean theorem. That is covered because they have to figure out the angle measurements of their catapults and launches in physics. We're covering one-dimensional and two-dimensional motion. So, they're doing all those calculations, and they have to do it backwards because they know how far it needs to go, and they just need to figure out how to make the angle of their launch.

MS then described the cruel reality of the differences in building and testing catapults inside versus outside. The students sometimes fail to consider outside effects, such as the wind, which will impact their final product.

> We'll tell [them] a couple of days before, right, "You need to make sure you go outside and just see how it works," and then go outside, and if it's a windy day, they're like, "Why is it not going as far as I calculated it?" I'm like, "Well, now you have to take air resistance into effect, to have to go back and figure things out and figure out how to make [the] tension a little bit stronger in their bungee cords, so they get the force that it needs to go.

This glimpse of the classroom provides that all-important look into students being presented with challenges and needing to think critically to overcome them without being guided by the teacher. Additionally, the students are given a day to compete to show which catapult design is the most accurate. In this instance, MS indicated the winning group receives a grade of 110 for the project, which is sure to bring out the best competition from the students.

Program Goals. When discussing the goals of the STEM program, MS provided a look into what she hopes to achieve with the program and with each student that completes the program's requirements. From an organizational perspective, the program needs to be organized so students can benefit the most from course sequencing. As mentioned previously, the ninth grade offers a chance for STEM students to become immersed in the program's expectations and develop the skills needed to succeed. Following the ninth grade "introductory" year, things become more specialized for the student.

> After their ninth-grade year, our goal is for them to be independent learners and able to work in groups. So, then their 10th-grade year we apply [the independent learning] more. We get them more out into the community, and they're doing more things where other people see them. We want them to be respectable students, you know. They learn how to listen and be respectful in those different types of scenarios: out in the hospital, out in the different businesses in the life science world. We just continue to build those group skills and [implement] projects that they're able to complete and increase the level of difficulty of the content that they're covering.

MS further elaborates that the increase in difficulty is designed for beginning to prepare the students for their insertion into dual enrollment classes through local colleges. Dual enrollment is not the only focus deeper into the high school curriculum.

> We will bring them into dual enrollment classes and their internship opportunities, and we still have projects and things that they have to complete that are STEM-based, where they're still integrating all that technology and engineering into their content. And then as an intern, we want them to be an asset to their business. I can't tell you how many interns that we've had go out of the businesses, and [the business owners say], "We wish they didn't have to go to college for four years. We would love to keep them here. We want them to come back, but we know they're not going to probably." There are opportunities for them to have full-time careers here. They established very positive [relationships], wanting to establish positive roles in their community so that they do have those experiences of job offers when they do come out of college if they were to come back home and have that option [available]. A lot of [business owners] are very disappointed when [our students] have to move off to college.

MS then provided a specific example of the success behind internships.

> I had a girl who went to Georgia Tech, and she worked at EMC, and they were just brokenhearted when she left to go to Atlanta because she basically kept their mapping systems updated for them. That's a huge responsibility, the mapping systems that they use to run all of their computer-generated stuff were run by an intern because she was that capable, a high school girl. That's what I want to have to happen over and over again. … I have a student who's working [for] another

> company. She develops automated CAD [Computer Aided Design] drawings with the electricity and all the different things of the buildings that they prefab for the multimillion-dollar sales that they do. She's the one who does a couple of those jobs. That's a huge responsibility for [a high school student], and she learned those skills in the STEM classes.

When students can seamlessly integrate themselves into complex job situations, MS truly believes it is a testament to the success they are experiencing in the program with these students. These results are the goal of the program continually.

On an individualized basis, MS wants the STEM program to become a transformative experience for each student. She understands that each student's interests and needs will differ, but the outcome for each student in the program must remain the same.

> That's what I always tell the kids. They're like, "Well, why do you make me do this?" I'm trying to prepare you for what we don't even know you're gonna be faced with. Because the problem that you are going to be faced with doesn't even exist right now. Who knows what the future is gonna look like for you guys.

Elaborating more on students becoming independent, MS continued her thoughts.

> My goal for them is to be independent learners and to be able to do science on their own. That's what I want them to be, so by the end of the year, I want them to not only have a good foundation of the content but to be able to apply that content on their own without me holding their hand. I think that would be my goal. Because if they're independent learners and they're responsible, then they're

> motivated, and then they take ownership of their learning, and from that point on, everything else is a breeze. They own it. That's what matters.

MS speaks to the importance of individualized ownership. She wants each student to own their education and views completing this goal as a sign of success in her classroom and the program.

The way MS blends her thoughts on the goals within the program and how she views success shows how closely married the two entities are.

> So, success in my classroom would be students being able to overcome obstacles, overcoming failures, overcoming difficulties learning the content, yet still coming out with positive applications for future courses content, career, etc. That's what I would label success. It's not whether they get an A, B, C, or D [as a grade]. It's whether or not they were able to overcome obstacles in their way and continue to learn and keep moving forward. They didn't get stopped, you know, didn't stop and just got completely railroaded. They were able to keep moving forward no matter what. And that way, we were able to continue to raise the bar higher and higher for them.

Raising the bar speaks to setting appropriate goals. Goals that are lofty and just within reach, but also being able to continually move the bar to promote student growth.

> Success in the STEM program, I think it's kind of the same thing, but just to the next level. Overcoming everything that was put in [their] way, but yet now they have a plan. They have a good background. They have good content [knowledge], [and] they have fulfilled their obligations of completing a math and science honors track. They've done an internship, they have an idea of what they want to

> do, and we've kind of sort of help them guide them into what their future could be and put them in contact with people who can help them further on. That to me, I feel like when students are confident when they graduate. That makes me happy.

MS finds great joy in seeing these students challenge themselves and struggle at times during their high school careers, only to rise up and graduate with the skills needed for post-secondary excellence, workplace excellence, and collaboration in general.

The Importance of Collaboration. When working together, MS described an atmosphere of teamwork, acceptance, and humility. Her thoughts throughout our time together constantly emphasized how vital it was for the STEM teachers to communicate about everything that transpired in their classrooms.

> We do have common planning periods. Up until this year, we all had third-block planning. So, we would devote one day a week when we get together, and … go over everything we've done, we'd look at students who work well together, who don't work together, look at their data, look at who's struggling, who's not struggling, those kinds of things. We're trying to do that on a weekly basis, like the formal sit-down together thing, but on a daily basis, we're always communicating with each other. We converse [with] each other in the hall. "Hey, we're on this today. We're still good." We may be in the same classroom together at the same time, so we're talking with each other [for] the whole hour and a half. … So, it's a continuous process. Again, we do have more formal things. We even have once a month [when] we will take a whole day, and we'll get a sub for all the classes, and we just go into our conference rooms, and we have a whole day, and that helps us to keep our projects lined up together, you know, long term goals.

> Then we talk about our long-term goals. [It will be] within the next four to six weeks before we have our next meeting. "Where do we want to be? What are we going to accomplish" "What projects are we on?" "What standards do we want to cover?" Those kinds of things [are addressed].

MS further elaborated that their weekly collaborative planning sessions will typically only last 10-15 minutes. They just need long enough to ask and answer the most pertinent questions and ensure everything remains aligned curriculum-wise. Sometimes these sessions can last a little longer if they are working on summative assessments across content areas. She then told me the all-day sessions typically happened every nine weeks, so three were needed throughout the year to ensure projects, timelines, and standards were where they needed to be.

However, it was interesting to note that the emphasis on collaboration between teachers was not a product of the STEM program development. Instead, the program partially resulted from this environment already being in place.

> We had pretty much started the development of our collaboration long before the STEM Academy ever became salt in our minds. We had worked together on some (before it was called STEAM) STEAM units together in the past, so we already had the experience of working together. So as the superintendent at the time had brought this idea to us, we were like, "Oh yeah, we can do this!" This would be an easy marriage, and we started thinking about different areas of things that we could bring in, and as we just kept collaborating [with each other]. We just kept open minds and [remained] open to listening to other opinions. I say most of the people who work in the STEM Academy are very humble.

Being a team player is paramount to making the STEM program successful in MS's eyes. She says, "I just think the collaboration, that humbleness, and honesty [are so important]. Being honest, being receptive."

Planning and developing the STEM program was not an overnight success story. MS described the process they embarked on to guide the teaching component of the program in the direction they desired.

> We spent a whole year planning our curriculum and a whole summer before planning our curriculum. … I was the engineering teacher at that time. We just started out with three people collaborating. We just had English, chemistry, engineering, and physics. We didn't bring the math in yet, because we wanted to start small and doable. … We created big ideas for each of our standards. We looked at the big ideas for each standard [using] the Understanding by Design model that we've been taught. … So, then we looked at our big ideas, and we looked at how we could connect those big ideas. Once we started finding those connections, we developed our units based on those big ideas. What standards do we need to meet? What are our essential questions? What can we do with this? What are our driving questions going to be? What are the activities we're going to do with the kids? How are we going to make this work? What's our schedule? What's our timeline? So that's how we started, and again like I said, constant communication.

At this point, the teachers taught their content. They would daily communicate with each other asking about progress, the need for extra time, and adjusting timelines as needed. MS described it as "fluid" instead of "regimented" between the teachers. They learned to become a bit more patient during this process due to the dynamic nature of their pacing and how it could change regularly. "You have to learn to step back and just be patient and let it happen sometimes, you know. You can't be in control the whole time. Once you learn that, then you're okay."

Words of Wisdom. I asked MS to provide her insight on how to make the journey of developing a STEM program as seamless as possible. Granted, she acknowledged the process is long and arduous, but her thoughts were poignant.

> Don't give up. Be patient, open your doors, and just be willing to try anything. Find a person, start with one who you can get along with and you mesh well personally. And then, regardless of the subject area, start looking at your standards, try and make some connections and then just build it. Start with one and then … build from there. You can't put five people together and expect them to come up with a beautiful lesson automatically.

In her mind, the simplest suggestions are the most important. She believes finding something to try and putting it in motion is critical. In her mind, forward momentum is still momentum, no matter how much or how little there is. "It's a slow process. Don't try to rush it. Start small, dream big."

MS also alludes to the constant need for self-assessment, whether new at a STEM initiative or a seasoned veteran. This reflective nature ultimately impacts the students, the reason for the program from the beginning.

> [W]e all have to continue to work to have a successful STEM curriculum [and] STEM program. It's going to build their characters. It's going to build their abilities in the future because truth be told, we're preparing students for a world

> that we don't know what it's going to look like when they graduate. In order to do that, we have to prepare them to learn in a way that is so different than the past so that they can take those skills and apply them in the future to solve problems that aren't even here right now but will exist for them. So, just giving them those skills to be innovative and trying to model that as best as we can.

The last phrase, "trying to model," speaks volumes. MS understands that teachers are imperfect individuals trying their best to prepare students for the unknown world that lies in wait.

> They know we're not perfect. We're gonna make mistakes. You can get past the mistakes. It's okay. And sometimes, some things that we try might not work the best the first time. Sometimes it'll be a disaster and sometimes it'll be great. And just having enough confidence in yourself to accept the failures, and to learn from them and move forward is, I think, a necessity of a quality of a person in a STEM instructor. You want the same quality to be in your students. You want them to be able to fail and learn from those failures and then take the next step. So, I would say that the ease of not getting too prideful is very important. And if you have a person on your team that thinks they are everything, they need to get off [the] team because that's the first indicator. You are not everything. So, you can't help me because I don't want people to tell me what to do. I want to learn and work with them and figure it out together. It needs to be collaborative, just like we want the students to be collaborative.

MS wants to do her part to prepare them for the future. Her words of wisdom: don't give up, model what the kids need, and start small but dream big.

Chapter V

COLLECTIVE PORTRAIT AND ANALYSIS

This chapter provides an examination of the data analysis process used throughout this study. Here I discuss the process in which each participant's data were analyzed for categorically specific codes. After a breakdown of codes into overall themes, each theme is presented with a further analysis of quotes provided in each participant's portrait. The findings are directly connected to the research questions of the study. In this study, I examined the lived experiences of three teachers and two administrators in a small rural Georgia high school with a STEM program that has been certified by the Georgia Department of Education (GaDOE). I wanted to better understand the strategies and practices these professionals exhibit regularly within the school to increase student science proficiency within the STEM program at the selected school. The following research questions guided this study:

- RQ 1. What were the lived and career experiences of school personnel who were responsible for increasing student science proficiency in a certified rural high school STEM program?
- RQ 2. What strategies were used by school personnel who were responsible for increasing student science proficiency in a certified rural high school STEM program?

- RQ 3. What practices were used by school personnel who were responsible for increasing student science proficiency in a certified rural high school STEM program?

Data Analysis

The data collection of this research was completed over a four month period of time (March 202 through June 2020) and the corresponding analysis of the data took place over a twelve month period (March 2020 through March 2021). Using purposeful sampling, three teachers and two administrators were selected to participate in a series of three interviews that followed Seidman's (2013) interview model. These participants were identified and selected based on their high level of working knowledge within the STEM program so the resulting data would be as valid as possible (Patton, 2002). The first interview covered each participant's path into the education profession and established a baseline for their educational philosophy based on their life experiences leading up to their beginning in the educational field. The second interview delved into each participant's perspective and experience with the STEM program. The final interview involved the participants reflecting on the meaning of their experiences within the STEM program's confines.

To identify initial participants, I first sought permission to contact teachers from the school principal. I asked the principal to help me identify teachers who fit my inclusion criteria for the study. Ultimately, I recruited a sample of three teachers and two administrators at the school. These individuals provided their perspectives of their work in the classroom during implementation and the current daily activities in which they are involved. These teachers provided a varied yet cohesive view of the STEM program's inner workings at the selected school. The day-to-day strategies and practices of the teachers in the STEM program came to light as a result of these interviews. Discussion with the principal also yielded two potential administrators to participate in the study: the principal and the CTAE director. These individuals have the closest working relationship with the STEM program. Their perspective of the STEM program from an organizational standpoint, from a collaborative standpoint, and how it blends with the rest of the school yielded rich data that corroborates what I gained from the teacher participants. Table 1 includes basic demographic information for the participants in the study.

Table 1

Participant Demographic Information

Pseudonym	Age	Time at School	Role at School
AM	49	7 Years	ELA / Media Specialist
JH	46	11 Years	ELA
KM	46	4 Years	CTAE director
DW	46	16 Years	Principal
MS	42	8 Years	Science / STEM director

I conducted the interviews face-to-face in semi-private locations on the high school campus. The sole exception involved my final interview with MS, which took place via the telephone. I audio-taped the interviews and transcribed them immediately afterward using the Otter recording app. Merriam (2009) explained that using multiple methods of collecting data can support statements provided by participants during the interview process. In this case, documents of meeting agendas, notes, and curricular documents were also gathered and analyzed to corroborate the claims made throughout interviewing. Interview transcriptions and participant written narratives were compared throughout the process for similarities and differences while examining the conceptual framework of this study for evidence. I used interviews and school documents as my two sources of data.

The data analysis process began by reading through each interview transcript while listening to the audio recording. Listening while reading allowed me to better understand inflections in the voice and emphasis the participant may have placed on certain words or phrases so that I could be as contextually accurate as possible during the coding process. As I read the interviews, I reduced the text to specific chunks of data that allowed for a descriptive narrative of each participant in their own words. I used a system of highlighting and notecards to code my data from the transcripts. Each type of code (in vivo, process, emotion) received its unique color and was used when identifying sections of the text that were highly relevant to the study.

As I continually revisited the data, consistencies were identified from the assigned codes. I formed patterns amongst the coded data and grouped them into categories. Finally, I used notecards to take my grouped codes and further connect them to major themes across participants. In the end, I grouped codes by the participant to generate participant-level themes as well as grouped codes across participants to generate cross-comparison themes based on all the participants. This analysis allowed me to better establish relationships among the themes of each participant and ultimately generate meaning to answer each of the research questions.

Discussion of Themes

I used comparative analysis (Patton, 2002) across each of the five cases and other data sources. Patton indicated that using a comparative analysis approach "builds a foundation for the interpretive phase when meanings are extracted from the data, comparisons are made, creative frameworks for interpretation are constructed, conclusions are drawn, significance is determined, and, in some cases, theory is generated" (p. 465). In this study, each participant provided a rich portrait of their lived experiences within the STEM program. The data collected from each individual as well as documentation from the program allowed me to continually compare various chunks of data to determine similarities and differences while simultaneously determining existing patterns and tendencies between participants. Over time, the chunks of data and the associated codes developed became grouped allowing me to create themes. By simultaneously analyzing data collected and reviewing the literature from the study, final themes were identified and used to provide answers to the research questions. I created the themes from a constant and continual analysis and review of all audio recordings, corresponding interview transcripts, program documents, and personal reflections from visiting the research site. Three major themes were formed after data analysis that include the *importance of peer collaboration*, *goal setting and success for all*, and a *progressive program pedagogy*. Each of the themes discussed contains aspects that flow between them and should not be considered only in isolation. Rather, these themes provided a collective picture of how the STEM program and the participants within realize their success.

The Importance of Peer Collaboration

This theme details the emphasis participants placed on teachers' collaboration within the STEM program. Peer collaboration involves the work done between teachers within the STEM program as well as the interactions between teachers and administrators to further the work in the STEM program. Four of the five participants spoke directly about the importance of being collaborative within the group and what that dynamic needed to look like for the program to remain effective for student learning. These aspects of collaboration included teachers working with teachers and students working with other students as well. Ntemngwa and Oliver (2018) confirmed the importance of collaboration within the implementation of an integrated STEM approach through adequate utilization of available external resources to enhance STEM content. Tofel-Grehl and Callahan (2014) alluded to the importance of collaboration among students and how working together builds "a sense of community" (p. 254). An interesting point to note involves the lens through which the participants viewed collaboration. While the classroom teachers discussed aspects of their day-to-day interactions with each other, memorable planning sessions with teachers, or co-teaching in a room and the impact it had on the students, the two administrators saw collaboration from a different light. Instead, the administrators constantly spoke toward the bigger picture of the school and how the collaborative efforts of the STEM program have previously affected the school and how they will affect the school moving forward. Regardless of the point of view, these results align with the study by Tofel-Grehl and Callahan indicating that STEM schools developed an appropriate school culture among administrators, teachers, and students. The responses given by the participants also align with Wang et al.'s (2020) study indicating the beliefs teachers held regarding collaboration in the classroom and its effect on significantly impacting interdisciplinary STEM instruction. The consistent nature of how the participants spoke about the importance of collaboration among teachers and students also firmly corroborates the need for implementing quality levels of communication and collaboration in the STEM classroom environment (Al Salami et al., 2017; Margot & Kettler, 2019). The level of collaboration seen in the STEM program of the selected school between both students and teachers confirms the results of their study within this context. Key points generated within this theme include peer collaboration among teachers, teachers working with a common mindset, collaboration to overcome an individualized fear of failure, and the collaborative relationship between teachers and administrators.

When focusing on aspects of peer collaboration among teachers, several of the participants were specific in describing their experiences. MS spoke of the need to start with a small but manageable workload across subject areas. She indicated they slowly added subject areas to the STEM program to make sure each step was doable and could generate student success.

> We just started out with three people collaborating. We just had English, chemistry, engineering, and physics. We didn't bring the math in yet, because we wanted to start small and doable. … We created big ideas for each of our standards. We looked at the big ideas for each standard [using] the Understanding by Design model that we've been taught.

MS also described how important it was to keep the collaborative situation fluid as much as possible. JH added that the constant collaboration she has experienced with other teachers in the program helps to drive the success she perceives in her classroom. She also indicated that the level of collaboration she experiences in the program leads her to handle problems that arise in the classroom in a better fashion.

> So, I think I've become much better at mediating situations and feel very just much calmer, and I'm telling you right now it is. I know it's 100% from working with [the chemistry teacher] and [the biology teacher] and down here and just learning that okay, it may not have gone the way we wanted but we'll figure it out. It'll be okay. It'll be okay. We'll figure it out.

JH values the opportunity to work closely with her peers and to use constant communication to reflect on her classroom practices and, when needed, improve upon them.

A secondary aspect described by multiple participants involved having teachers in the STEM program that not only work together but do so with a common mindset. AM described the importance of agreeing philosophically with her professional peers when collaborating. She also noted that during her time as a teacher in the program, there were no issues with ego problems among co-workers. Instead, she described a seamless experience that was slowly crafted that strongly emphasized an interdisciplinary focus and was constantly considering the big picture to make sure the students were gaining the benefit from the program they needed.

> We went through what we needed to cover. So we had all our standards laid out, and then we talked about the best things to pull in. So we call the minds were together and all of us are working together in the same room, thinking about projects and plans and what tied in...You really need everybody in the same room,

> and you need to know what standards you're trying to get a look at [across] the whole year. And we plan for the whole year. I didn't mean it didn't change, but we laid it out in a big spreadsheet grid, and we named them by units, and we brainstorm what's going to go in each unit so we can cover all these [topics]. And I didn't go in the textbook order, because we just needed it to fit where it fits best.

In her mind, the gradual development of the collaborative approach in the classroom became a seamless educational experience for the students with multiple disciplines in the room simultaneously. MS spoke to the fact that healthy communication is key within the STEM program for their levels of collaboration to be effective.

> So, we would devote one day a week when we get together and … go over everything we've done, we'd look at students who work well together, who don't work together, look at their data, look at who's struggling, who's not struggling, those kinds of things. We're trying to do that on a weekly basis like the formal sit-down together thing, but on a daily basis, we're always communicating with each other. We converse [with] each other in the hall. "Hey, we're on this today. We're still good." We may be in the same classroom together at the same time, so we're talking with each other, [for] the whole hour and a half. … So, it's a continuous process.

She also mentioned the successes possible when you have the right personalities working together, able to set aside personal interests for the kids in the classroom.

The third aspect of collaboration and teamwork expressed involved the importance of collaboration for the sake of moving past the fear of failure as a teacher. When implementing such a new academic approach, MS described the fear of the unknown that can exist because the classroom approach is so different from what is traditionally done. MS continued to describe how trusting in what the team of teachers decides to do is vital for group success. She must be willing to uproot her schedule and pace in some cases for the greater good of pacing for the program at large.

> A lot of teachers are really afraid of failure, and they're afraid of their kids not learning the standards by doing it the same old way and they're afraid of opening their doors and using time more freely as opposed to [a] very structured [approach]. It's hard, it does take special people to teach STEM because you have to let go of a lot of control. As a STEM teacher, I have to be willing to listen to what [various STEM teachers] have to say. and we have to put our ideas together. It's not just one of us. We're always a team, and sometimes you're like, "I don't know if that's right." But if the team agrees we do what the team says, and we always try to do what's best for the kids.

The sense of letting go of control in the classroom can be difficult, but JH spoke about how important it was to be willing to try something new and even be willing to fail the first time to learn. JH spoke to the vulnerability that comes from trying something new and that this feeling leads her to success. As the teachers in the program work together, they end up modeling the behaviors they want to see out of their students with each other.

> They see that interchange … they're watching adults model behaviors and relationships that they are going to have to model soon. I mean, I dare say that a kid that graduates today, you know, almost any of them are going to be working in some type of collaborative environment.

They also show the students the importance of the relationships they build with each other and instill this importance in the students. The students in turn see these actions and through them learn how to interact with each other in the classroom. MS described this as teaching through actions and not words. JH elaborated that their modeling of communication for the students in the classroom pushes them to better develop their explanation of why they choose to do what they do when solving academic problems.

Interestingly enough JH asked the questions, “How do we support each other in our content?” and “How do we bring out the best aspects of the content together?” Through an analysis of the collective response about the STEM program, the teachers all answered the question. They support each other through being flexible in what they do for the bigger picture of the program, collectively letting go of the reins of power when needed, by agreeing to follow what the team decides so they can always move in a singular direction as a group, and by modeling the behaviors they want to see out of the students.

> I would look at what I needed to cover, and we will kind of seamlessly try to work the materials in with each other. So, we really do a lot of breaking down to the standards and just kind of unpacking all of that and looking at it and, and looking at them side by side…

JH alluded to keeping the students just outside their comfort zone when engaged in the learning process. The students need to struggle just enough, to become stronger and pull themselves out. The teachers, as a reflection of this, have placed themselves in a similar situation. The teachers are constantly trying something new and pushing their comfort zones to find the right balance of learning and engagement needed in the STEM program classes.

A final consideration regarding the importance of collaboration involved the level of communication that takes place from school administration and how the administrative team works with, and for, the STEM teachers. DW spoke about several aspects of being there to support the needs of the teachers in ways that are meaningful to them. He referred to the importance of modifying other responsibilities outside of the classroom to give these teachers more time to plan together.

> I mean I'll go to bat for them, but I think that's just what you're there for: support. And coming from a teaching background, I think it's important. I think that a teaching background, not forgetting what it's like to be an educator, and setting things up, like the schedule or the bell schedule or the requirements and duties, and responsibilities free them up to do their job. I think that's the most important thing we don't require them to [do] hall duties or parking lot days or lunchroom duties. We try to [give] them common planning [so] they have time to meet.

He also understands that they are content experts, so he tries to let them do what they feel is most important at the moment because of the level of trust he has in his STEM teachers.

> You've got to let them be experts and you don't want to micromanage them. You want to have good trust [with] them and [I] trust her totally to make the right decision for kids. Well, more than I would trust some of the other entities if that makes sense because she's proven time and time again to make the right decision.

This trust is built on communication and cooperation over some time. DW even acknowledges that communication with his teachers helps them realize that some decisions made are done from the big picture and not necessarily something happening at the moment. His teachers, though, understand the high standards he holds for his teachers trickle down to the students and he constantly works to help his teachers anyways he can. All of these are accomplished through the tight-knit working relationship DW has with his STEM teachers.

Goal Setting and Success for All

This major theme examines the participants' views regarding the importance of setting goals for student and teacher growth alike. Goal setting involves working with students to identify where their interests are and how the school can help them to reach the level of success they desire for themselves. The notion of success for all is derived from the vision of the school as a whole. The teachers and administrators at the school work with the understanding they wish to provide the opportunities for all students to realize success in their lives. All five participants spoke directly or indirectly in some form regarding the value they placed on goal setting in their professional lives and the importance of setting goals for both the teachers and the students within the program. Alsbury et al. (2018) asserted the two most effective variables in leading large organizational change included having an attainable and precise vision within the organization and planning appropriately to see the vision become a reality, echoing the results from the participants in this study. Participants' responses in this study supported Tofel-Grehl and Callahan's (2014) findings, which indicated that scientific learning environments encouraged students to take responsibility for their education and for independent learning. Nadelson and Seifert (2017) addressed the initial institutional change possibly occurring in a more segregated fashion (smaller number of classrooms during the STEM program development) and slowly integrating to realize long-term success (full STEM program implementation and current expansion of STEM model into the CCA). With the selected school's focus on gradual change, setting appropriate goals, and realizing success for all students, a commonality appears to exist between this study and the participants in the study. Honey et al. (2014) also supported the importance of setting goals, including "building STEM literacy and 21st-century competencies, developing a STEM capable workforce, and boosting interest in engagement in STEM" (p. 224). Topics that came to light within this theme include the process of establishing a blended pedagogical approach, goal setting for everyone in the program, defining success in the program, and how this success will ultimately impact the entire student body as opposed to only a select group of students at the school. By establishing attainable goals, the participants either directly stated or strongly alluded to the motto for the school "Success for All."

A key goal for the teachers in the STEM program is the establishment of a unique pedagogical approach involving consistent application of knowledge for the students in the classroom. The teachers in the program believe the experiences they provide, the inquiry-based learning they promote, and the research-oriented work the students complete all lead to better preparing their students for life after high school. MS spoke often of the paramount importance of applying the knowledge learned through as many relevant avenues as possible.

> But in STEM, we don't focus so much on testing, we focus so much on projects in elongating the need to know that knowledge that goes into their long-term memory. So, if they get to the end of the year, they're still able to remember what they did in August and September, and sometimes they have to remember a lot, learn that content with this project, and then they remember what it is, but they have multiple connections in their brain and we've kind of networked their brains into a concept map.

These relevant connections allow for the long-term storage of information as it is connected to a specific entity instead of a unit of content. Yes, the content will come, but, instead, it arrives through a specific project or task. MS provided multiple examples of how this occurs in the STEM program. This is one of them.

> We [coordinated with] a company that builds metal parts. She trains the people that are on the job, but she has engineers who draw up the parts before they send it to the machines. Companies say, “Hey, we need this.” They have a certain measurement, they draw it up, they send it out, it gets printed, and they ship it off. You know, those kinds of production things. And so, talking with her, you know, we wanted to set up internship opportunities. That was my goal. But it evolved into her engineers coming into my classroom and teaching them how to read blueprints. Um, so, you know, just different things like that. … They just came in, brought a whole bunch of blueprints and we used some calipers and measured blueprints and taught the kids what it looks like, those types of things.

KM also spoke about why interdisciplinary instruction directly involving the community is so powerful. Due to the direct connections between CTAE instruction in Georgia and the emphasis on STEM educational practices, the two disciplinary areas share a similar method of impacting students.

> I mean, those teachers pour their heart and souls into the STEM program. All of them, I mean, down to the individual. And I think the STEM program here, we're talking about individualized instruction goes above and beyond. I would say I've never seen individualized graduation plans laid out [for] every kid. They know every kid, [what] they want to do, and they put them in dual enrollment, specific to them. … And so, it's amazing, really, the time it probably takes to sit with every student and do that, but how valuable that is. So that's kind of our goal when I say schoolwide that's another aspect of it like every kid that graduates from this high school, walks across that stage, should know where they're going the next day.

KM sees the connection of what the students learn as being so impactful that immediately following high school, there is a direct plan in place to move to the next level. Each student in their CTAE classes gains direct knowledge in their areas of interest, from healthcare to engineering, to mechanics. From the unique instruction to the individualized attention students receive when planning out their future after high school, the program is geared to place each student in the best place to move to the next level.

Building from the establishment of the unique approach the school desires for these STEM students, goal setting was a concept that became a central theme in the program as well. Each student is targeted within the STEM program and assisted with scheduling, college applications, scholarships, and internships by the STEM director. These opportunities are generated from the relationships built within the STEM program between the students and teachers. These relationships allow the teachers to push the students to become the best they can become while in high school. JH acknowledged an emphasis on not just generating students with a specific type of knowledge but instead producing students who can think for themselves, students who are adaptive thinkers.

> I want to produce critical thinkers, adaptable critical thinkers really … kids who could solve problems. That's really what I want: kids who can synthesize information. They're inundated with knowledge and information and statistics and fake news and whatever. … The ability to sift through that to me is a critical skill that we've got to start getting to, they've got to learn how to be critical consumers of information, and they've got to learn how to be critical thinkers and adaptable.

Being able to sift through information and become a critical consumer of that information is supremely important to JH as the English teacher in the STEM program. She wants the students to learn how to search for knowledge and be able to apply it throughout their lives, whether that involves future employment or other personal endeavors. Regardless of the content, generating students with these skills produces individuals ready for the next generation workplace. MS explains to them constantly the “why for everything they are doing.”

> I'm trying to prepare you for what we don't even know you're gonna be faced with. Because the problem that you are going to be faced with doesn't even exist right now. Who knows what the future is gonna look like for you guys.

MS also spoke multiple times about the goals the program has for the students within.

> After their ninth-grade year, our goal is for them to be independent learners and able to work in groups. So, then their 10th-grade year we apply [the independent

> learning] more. We get them more out into the community and they're doing more things where other people see them. We want them to be respectable students, you know, they learn how to listen and be respectful in those different types of scenarios, out in the hospital, out in the different businesses in the life science world, and you know we just continue to build those group skills and [implement] projects that they're able to complete and increase the level of difficulty of the content that they're covering.

The nature of the STEM program is progressive in that the skills the students need are slowly layered into the curriculum over the course of the entire high school experience. Due to the nature of the workload in the STEM program, the students see levels of individual growth not traditionally seen in previous methods of academic instruction.

Goals for the program also include how it is determined that success has been achieved for everyone involved, student and teacher alike. This aspect participants repeatedly mentioned was defining how success appears for students and the program in general. AM spoke to the fact that life is rarely about a single subject or topic; an interdisciplinary approach provides the best instruction for students because it mimics the interdisciplinary nature of life. Problems are not solved without considering every aspect of the context, so the teachers in the program pushed to consistently blend the subjects together to increase academic relevance to real-world scenarios. AM also loved the process of critical thinking and wanted to see the kids go through the process and come out on the other side as stronger and more capable individuals.

> We wanted to integrate all those subject areas so that every unit was interdisciplinary and connected with all four subjects, every time. And we wanted

> kids to see how that tied to real-life skills … But that's a really big piece of it that they had to do real-world things so at the end of every unit there was a public performance piece like we would invite judges outside of school, to come and evaluate the things they created or the presentations they were doing, and we gave those judges rubrics that the kids had too, and we said they're going to be looking at all these things and they're going to grade you and what they tell you got is your grade. We're going to give you a grade too for what you've done, but what really matters is what those outside people think because they're the experts in their field.

Tying all the content together in a meaningful way is what AM believed pushes these students and is what they thrive on. Bringing the community together with the students in an educational venue generates success, according to KM.

> It's a bigger thing in my mind, when you say success, our STEM program, it's a bigger conversation because, ultimately, you're impacting the community, the region. If you want to say success, what is success? Well, that's the end goal. Success is providing that future workforce throughout this region and breaking [down the] generational poverty [barrier].

The connection between the program and the community is mutual with the STEM program. The program consistently reaches out to local business partners to provide relevance for the students in the classroom. The students attend field trips and complete projects designed to emulate workplace tasks. The community experts in their respective fields provide feedback on student work to help students develop and they ultimately strengthen the local workforce through their educational endeavors. Goals are established from the beginning of students entering a CTAE pathway in their successful completion of the three-course sequence to making connections for future potential job opportunities. JH finds success in the program from the inclusive nature of entry into the program for the student.

> So, you know, what's wrong with the kid being in the STEM program and being a "B" student? What's wrong with that? If they're challenging themselves, if they're rising to the occasion, if they're growing in their academic abilities, in their reasoning abilities, in their responsibility as a student, aren't we doing what we need to be doing?

JH explained the importance of maintaining the program identity of STEM not being an honors club. She appreciates students of multiple ability levels wanting to embrace the challenge of the STEM program. DW summed up what they are trying to accomplish with the program, a goal to strive for every year.

> I think that the STEM program should breed more MIT (Massachusetts Institute of Technology) kids, not [that they're] going to go to MIT. The reason why it's so hard to get into MIT is because you have to be smart and good with your hands like you have to be smart and technical, you have to be a genius welder. Not necessarily a welder, but you're a welder plus [you] know how to do AP Calc. You have to be the kid that can do both. … They are rare, so we're trying to build more kids like that … just smart, hands-on, and reliable.

DW indicated the success of the program also by discussing the impact it has had on the school's long-term plans. With the school using the STEM program as a blueprint for the rollout of their College and Career Academy, he contends "nothing will change for them because their model is going to be the model. They're the model for the other academies to follow." The collective vision of the program by those within involves generating success within students by pushing all their faculties in such a manner that they become the most well-rounded individuals possible. Using a broad range of skills in a highly technical environment can produce amazing results. These are the results that the teachers and administrators deem to show success.

The teachers and administrators support the concept of "Success for All" through their actions within the STEM program. They were quick to provide their own words of wisdom for others considering a journey similar to theirs. When considering their thoughts about how to accomplish a task such as this, the notion of teacher and student success became pervasive throughout their comments. AM spoke about the importance of letting go of the reins and allowing the kids to explore in the classroom to seek out knowledge.

> So they have to be willing to let go of the reins, they have to be willing to let kids explore and not have all the answers. It's okay not to have the answers. So they just need to have that same kind of attitude that … we're going to try all this. If it doesn't work out, what are we gonna do differently to make this successful?

AM also highly regarded the importance of being a team player and enjoying the collaborative approach that interdisciplinary learning can provide. KM indicated how important it was to not be afraid of failure and to keep pushing to make the content as relevant as possible.

> If you're talking about project-based learning, do it [the right way], and don't throw in a little fluff project. I know in the education world it might be hard to do

> that 100% of the time. … Venture out, be creative, and just make it as real as you can make it.

MS spoke about how crucial patience was throughout their process. She indicated they were willing to learn from their failures and try anything to see the student success they desired.

> They know we're not perfect. We're gonna make mistakes. You can get past the mistakes. It's okay. And sometimes some things that we try might not work the best the first time. Sometimes it'll be a disaster and sometimes it'll be great. And just having enough confidence in yourself to accept the failures, and to learn from them and move forward is, I think, a necessity of a quality of a person in a STEM instructor. You want the same quality to be in your students. You want them to be able to fail and learn from those failures and then take the next step.

Her emphasis was constantly on remaining methodical in the implementation of STEM to realize success in the classroom. “It's a slow process. Don't try to rush it. Start small, dream big.” As a leader in the building, DW spoke to not forcing an agenda during implementation. He hinted at a potentially unsustainable direction if there are too many issues while a program is trying to get off the ground.

> To get it off the ground taking the whole school into account, knowing that it is important to take into account the effect on other areas. If it starts to grow and take root, you can also be negative [regarding the impact on other areas in the school]. … Eventually, it might be unsustainable if you hit too many landmines.

If starting from ground zero, MS described how to start a long journey: with a single step.

> Be patient, open your doors, and just be willing to try anything. Find a person, start with one who you can get along with, and you mesh well personally. And then, regardless of the subject area, start looking at your standards, try and make some connections and then just build it.

A Progressive Program Pedagogy

This final theme considers the teachers' and administrators' views of the progressive nature of their classroom instruction and the effect they perceive it has on the students. The progressive pedagogy evident in the STEM program involves experiential learning through the various PBL activities the program provides, self-directed learning when progressing through application-based content with collaborative group members to solve problems, and the iterative nature of learning through showing learning by mastery during the interactive components of the classroom experience. The teachers in the STEM program at the school are staunch supporters of what the program has accomplished in the last several years and believe in the product resulting from their hard work.

In conducting classroom observations, Gilson and Matthews (2019) concluded students' learning environments involving hands-on approaches, inquiry-based teaching methods, student collaboration with peers promoted high quality teacher/student interactions, leading to student growth through appropriate classroom rigor, promoting the importance of learning from mistakes, and promoting students to become better critical thinkers. STEM education contributes to a student developing creative thinking, problem-solving skills, innovate thinking, and the ability to critically consider sources and information to integrate with the most concise fashion through an inquiry-based learning approach (Ertmer et al., 2014; Thibaut et al., 2018; Yildirim & Turk, 2018). These characteristics were all prevalent during the course of data collection and analysis. Teachers within the program spoke often about the value the students gain when learning from their mistakes in class and working together to solve meaningful and relevant problems in the classroom. All five participants provided insight into the pedagogical approach within the STEM program at the school. The nature of the instruction in the STEM classroom provides the STEM program with its identity within the school. Teachers in the STEM program consistently sought ways to implement critical thinking and an integrative STEM approach to encourage students to become active problem-solvers.

These efforts are consistent with studies where the researchers determined these unique situations help students develop positive reinforcing thoughts about their work (Gulen, 2018; Lesseig et al., 2016; Lin et al., 2018). By being placed in these particular learning situations, students can develop the ability to analyze real problems and use their knowledge from multiple disciplines to create a live scenario. Key insights within this theme include the development of the program's structure and culture, various views within the classrooms of the STEM program, the components of the program that cause it to stand out within the school, and the importance that is placed on building relationships with the students in the program.

The seeds of the STEM program were planted years before actual implementation took place. This development began, according to MS, through learning-by-doing in the classroom.

> I never even used a drill until I had to teach my students how to use a drill. So, I have learned a lot as a STEM teacher, just as much as my kids, because I have never had, I don't know if I could do what I'm asking my students to do, to be honest with you. When I was their age, there's no way I could have done it because I didn't have the support in the background that they have now received but I mean the problem-solving skills that they have to use with [the] engineering design process that we forced them to do, is something that I have learned through building a STEM Academy…

Over time, the expansion of the program into other subject areas was slow but steady. What started only as Chemistry and ELA started to include mathematics as well.

> Then I started doing it [collaborating] with my math teacher across the hall and so we'd do something with all three of us together and then we'd expand to a history teacher and so we just began to open our doors. That's when the beauty in the magic started happening.

DW spoke about the initial development of the program and how important it was to protect the school's vision of "Success for All" throughout the process.

> I'll tell you it's gotten more inclusive, and I like that because it's just better for the whole school. Right? Success for all, [that's] what we're about. I mean, you've got to protect that. If you don't, it'll never really be good for an exclusive elite group of kids, and you get the wrong board member, the wrong parent out in the community that's like, "They're just doing all this just for the VIP kid" and then it could shut down and go away quickly.

DW also spoke to the level of trust that outsiders have for the teachers in the STEM program and how that trust enables them to accomplish their goals.

From a cultural standpoint, MS described the program as being “fun, challenging, collaborative, and student-centered,” echoing the other participants’ thoughts about the program. The classroom experiences echo a shift that takes place, as multiple participants mentioned, of a gradual release of control so the students can take ownership of their learning. MS described such in her science classroom.

> We still have those times [of traditional instruction] because you know that kids need to learn how to take notes. So, we still have some traditional aspects, more so in the fall semester, and [in the] spring you hardly ever see us at the board. We usually introduce things, introduce topics, and then, boom, they're off to work, they're off to the races. So, it comes, you know, it starts out a little more teacher-centered, and you teach them how to work together, you teach them those group skills and how to collaborate with each other, how to be team leaders, how to be team followers, how to be team players. And you know as you get on towards the end of the year you reach a point where (and now we always love this time of year) we can sit down, and we can relax. Now we can let them run with it. So, we’re trying to make them [become] the owner of their knowledge and learning.

By taking ownership of the learning, sometimes the students experience the struggle in a more pronounced way. AM described a similar struggle in her classes and how the students could become overwhelmed with determining the direction they choose to take their work.

Our first unit is on religions as well as the chemical and physical properties of buildings and how you're going to build a structure that reflects that religion … We read *The Alchemist* which ties in three world religions, and then they did projects researching … six to eight world religions, and then they had to read a piece of the sacred text and then tie that back into what was valued in the religion. They also had to research the kind of structures that their religion had … So they looked at the chemical and physical properties of the things that they might use to build a structure that fit that religion and they have to design and build it, not out of the structure, not out of those components because some of them are obviously not reachable, but they might 3D print something. They might build something out of wood or whatever it was, so they had to come up with this large presentation at the end that shared all of these things in a succinct way with outside judges who are experts in world religion, and some of the physics and chemistry parts and, you know, they were very, very daunted by that task because most of them were like I don't want to talk to anybody, much [fewer] people I don't know, and so it's pretty challenging, but they have little pieces along the way.

AM also spoke about the importance of grading the students very tough but allowing opportunities to fix their work so they could ultimately see success in the end.

Grade 'em hard. Be super rigorous, don't just give them something because they turned it in. There's no effort here. If you did it wrong, you're gonna fail. You got to do this right. So, ride them just as hard as you would, you expect them to do it right, knowing they're not going to get it all right because they don't have all those

> skills yet. But you're going to see where they are, and then you're going to be able to teach them the skills they need to do better. … And then they get the grade, it's not [an] average. They get a new grade, and if they need to do it three times or four times, that's fine too. So sometimes you're doing that first essay in December, again, and you're so tired of reading it, but they finally got it. So, it's kind of nice. [It] happens less and less as you go on, and same with the science test they would get corrections on. They have to come in and do those, they didn't have to make corrections, but you would expect them, they will because they don't want a bad grade. So, just making sure that they get a realistic idea of what they know and don't know, and then let them fix it because very seldom in life are you not going to get a redo. If you fail your driving test, you're gonna go take it again until you get your license. Failed the bar? You're gonna go take it again. So … they're not going to move on because they didn't get the first part, they need to get that before they go on.

The teachers in the STEM program place their emphasis on allowing students to learn through mastery, rather than just performance. In some cases, the mastery may take three or four or five opportunities. Other times, mastery may be achieved much more quickly. Regardless, allowing the students to work through their struggles and failures on their terms helps the teachers mold the students into the type of students they want to produce.

KM describes one of the outputs of this educational approach in that “they're learning some life skills that will never leave them.” These life skills include the ability to communicate with professionals and experts in various fields. AM spoke about using her classroom as an outlet to develop these skills.

> Communication skills were the most important, being able to stand up and give a presentation with all the good things that we know they should do: making eye contact, talking loudly enough so everyone in the back can hear, and having the presentation go along with that, having the gestures, making sure that they didn't have too much on a slide. You know, we said 10 words [on] the slide is more than enough. And so that's hard for them. And so, I started learning how pictures tell a better story. So, communication skills for me, [are] really important.

JH described the importance of using her classroom to teach the kids how to "succinctly communicate" in the classroom.

> But, again, I think I've had to take a step back and look at what that means to be an English language arts teacher in a STEM program. We know we're definitely not the norm. So that's why I think, you know, my focus shifted to communication, and teaching them to be critical thinkers, critical readers, and learning how to communicate effectively, and I tell kids all the time technical writing is the most difficult writing I've ever done in my life, in my life, back when we had a software company, and I was responsible for the … technical manuals on the software. That is some very difficult writing because in your head like you asked me right now how to bake cupcakes, and I'd be like measure flour measure sugar, you know [because] I've done it so many times, but when you're writing that out you have to be very specific. You need to be very clear in your instruction and so you know we do some of that type of writing and that practice writing on telling people how to do things because you are an engineer or whatever it is that you're going to be doing, you're going to tell people how to do

> things. And so, my work, so to speak in this realm is communication is really what I focus on.

The emphasis on using the teaching standards to guide instruction but not dictate it is profound. These teachers have found a balance that works for them and their students. This balance involves having the students generate a deep understanding of what they work on from every facet possible.

The practice within the program stands out on its own in providing a unique classroom experience for the students. This approach, according to DH, involved the school setting its terms for implementation.

> …I've been in a position since the beginning of this with other people that are not tying our hands, and it's a team approach that I feel like we've made it together, and I think we were able to have the freedom to be able to do these things and just make something as a blank slate and write it however we want to.

They focus on reinventing education for these students in a way that makes them better prepared for the next step after high school. DW continues to describe the individualized approach from the STEM director that each student is afforded in the program as well. "[The STEM director] meets with all of those students regularly. And she's pretty straight with them. She knows and she's worked with them for four years." This work includes helping them determine their wants and needs while a student is in the program, almost acting as a specialized counselor. JH acknowledged that relationships drive the program. It starts at the top with the principal and how he approaches every student in the school.

> And I do feel like [he] does a great job as the principal of holding the expectation. Meeting the individual needs of the student at that moment … But also, still

> engaging the student body. They love him, you know, and he's created a relationship with most of the students.

This level of communication is established from the beginning, even before the students step foot on campus as freshmen. The teachers in the program approach the students from the perspective of doing what is best for them and keeping their trust. JH spoke to this point.

> We've had lots of conversations as faculty about students as consumers because they really are consumers, they have to have faith in what we're selling. You know, one of the things I think about all the time is that education is changing. And there are lots of avenues for kids to get an education.

As a result, the teachers push the boundaries of engaging their students uniquely, giving them the freedom to become owners of their education. They understand that every moment is vital while in class, but sometimes priorities need to be adjusted to consider the bigger picture. As DW describes it, the program is “pioneering, engaging, empowering, inclusive, rigorous, and accelerated.” All of this is due to how the teachers approach the students. The teachers push beyond what the traditional classroom expects, including all students to become owners of their learning in a rigorous and accelerated manner. The soft skills such as communication developed in each student only further strengthen each student’s ability to become a truly well-rounded individual.

A final point of emphasis when considering the progressive nature of their STEM program is the emphasis placed on building relationships within the program. Not only do the teachers emphasize a student-centered and rigorous approach, but they take the time to build a relationship with the students to support them in their journey through the program. During her time with the students in the STEM program, AM recalls the feelings developed because of the time spent with them.

> …I've connected with them somehow in some way and so those, those are success moments for me that they remember [me]. So, they come to find me when they need something related to English, you know, they're like, "How can we do this?" and so, they're good kids. I just like it. They asked you for those letters of recommendation for their schools and their scholarships because they know that you know them. It's not going to be a form letter, you're going to tell them specific examples of how this kid is a critical thinker or how this kid did [something significant], so I can write those letters for the STEM kids because I know them. You get to know them and you know their strengths and weaknesses and you can tell them, even to their face, what they're good at and what they need to work on, but they know that already because you already critique them in class. So, it's just you get really close to them. And I think that's a huge part of the STEM program is that sense of family...

When describing the relationship that MS has with all of the students in the program, AM put it this way:

> …they felt special, because we celebrate them, and we do so much for them and with them. They become family. They call her momma [the STEM director]. They sure do. She's like, another mom, and I know they can go to her because she's our STEM director, they see her a lot more than anybody else.

JH spoke often about taking the time to sometimes help the students work through difficulties they were facing on occasion.

> You know, they had had a really, really rigorous physics test the block before. And then we were going to pound out some annotated bibliography stuff. And I was just looking at their little faces. And I'm like, they don't need this right now. What they need right now is just a moment … so I just said, okay, guys, we're gonna scrap that today. We're not gonna do it, and just tell me what's going on. You know, but I think that's just the counseling background.

Without collaboration, communication, and flexibility, these occurrences do not happen. Traditional high school teachers teach in their classrooms and focus on their needs day after day. These teachers, on the other hand, are constantly assessing the landscape, viewing the horizon, and adjusting to whatever may arise.

Chapter Summary

This chapter discussed the primary themes obtained from the analysis of data collected from participants throughout the study. The lived experiences they willingly shared with teachers and administrators in a rural Georgia high school with a state-certified STEM program were engaging, and authentic, and spoke to their perceptions of how STEM can work in a smaller school setting. Through data analysis and a review of the literature, three final themes were determined from an analysis of the original research questions and are the findings of the study. Each of the themes were identified from an intense analysis of interview transcripts and the associated audio recordings, collaborative planning documents, and my personal reflections throughout the analysis process. The participants' responses throughout the interview process gave me an in-depth understanding of the personalized approach the participants have taken in developing and establishing a certified STEM program and how this STEM program has positively impacted student growth at the high school level. The three major themes were identified following data analysis include the importance of peer collaboration, goal setting and success for all, and a progressive program pedagogy.

The participants spoke of the nature of collaboration and communication necessary between both teachers and students to generate program success. An analysis of the data confirmed that communication between teachers and administrators greatly influenced their ability to work as a cohesive unit for the benefit of the students. Although it seems as though collaboration has always been second nature to the teachers, it is possible that, as was mentioned regarding the implementation of the program, collaboration was introduced and successfully developed over time. The levels of collaboration allow for the teachers and administrators to set appropriate goals for students to realize the success that the teachers and administrators believe is achievable. Finally, the constant striving to develop and implement a progressive approach in the classroom drives the faculty at the school. They believe the change they are enacting is for the sake of the student and better prepares their students for the future workplace.

Each theme provided in the analysis was generated using the participants' own words. It was important to weave all the participants together throughout each theme to provide a complete picture of how each participant views the STEM program but to also show how the teachers and administrators at the high school are effectively working on the same page and striving to achieve designated goals within the program. It is also important to underscore that each of the themes specifically developed from the data emerging from the totality of the study.

Chapter VI

DISCUSSION AND CONCLUSION

The purpose of the study was to determine the strategies and practices used by school personnel responsible for increasing student science proficiency in a certified rural high school STEM program. In Chapters One and Two, I introduced the difficulties surrounding the preparation of students for careers in STEM fields, leading to issues in students competing for high-paying jobs in the global economy. The literature addressed the benefits of embracing STEM-focused pedagogy through problem solving, inquiry-based learning, and cooperative learning. In Chapter Three, I presented the research design and methods for data collection and analysis. In Chapter Four, I shared a detailed overview of the STEM program at the selected school and each of the five participant's portraits detailing their involvement and experiences within the STEM program. In Chapter Five, I analyzed the data and identified key themes from the data. In Chapter Six, I discuss the findings and implications, make recommendations for future research, and bring the dissertation to a close.

Science and STEM education are becoming more emphasized in classrooms across the United States so as to better meet the needs of citizens in the 21st century (Nadelson & Seifert, 2017). In Georgia, the Department of Education (GaDOE) developed certification protocols for schools desiring to implement STEM pedagogy in their classrooms. However, among STEM certified high schools, there is a disproportionately low number of STEM programs in rural communities as compared to their urban and suburban communities. This study examined the life and educational experiences of teachers and administrators working in a rural Georgia high school with a STEM program certified by the GaDOE. The purpose of the study was to determine the strategies and practices used by school personnel responsible for increasing student science proficiency in a certified rural high school STEM program.

I conducted this study at a rural high school in Georgia, recognized as one of the few certified high school STEM programs located outside of the large metropolitan regions around the state. I recruited five teachers and administrators to participate in this study. As the researcher, I intended to build an understanding of the characteristics and experiences in a certified high school STEM program to develop an understanding of how a successful STEM program functioned on a daily basis. I interviewed each of the participants as I sought to make meaning of their experiences and determine what practices within the program impacted students the most. I conducted this study to answer the following research questions:

RQ 1. What were the lived and career experiences of school personnel who were responsible for increasing student science proficiency in a certified rural high school STEM program?

RQ 2. What strategies were used by school personnel who were responsible for increasing student science proficiency at a certified rural high school STEM program?

RQ 3. What practices were used by school personnel who were responsible for increasing student science proficiency at a certified rural high school STEM program?

I used purposeful sampling to interview five participants actively involved in a rural Georgia high school certified STEM program. Once the participants were identified, I conducted interviews using Seidman's (2006) series of three interviews over a four-month period of time. I met participants at the school and conducted interviews in classrooms or offices. The purpose of interviewing was to learn from the perspectives of each participant and their experiences in the STEM program at their school. Throughout conducting interviews, I constantly reflected upon my purpose in the study and sought to learn about the experiences of each participant through a conversational interview approach. By reminding myself that they were successful experts in their respective fields, I maintained control of any of my personal biases or subjectivities.

Data were transcribed using the software Otter, which is capable of audio recording conversations and transcribing the audio into text. I then compared the text to the original recordings to ensure the accuracy of the transcriptions. Data analysis began with a reduction in the interview transcripts to identify the meaningful data that spoke directly to the STEM program being researched. Following the completion of each transcript, the documents were converted into Word files, printed out, and hand-coded using highlighted colors to indicate the types of code used (in vivo, emotion, process) for each participant. Through continued analysis of the codes highlighted, I identified and developed specific commonalities among the assigned codes. I then grouped them into various categories by participant, ultimately becoming the headings for each portrait. These headings or categories were then used across all five participants to identify significant themes from the data collected. By connecting the data across all participants, cross-case comparisons helped to establish relationships between categories and ultimately develop cogent themes that qualify the data and help to derive meaning from answering the research questions.

The findings of this study are discussed within the themes I constructed from the data I presented in Chapter Five. In this chapter, I interpret the findings and apply them to answer each research question, discuss limitations that impacted the study, and discuss implications for future research. I also make recommendations for those interested in developing a STEM program in a rural school environment based on personal experiences as a researcher and an educator currently implementing STEM pedagogy in my school.

Research Questions: Final Discussions Summary

Each of the research questions aligns with the findings in the identified themes of the results of the study. RQ 1. What were the lived and career experiences of school personnel who were responsible for increasing student science proficiency in a certified rural high school STEM program? The results from the study align with the literature (Alsbury et al., 2018; Sebastian et al., 2016; Tofel-Grehl & Callahan, 2014; Wang et al., 2020). Each participant had decidedly individual life experiences on their way to becoming an educator. There was no consistency regarding socioeconomic status or whether they entered the education field through a traditional means (college major to become an educator) or nontraditional means (noneducation major starting in the workforce). All five participants did, however, come from homes that valued education and were supportive of their academic pursuits. Each participant spoke about aspects of school that they enjoyed as a student and felt they thrived in. AM did not feel confident when discussing her prior math experiences but was decidedly more so when discussing her relationship with English Language Arts. KM spoke to the relevancy he found in industry when describing the usefulness of CTAE instruction. His background in the workforce and appreciation for always building something motivated him to seek ways to make these instructional approaches more meaningful for students. MS always gravitated toward the sciences and ultimately found her calling in educating others and the relationships she can build through these interactions. All five participants showed in the study that their academic experiences as students shaped their careers.

Another commonality involved the positive outlook and approach that all five participants shared regarding their jobs and the school. The positive outlook the teachers shared aligned with McConnell's (2017) study regarding the importance of leadership supporting teachers to maintain positive morale and culture within the school. Each participant spoke at length about the aspects of their work they enjoyed. A prime characteristic of the teachers in the STEM program was a sense of family. They treated each other respectfully and with a positive mindset. Their ability to work together as a cohesive unit was a testament to the closeness established among the individual teachers and administrators in the program. The development of such a close bond indicated the trust cultivated over time. This characteristic, according to multiple participants, was pervasive throughout the school. Bruce-Davis et al. (2014) found that teachers appreciated academic and practical support in the classroom and this support helped to foster a sense of family among faculty and students. The sense of family that the teachers in the STEM program exuded spills out to their students as well. JH referred to MS (the STEM director) as the "momma" of the STEM program. She indicated this relationship is built from the time she spends developing rapport with each student and her looking out for their needs. JH saw each teacher in the program filling a familial role, from mother to father to the "crazy aunt." As several participants alluded to, the sense of family in the program is very appropriate, with the smaller, rural community acting as the backdrop of the school. Participants commented that the community is tight-knit in nature and loyal. Capitalizing on this closeness was a vital experience that the teachers and administrators in the program experience daily.

Throughout interviews, each participant spoke of the STEM program and the work being accomplished with a sense of pride and ownership. Despite each participant's varied backgrounds and personal preferences, the commonality they shared within the STEM program always kept them smiling and joyous throughout each interview. The nature to which they spoke of their work and how it affected them individually confirms the positive relationship each participant felt as a part of the program. When considering each participant's experiences as a part of the STEM program, the development and maintenance of a pervasive positive environment were challenging to ignore, especially in education. Difficulties in any public school setting will exist and be problematic for teachers. However, the participants in the study never felt the need to vent or unburden themselves of the stresses of their job. They admitted that students will make poor choices from time to time, and they witness those decisions, but the overall positivity of the school and especially the program sustained them daily.

RQ 2. What strategies were used by school personnel who were responsible for increasing student science proficiency at a certified rural high school STEM program? Within the scope of this study, a strategy was defined as a plan of action or policy designed to achieve a principal or overall aim. Several strategies were identified from the study's results, including deliberate and constant communication among educators, a consistent dedication to keeping the content relevant to real-world application, a pervasive focus on daily interdisciplinary instruction, and maintaining a unified front and approach toward the students. The strategies and practices uncovered in the study are linked together in that the practices illustrate how the teachers and administrators execute their designated strategies for success. In addition, the strategies uncovered align with the findings from the literature review (Ertmer et al., 2014; Gulen, 2018; Havice et al., 2018; Lesseig et al., 2018; Lin et al., 2018; Wang et al., 2020; Yildirim & Turk, 2018) emphasizing collaboration, maintaining a unified vision, and implementing a unique and progressive pedagogy for students. While I have addressed each of the strategies employed by the participants in the study here, the associated practices will be further explained in the discussion around research question three.

One key strategy of the participants in the study involved educators being deliberate and constantly communicating with each other. This constant communication was realized in teachers working together to see a school or program's vision become a reality (Alsbury et al., 2018). Wang et al. (2020) focused on the importance of teachers working together to develop a cohesive curricular roadmap by working in unison. The STEM program at the research site was built upon educators working together and working in harmony. As teachers within the STEM program, MS, JH, and previously AM often spoke of the importance of working together and being on the same page when teaching the students. This approach requires them to express their thoughts clearly and often when determining how to facilitate instruction in their classes. Teachers in the study noted that all communication was valuable, whether that involved a detailed sit-down meeting or just a quick conversation in the hallway to check the progress or timing of a project. Based on the data, this constant communication trend was bolstered by the comradery developed between the STEM program teachers.

Teachers in the STEM program also portrayed a consistent dedication to keeping the content relevant to real-world applications. Eastwell (2002) indicated the importance of building a better understanding of content through classroom experiences being designed and placed in the proper context with outside influences, such as job-readiness. MS spoke at length about why the content relevance was so crucial to the outcomes they all wanted from the students. In addition, there was an intense desire on the part of the teachers to prepare these students for immediate work-readiness while in high school, regardless of their plans following graduation. Developing job skills and teaching critical thinking was an integral part of what the teachers tried to accomplish with their students in the STEM program. In addition, they made sure that projects or activities completed by the students tie into the skills or expectations of community members of the workforce.

For content areas to seamlessly blend cohesively, teachers in the STEM program emphasized a pervasive focus on daily interdisciplinary instruction. They believed in the importance of weaving together content areas that fit well together and areas that may not be such an obvious choice. Bruce-Davis et al. (2014) illuminated the importance of proper curricular and instructional strategies, including, “PBL, questioning techniques, inquiry-based learning, guided independent research studies, and discussion groups” (p. 285). These types of strategies were pervasive at the research site. For example, MS spoke about the collaborative projects between geometry and physics, which ranged from PVC catapults to building digital clocks. While those connections seemed easier to integrate, other choices, such as chemistry and literature, were not as seamless. When teachers were provided enough time and collaboration, interdisciplinary projects were designed to bridge literary works with chemistry content focal points to teach the critical aspects. Regardless of the marriage of content areas, each scenario ultimately produced PBL-infused teaching, bridging the gaps between multiple content areas for the student in the STEM program.

A final consideration toward this research question underscores the importance the school personnel placed on maintaining a unified front and approach toward the students. Alsbury et al. (2018) noted the importance of being unified when acting on large institutional change. The teachers and administration at the research site spoke to the careful planning and focus on their priorities to get the STEM program up and running. Considering the difficulty in generating major institutional change that multiple participants spoke about during interviews, these changes were weighed and measured with the entire group working toward successful STEM implementation in a unified manner. DW discussed how early on, recruiting students and getting a clear message out about the STEM program was challenging and was ultimately solved by involving more students in the recruiting process. He believed that students would trust the words of their peers over teachers, and he used this to the advantage of the fledgling program while in development. Grading students' work and class expectations were other aspects that the teachers often mentioned in working to maintain uniformity across classes. AM noted how important it was for the spirit of the STEM program to allow students to work to improve their work and promote mastery constantly. This constructivist mindset is a vital component of STEM-infused pedagogy.

RQ 3. What practices were used by school personnel who were responsible for increasing student science proficiency at a certified rural high school STEM program? Within the scope of this study, a practice was defined as the actual application or use of an idea, belief, or method, as opposed to theories relating to it. The participants utilized many applicable practices to act upon the designated strategies described in prior discussion around research question two and align with data from the literature (Alsbury et al., 2018; Bruce-Davis et al., 2014; Havice et al., 2018; Nadelson & Seifert, 2017; Proudfoot et al., 2018; Yildirim & Turk, 2018). Collaborative lesson planning, program planning sessions, and a dedication to the constant conversation about the STEM program were done to maintain constant communication with one another. Consistent use of community partners and a thorough contextualization of the PBL-focused instruction within the STEM program allowed the participants to dedicate appropriate time and resources to maintaining content relevance to real-world contexts. Content specialists co-teaching in the same classroom and dedicated collaborative planning sessions allowed teachers in the STEM program to focus their instructional time using an interdisciplinary approach. Setting appropriate goals, implementing the school's vision, consistent expectations for students, and individualized student support helped the participants maintain a unified front for the students in the STEM program. Each set of practices will be addressed below according to how they helped the participants achieve their strategies toward success.

To ensure that the school personnel in the STEM program could maintain constant communication, they engaged in collaborative lesson planning and program planning sessions and were generally dedicated to constant conversation about the STEM program in multiple settings. These planning sessions allowed the teachers to develop units and lessons that acted as "…the seamless amalgamation of content and concepts from multiple STEM disciplines" (Nadelson and Seifert, 2017). The teachers at the site knew they needed this integrated approach to provide students with opportunities to thrive academically by the added exposure to real-world problems and the time needed to develop solutions to those problems (Havice et al., 2018). Conversations abounded between teachers that taught together in the classroom. They believed in being flexible in their pacing and content coverage while constantly assessing the effectiveness of their current projects in class. Every nine weeks, an all-day planning session was scheduled for all STEM teachers to attend. This session allowed the teachers to all communicate how they were pushing the PBL initiatives within the STEM program at that current time. Communication was even as quick as a simple conversation in the hallway to discuss current pacing and adjustments needed. The teachers in the program were dedicated to ensuring they often spoke regarding the academic progress within their classes. They believed the conversations were critical to maintaining continuity within the program.

The teachers in the STEM program were also dedicated to content relevance throughout the STEM-specific courses. To promote this content-driven advantage within the classes, the teachers emphasized a consistent use of community partners and a thorough contextualization of the PBL-focused instruction within the STEM program, aligning with the literature in this fashion as well (Havice et al., 2018). As a result of these efforts, the participants found themselves better able to dedicate a sufficient amount of time and resources toward maintaining content relevance within locally inspired real-world contexts. Teachers spoke of regular opportunities to bring in guest speakers from local businesses. These speakers better related the content from the classroom to real-world scenarios. Field trips were the norm for STEM students as well. These trips were focused on content application, such as visiting the local hospital. All contact outside of the school was intended to reinforce the teaching within the program. PBL projects were sometimes graded by these very business leaders in the community. The teachers in the program believed the level of authenticity in having local tradespeople and business owners judge and grade products of final projects was a step in requiring authentic accountability on the part of the student for the quality of work they produced.

Interdisciplinary instruction, a core tenet of STEM pedagogy, remained a key focus for teachers in the STEM program (Thibaut et al., 2018). Content specialists were assigned to co-teaching in the same classroom simultaneously to push the narrative of blending coursework in a symbiotic manner. The teachers and administration within the school believed in bringing these content specialists together to create an immersive learning experience incorporating multiple subject areas. Dedicated collaborative planning sessions were organized to allow teachers in the STEM program to focus their instructional time using an interdisciplinary approach. These planning sessions varied from once-a-week meetings that may last from 15-30 minutes to all-day sessions once every nine weeks to determine what major PBL activities were planned and implemented in the STEM-specific courses. All of these choices made within the program showed further evidence of a conscious effort on their part to implement best practices on a day-to-day-basis (Alsbury et al., 2018). Depending on the current need, the teachers worked to meet with each other to ensure the instructional methods in the STEM classes were timely and effective for the projects being implemented.

The school personnel involved in the STEM program worked hard to develop a unified front and approach toward the students in the program. This endeavor was accomplished by setting appropriate short-term and long-term goals for students, implementing the school's vision of "Success for All" across the program, maintaining consistent expectations for each student, and providing individualized support through various means. High expectations were generated and maintained throughout the school, including the STEM program. Students were expected to work hard for their grades, and the teachers required a high level of effort. Teachers and administrators expressed the importance of equity across all groups in the school. Goal setting was also a vital part of the program. Students would learn to develop goals on a short-term basis early in the program, such as organizing time to finish a major project by the due date. Long-term goals were pushed as students progressed through their high school experience, including collegiate applications and internship opportunities while in school. The students were a part of the program because they valued how the instructional content was delivered. They enjoyed an inquiry-based approach and the challenges associated with it. For these students, completing this academic pathway was an indicator of achieving success and then taking that success to the next level, whether a four-year college, a technical college, or directly into the workforce based on their internship opportunities while in high school. Regardless of a student's desires, the teachers in the program worked hard to ensure all students were given the tools needed for success.

Implications and Discussion of the Study

The parameters of this study focused on the experiences of five teachers and administrators at a rural Georgia high school with a GaDOE-certified STEM program.

The participants in the study each had direct knowledge of the day-to-day operations of the STEM program and were interviewed to understand better the strategies and practices utilized daily within the STEM program. Findings from this study present implications for teachers and administrators at other rural high schools who desire to implement an interdisciplinary, project-based learning (PBL), or STEM-focused approach at their schools. Practitioners at other schools may better understand the lived experiences of teachers and administrators who have successfully navigated the STEM program certification process and how these experiences impact their decision-making regarding the strategies and practices utilized daily in the STEM program. By examining the lived experiences of teachers and administrators from the study, a better understanding of the positive and negative consequences of systemic change within a school may be developed and applied to other school settings. Although the study sought to examine the positive characteristics within the selected STEM program, examining the challenges the participants spoke about may provide a more comprehensive picture of how a STEM program may affect a whole school setting.

Three major themes were identified: *the importance of peer collaboration*, *goal setting and success for all*, and the *progressive program pedagogy* found in the STEM program at the school. The themes generally encapsulated the answering to all three research questions. The narratives on the importance of peer collaboration, goalsetting and success for all, and the progressive program pedagogy found in the STEM program provides context to the participants' experiences within the school and the STEM program. Each of these themes must be considered through the lens of rural program implementation and the successes the research site experienced while navigating the development and eventual certification of their STEM program.

These themes answer Research Question 1: What were the lived and career experiences of school personnel who were responsible for increasing student science proficiency in a certified rural high school STEM program? The data suggest that the participants frequently implement each theme in their daily practice. The themes act as an outline of how the participants approach their jobs concerning the STEM program. They consistently work together, set and maintain success goals, and use progressive instructional strategies.

Research question two focused on the strategies the participants used to increase student achievement in the STEM program. The three themes developed from the data explicitly describe the strategies enacted in the program. The teachers believed that constant and effective collaboration was vital, they established goals for students to reach, and they believed that all students could realize success in the program. They worked to accomplish these ideals through a progressive pedagogical approach.

The practical application of each of the three themes answered research question three, which asked about the specific practices the participants used to achieve success and improve students' science proficiency within the program. A unique relationship between research questions two and three exists in that the practices implemented by the participants in the program specifically address how the strategies were applied. All three themes provide insight into the STEM program's practices implemented by the teachers and administrators.

The results of the study in the form of detailed identified themes, lived experiences described, and strategies and practices articulated indicate the methods of success conducted by the teachers and administrators in the STEM program at the school. The data in the study confirmed much of what the literature has already identified in previous studies from various settings as cited within the literature review (Alsbury et al., 2018; Baker et al., 2015; Gonzales et al., 2014; Havice et al., 2018; McConnell, 2017; Wang et al., 2020; Yildirim & Turk, 2018). The critical difference between this study and any prior is the deliberate focus on successfully implementing a high school STEM program within a rural community.

It is vital to consider the accomplishments of the STEM program at the research site considering the challenges faced by rural schools in education today. In rural schools, there are perceived barriers to higher education due to an insufficient number of advanced and STEM focused courses offered at the high school level (Henley and Roberts, 2016). The authors also noted rural areas tend to lag more developed regions regarding industries embedded within the community. Stipanovic and Woo (2017) also recognized that rural schools have fewer course options for students to choose from, and students in their study confirmed this fact. Despite these potential limitations, the research site teachers and administrators were successful in overcoming these potential obstacles. They found a partnership with a local college for adding dual enrollment courses at the school to accelerate students within the STEM program. They showed a continual sense of flexibility in using the resources that were available instead of dwelling on the resources that were missing.

Another key point of emphasis when looking through the lens of rural school implementation is that no two rural communities look alike. The resources available in one community will not mirror another. Alsbury et al. (2018) brought to light that since rural schools do not fit many traditional models and can be unique in organization, there cannot be a single one-size-fits-all model for STEM curriculum implementation. Instead, a customized model for each school must be considered. These data are in direct alignment with the GaDOE model of STEM program implementation. The GaDOE believes that STEM program implementation will be unique at each school location and be determined by the resources and community partners available to supplement interdisciplinary instruction (STEM/ STEAM Georgia, 2019). The methods of recruitment to a program such as this must match the interests of the student body. Ertmer et al. (2014) posited that students within a rural school striving to implement STEM successfully appear to react in a more positive light when they can identify the relevance between the classroom activities and the local economic landscape. This same economic landscape will vary from one community to another. The teachers and administrators at the research site knew their community and how to present an educational option for the students that would directly impact the community in a positive manner and generate buy-in from local stakeholders.

The challenges of small, rural school systems can be narrowed down to specific issues, such as a lack of meaningful educational funding and resources, falling populations, and continual problems in hiring and retaining qualified teachers (Goodpaster et al., 2018; Payne et al., 2018). With population densities ever increasing in urban and suburban areas, these issues will not be reduced in the near future. Rural schools must do their part to make themselves attractive for potential teaching candidates, especially at the secondary level in math and science disciplines when many students develop a genuine appreciation for STEM related content (McConnell, 2017). Administrators within rural school systems must remain vigilant against these factors that can weaken a school's or program's ability to effectively instruct students. Also, these apparent challenges serve as a call to maintain a sense of proactivity in keeping quality educators in the building to ensure the education students are receiving will continue to remain at expected levels of excellence. My time with the teachers and administrators at the research site proved they are ever aware of the changing landscape around them within their community and are constantly working to maintain a level of excellence in their school. The development of the CCA proves they are listening to their community partners and attempting to mold the educational experience into one that will potentially have the greatest impact on the community for years to come.

The results of this study could hold relevance for administrators that seek to implement a STEM-focused pedagogy for a portion or all their student body. As leaders in their respective schools, these individuals may glean understanding from the participants' experiences in the study and find commonalities with teachers in their schools. Suppose administrators are willing to accept the developed themes from the study and find ways to implement these approaches within their schools specifically. In that case, they may see increased teacher collaboration working toward building advanced levels of science content knowledge in their students. Despite the identified themes specifically addressing success in a rural school environment, it is possible that the lived experiences of the participants, the strategies they developed, and the practices they demonstrated may not provide support for other practitioners seeking to implement a STEM-focused approach in their schools.

Limitations of the Study

Limitations within a study must be identified in qualitative research to provide authenticity and trustworthiness to the data collected and conclusions drawn (Patton, 2002). Although purposeful sampling and Siedman's interview process yielded quality participants and rich data, the lack of other participants impacted the depth of the results (Patton, 2002; Siedman, 2006). Participants included five teachers and administrators with roles directly linked to the STEM program. Other participants that were active teachers within the STEM program and could speak to the developmental process of the program were initially identified for the study but could not be included for various reasons. Each participant held varying roles within the school, including principal, English Language Arts (ELA) instructor, Career, Technical, and Agricultural Education (CTAE) director, media specialist, chemistry instructor, physics instructor, and STEM director. Other roles involved in the program, including geometry instructor, algebra instructor, and biology instructor, could not be used in the study due to difficulties in scheduling interviews and preferences to not participate in the study. As a result, some data comparisons across participants could not be conducted and could be a limitation.

Data in the study were collected over four months. All participant data provided during interviews were through individual memory recollection on the part of each participant. I presumed all participant feedback was comprehensive and accurate, but I cannot rule out the possibility of unintentional inaccuracies conveyed by any participants (Maxwell, 2013). I met with each participant face to face on campus for each interview except for a single interview for one participant being over the phone due to personal illness. While I diligently strived to keep the interview process casual and conversational, it remains a possibility that my physical presence may have impacted their responses. These factors were out of my control as the researcher (Maxwell, 2013).

Despite these limitations, this study's results may empower other teachers and administrators in rural schools to pursue a deeper implementation of interdisciplinary instruction, project-based learning (PBL), or a STEM-focused pedagogy for a portion of their student populations. By understanding the experiences, strategies, and practices used by teachers and administrators in a state-certified STEM program, education professionals may find ways to better support and increase the proliferation of this instructional approach on their campuses. In addition, this study may be used as a potential framework for other rural schools in Georgia that seek to implement STEM-based pedagogy for their student populations. These results may also help develop strategies for administrators to identify and develop teachers that desire to work in a more interdisciplinary learning environment. Finally, this study may support state and federal policymakers' efforts to provide additional educational reform opportunities that will benefit schools trying to implement STEM-based instructional practices. Additionally, colleges and universities may use the results from this study to consider how teachers are trained and prepared to educate students in an interdisciplinary, PBL, or STEM-focused environment.

Recommendations for Future Research

Opportunities for future research exist following the completion of this study. A more comprehensive sample of participants that covers every aspect of a school's STEM program may provide a more detailed look at the strategies and practices that successful STEM programs utilize in their day-to-day operations. STEM programs from rural, suburban, and urban regions could also be studied to search for commonalities in their successes. Additionally, time spent observing teacher-student interactions during the school day within a rural STEM program would powerfully work to illuminate critical strategies and practices that successful STEM programs utilize in their day-to-day operations. Student feedback, including the differences between male and female students or across multiple ethnicities, may help ensure that schools provide equitable opportunities for all demographics represented in a school's population. As a different approach, a study on up-and-coming STEM programs seeking GaDOE certification may shed light on how schools attempt to shift their instructional practices to focus on an interdisciplinary approach and the possible pitfalls that may arise. Through these varied approaches, future practitioners may glean other qualities of a thriving rural STEM program and implement such instructional strategies more efficiently.

Final Conclusions

Within the United States, significant difficulties exist in adequately preparing students for careers in the STEM field, especially in secondary education (McMullin & Reeve, 2014). Businesses and educators alike have vocalized the need for a more intense focus on meeting these areas' future economy and job market (Boe et al., 2011). The Center for Advanced Communications Policy (CACP) for the University System of Georgia (USG) identified a significant discrepancy in the number of students graduating at the collegiate level with STEM degrees and the number of STEM jobs available in the state with the STEM jobs vastly outnumbering the degrees earned (CACP, 2017). Despite this knowledge, the implementation of STEM in schools has not shown uniformity within Georgia. Compared to their rural counterparts, schools in urban and suburban areas show more success at meeting the state's criteria for STEM certification (STEM/ STEAM Georgia, 2020). Margot and Kettler (2019) determined that there is currently insufficient information in the literature to adequately understand what effective implementation looks like in a rural school. They further concluded the need for additional research in rural, suburban, and urban settings involving diverse student populations to learn more about appropriate implementation strategies with STEM (Margot & Kettler, 2019). This study gave five participants from a rural Georgia high school with a GaDOE-certified STEM program a voice in describing their lived experiences and the strategies and practices they implemented to raise students' science proficiency in the STEM program.

Findings from the participants revealed critical characteristics of their experiences working within the STEM program. First, to highly impact the students within the program, the teachers and administrators work to identify key strategies that will yield the most significant impact on their students, including constantly collaborating, working to maintain a common goal and focus across the program, and teaching the students through progressive means. Following the identification of these strategies, specific practices are utilized daily by the participants. Second, communication is maintained by setting aside regular times to meet for both short-term and long-term planning. Informal meetings also happen regularly in an impromptu fashion, indicating the desire and focus the participants have in maintaining success within the STEM program. Third, due to their constant collaboration, the teachers and administrators can better create a singular and unified vision and set of goals for the students and work toward helping them become successful based on these goals. Finally, the progressive nature of their pedagogical approach in the classroom is realized through strategies such as inquiry and project-based instructional formats that heavily emphasize applying knowledge in realistic contexts.

The participants in the study all showed a strong sense of pride regarding their work in and around the STEM program. They found value in their work to better prepare students for the next step in education or the workplace. In addition, they valued the real-life context the coursework embodied, from the physics projects that aligned with engineering principles and geometry to the biology courses filled with out-of-school experiences such as visits to the hospital to see the practical application of the content being taught.

Studies in recent years on STEM education and rural schools have justified continued research on this topic and validated the completion of this study (Goodpaster et al., 2018; Gulen, 2018; Margot & Kettler, 2019). It is encouraging that schools such as the one in the study are pushing the implementation of inquiry-based and project-based instruction to help eliminate the workforce trends that have shown a gap developing in the national workforce's ability to adequately meet the needs of an evolving job market due to a lack of STEM knowledge and technical understanding (McMullin & Reeve, 2014). The work of the teachers in the program confirmed within a rural setting the benefits of placing students in academically challenging learning environments to build their critical thinking skills in solving real-world problems (Havice et al., 2018). For students seeking a STEM-related career in life, experiences like these are needed to diversify their abilities and prepare them for the rigors of the collegiate environment and the workplace.

The GaDOE consistently supports schools desiring STEM-focused educational strategies through the clearly outlined expectations of the STEM Continuum Requirements for a whole school or program implementation. The apparent discrepancy of high school STEM programs in the state vastly favors those schools in and around prominent urban locations. Through the completion of this study, I hope that the successful characteristics of a certified STEM program in a rural high school can become more discernable to practitioners seeking a similar educational format for their students. With a better understanding of what makes STEM pedagogy successful in a rural environment, smaller schools can plan for their STEM-focused implementations by focusing on strategies and practices that may expedite the process while simultaneously avoiding pitfalls that either slow or nullify progress made in this arena. As a teacher and STEM coordinator at my school, this journey has enlightened my practice as an educator. I have been able to mold my professional practice based on my understanding of the experiences, strategies, and practices of the study's participants at the high school. My experiences have allowed me to ensure the participants' voices have been heard. My hope remains that their voices will impact others in rural high schools to bring STEM-focused educational practices to their students, as I have been able to do with my students.

REFERENCES

Akran, S. K., & Asiroglu, S. (2018). Perceptions of teachers towards the STEM education and the constructivist education approach: Is the constructivist education approach preparatory to the STEM education? *Universal Journal of Educational Research*, *6*(10), 2175–2186. https://doi.org/10.13189/ujer.2018.061016

Al Salami, M., Makela, C., & Miranda, M. (2017). Assessing changes in teachers' attitudes toward interdisciplinary STEM teaching. *International Journal of Technology & Design Education*, *27*(1), 63–88. https://doi.org/10.1007/s10798-015-9341-0

Alsbury, T. L., Blanchard, M. R., Gutierrez, K. S., Allred, C. M., & Tolin, A. D. (2018). District strategic teaming: Leadership for systemic and sustainable reform. *Research in Educational Administration & Leadership*, *3*(2), 139–177. https://doi.org/10.30828/real/2018.2.2

Alvarado, S. E., & Muniz, P. (2018). Racial and ethnic heterogeneity in the effect of MESA on AP STEM coursework and college STEM major aspirations. *Research in Higher Education*, *59*(7), 933-957. https://doi.org/10.1007/s11162-018-9493-3

Baker, W. P., Barstack, R., Clark, D., Hull, E., Goodman, B., Kook, J., Kraft, K., Ramakrishna, P., Roberts, E., Shaw, J., Weaver, D., & Lang, M. (2008). Writing-to-learn in the inquiry-science classroom: Effective strategies from middle school science and writing teachers. *The Clearing House*, *3*, 105-108.

Baker, M. A., Bunch, J. C., & Kelsey, K. D. (2015). An instrumental case study of effective science integration in a traditional agricultural education program. *Journal of Agricultural Education*, *56*(1), 221–236. https://10.5032/jae.2015.01221

Boe, M. V., Henriksen, E. K., Lyons, T., & Schreiner, C. (2011). Participation in science and technology: Young people's achievement-related choices in late-modern societies. *Studies in Science Education*, *47*(1), 37–72. EBSCOhost Database

Bruce-Davis, M. N., Gubbins, E. J., Gilson, C. M., Villanueva, M., Foreman, J. L., & Rubenstein, L. D. (2014). STEM high school administrators', teachers', and students' perceptions of curricular and instructional strategies and practices. *Journal of Advanced Academics*, *25*(3), 272–306. https://doi.org/10.1177/1932202X14527952

Center for Advanced Communications Policy (CAPC). (2017, May). Advancing Georgia's regional STEM workforce development ecosystem: Preliminary findings. https://www.usg.edu/assets/academic_affairs_and_policy/alc_documents/Advancing_Georgias_Regional_STEM_Workforce_with_Executive_Summary_and_Appendices.pdf

Chiyaka, E. T., Kibirige, J., Sithole, A., McCarthy, P., & Mupinga, D. M. (2017). Comparative analysis of participation of teachers of STEM and non-STEM subjects in professional development. *Journal of Education and Training Studies*, *5*(9), 18–26. https://doi.org/10.11114/jets.v5i9.2527

Christensen, R., & Knezek, G. (2017). Relationship of middle school student STEM interest to career intent. *Journal of Education in Science, Environment and Health*, *3*(1), 1–13. EBSCOhost Database

Dare, E., Ellis, J., & Roehrig, G. (2014). Driven by beliefs: Understanding challenges physical science teachers face when integrating engineering and physics. *Journal* *of Pre-College Engineering Education Research*, *4*(2), 47-61. https://doi.org/10.7771/2157-9288.1098

Eastwell, P. (2002). Social constructivism. *Science Education Review*, *1*(3), 82–86. EBSCOhost Database

Ertmer, P. A., & Newby, T. J. (2013). Behaviorism, cognitivism, constructivism: Comparing critical features from an instructional design perspective. *Performance Improvement Quarterly*, *26*(2), 43–71. https://doi.org/10.1002/piq.21143

Ertmer, P. A., Schlosser, S., Clase, K., & Adedokun, O. (2014). The grand challenge: Helping teachers learn/teach cutting-edge science via a PBL approach. *Interdisciplinary Journal of Problem-Based Learning*, *8*(1), 4–20. https://doi.org/10.7771/1541-5015.1407

Fan, S. C., & Yu, K. C. (2017). How an integrative STEM curriculum can benefit students in engineering design practices. *International Journal of Technology & Design Education*, *27*(1), 107-129. https://doi.org/10.1007/s10798-015-9328-x

Gilson, C. M., & Matthews, M. S. (2019). Case study of a new engineering early college high school: Advancing educational opportunities for underrepresented students in an urban area. *Journal of Advanced Academics*, *30*(3), 235–267. https://doi.org/10.1177/1932202X19840024

Glennie, E., Mason, M., Dalton, B., & Edmunds, J. (2019). Preparing students for STEM college and careers: The influence of redesigned high schools in North Carolina. *High School Journal*, *102*(3), 228-257. https://doi.org/10.1353/hsj.2019.0008

Gonzales, A., Jones, D., & Ruiz, A. (2014). Toward achievement in the “knowledge economy” of the 21st century: Preparing students through T-STEM academies.

Research in Higher Education Journal, *25*, 1-14.
https://eric.ed.gov/?id=EJ1055333

Goodpaster, K., Adedokun, O., & Weaver, G. (2018). Teachers' perceptions of rural STEM teaching: Implications for rural teacher retention. *The Rural Educator*, *33*(3), 9-22. https://doi.org/10.35608/ruraled.v33i3.408

Gulen, S. (2018). Determination of the effect of STEM integrated argumentation based science learning approach in solving daily life problems. *World Journal on Educational Technology: Current Issues*, *10*(4), 95–114.
https://eric.ed.gov/?id=EJ1193780

Havice, W., Havice, P., Waugaman, C., & Walker, K. (2018). Evaluating the effectiveness of integrative STEM education: Teacher and administrator professional development. *Journal of Technology Education*, *29*(2), 73-90.
https://doi.org/10.21061/jte.v29i2.a.5

Henley, L., & Roberts, P. (2016). Perceived barriers to higher education in STEM among disadvantaged rural students: A case study. *Inquiry*, *20*(1), 19–38.
https://commons.vccs.edu/inquiry/vol20/iss1/4

Honey, M., Pearson, G., & Schweingruber, H. (2014). *STEM integration in K-12 education: Status, prospects, and an agenda for research*. National Academies Press.

Johnston, M. P. (2018). Supporting STEM education: Needs assessment of southeastern rural teacher librarians. *School Libraries Worldwide*, *24*(2), 62–79.
https://doi.org/10.14265.24.2.005

Lawrence-Lightfoot, S. L. (1983). *The good high school*. Basic Books.

Lawrence-Lightfoot, S. L., & Davis, J. (1997). *The art and science of portraiture*. Josey-Bass.

Lesseig, K., Nelson, T. H., Slavit, D., & Seidel, R. A. (2016). Supporting middle school teachers' implementation of STEM design challenges. *School Science and Mathematics*, *116*(4), 177–188. https://doi.org/10.1111/ssm.12172

Lin, Y. T., Wang, M. T., & Wu, C. C. (2019). Design and implementation of interdisciplinary STEM instruction: Teaching programming by computational physics. *Asia-Pacific Education Researcher*, *28*(1), 77–91. https://doi.org/10.1007/s40299-018-0415-0

Margot, K., & Kettler, T. (2019). Teachers' perception of STEM integration and education: A systematic literature review. *International Journal of STEM Education*, *6*(2), 1-16. https://doi.org/10.1186/s40594-018-0151-2

Maxwell, J. A. (2013). *Qualitative research design: An interactive approach*. Sage Publications.

McConnell, J. (2017). A model for understanding teachers' intentions to remain in STEM education. *International Journal of STEM Education*, *4*(1), 1-21. https://doi.org/10.1186/s40594-017-0061-8

McKinley, J. (2015). Critical argument and writer identity: Social constructivism as a theoretical framework for EFL academic writing. *Critical Inquiry in Language Studies*, *12*(3), 184–207. https://doi.org/10.1080/15427587.2015.1060558

McMullin, K., & Reeve, E. (2014). Identifying perceptions that contribute to the development of successful project lead the way pre-engineering programs in

Utah. *Journal of Technology Education*, *26*(1), 22-46. http://doi.org/10.21061/jte.v26i1.a.2

Merriam, S. B. (2009). *Qualitative Research in Practice*. Jossey-Bass Publications.

Nadelson, L. S., & Seifert, A. L. (2017). Integrated STEM defined: Contexts, challenges, and the future. *Journal of Educational Research*, *110*(3), 221–223. https://doi.org/10.1080/00220671.2017.1289775

National Research Council (2013). *Monitoring Progress Toward Successful K-12 STEM Education: A Nation Advancing?* https://doi.org/10.17226/13509

Ntemngwa, C., & Oliver, J. S. (2018). The implementation of integrated science technology, engineering and mathematics (STEM) instruction using robotics in the middle school science classroom. *International Journal of Education in Mathematics, Science and Technology*, *6*(1), 12–40. https://doi.org/10.18404/ijemst.380617

Odell, M., Kennedy, T., & Stocks, E. (2019). The impact of PBL as a STEM school reform model. *Interdisciplinary Journal of Problem-Based Learning*, *13*(2), 1-11. https://doi.org/10.7771/1541-5015.1846

Oxford English Dictionary. (n.d.). https://www.oed.com/

Payne, P. D., Sherbert, V., Goodson, T., & Goodson, L. A. (2018). Fences and families: A university project providing rural field experiences for pre-service teachers. *SRATE Journal*, *27*(2), 40–50. EBSCOhost Database

Patton, M. Q. (2002). *Qualitative research and evaluation methods.* Sage Publications.

Pearson, G. (2017). National academies piece on integrated STEM. *Journal of Educational Research*, *110*(3), 224–226. https://doi.org/10.1080/00220671.2017.1289781

Pedersen, D. E., & West, R. R. (2017). High school STEM teachers' perceptions of the work environment. *Education*, *138*(1), 89–103. EBSCOhost Database

Prawat, R. S., & Floden, R. E. (1994). Philosophical perspectives on constructivist views of learning. *Educational Psychologist*, *29*(1), 37. https://doi.org/10.1207/s15326985ep2901_4

Proudfoot, D. E., Green, M., Otter, J. W., & Cook, D. L. (2018). STEM certification in Georgia's schools: A causal comparative study using the Georgia student growth model. *Georgia Educational Researcher*, *15*(1), 16–39. http://eric.ed.gov/?id=EJ1194612

Saldaña, J. (2016). *The coding manual for qualitative researchers* (3rd ed.). Sage Publishing.

Sebastian, J., Allensworth, E., & Huang, H. (2016). The role of teacher leadership in how principals influence classroom instruction and student learning. https://eric.ed.gov/?id=ED577947

Seidman, I. (2013). *Interviewing as qualitative research* (2nd ed.). Teachers College Press.

Singer, J., Ross, J., & Jackson-Lee, Y. (2016). Professional development for the integration of engineering in high school STEM classrooms. *Journal of Pre-College Engineering Education Research (J-PEER)*, *6*(1), 30-44. https://doi.org/10.7771/2157-9288.1130

Smith, K. L., Rayfield, J., & McKim, B. R. (2015). Effective practices in STEM integration: Describing teacher perceptions and instructional method use. *Journal* *of Agricultural Education*, *56*(4), 182–201. https://doi.org/10.5032/jae.2015.04183

STEM/ STEAM Georgia. (2019, July). *High school STEM certification continuum*. http://www.stemgeorgia.org/wp-content/uploads/2020/04/High-School-STEM-July-2019.pdf

STEM/ STEAM Georgia. (2020, February 1). *STEM/ STEAM certified schools*. http://www.stemgeorgia.org/stem-steam-certified-schools/

Stevenson, M., Stevenson, C., & Cooner, D. (2015). Improving teacher quality for Colorado science teachers in high need schools. *Journal of Education and Practice*, *6*(3), 42–50. https://eric.ed.gov/?id=EJ1083814

Stipanovic, N., & Woo, H. (2017). Understanding African American students' experiences in STEM education: An ecological systems approach. *Career Development Quarterly*, *65*(3), 192–206. https://doi.org/10.1002/cdq.12092

Thibaut, L., Ceuppens, S., De Loof, H., De Meester, J., Goovaerts, L., Struyf, A., Boeve-de Pauw, J., Dehaene, W., Deprez, J., De Cock, M., Hellinckx, L., Knipprath, H., Langie, G., Struyven, K., Van de Velde, D., Van Petegem, P. & Depaepe, F. (2018). Integrated STEM education: A systematic review of instructional practices in secondary education. *European Journal of STEM Education, 3*(1), 02. https://doi.org/10.20897/ejsteme/85525

Tofel-Grehl, C., & Callahan, C. M. (2014). STEM high school communities: Common and differing features. *Journal of Advanced Academics*, *25*(3), 237–271. https://doi.org/10.1177/1932202X14539156

Van den Hurk, A., Meelissen, M., & van Langen, A. (2019). Interventions in education to prevent STEM pipeline leakage. *International Journal of Science Education*, *41*(2), 150–164. http://doi.org/10.1080/02783193.2016.1150376

Wang, H. H., Charoenmuang, M., Knobloch, N. A., & Tormoehlen, R. L. (2020). Defining interdisciplinary collaboration based on high school teachers' beliefs and practices of STEM integration using a complex designed system. *International Journal of STEM Education*, *7*(1), 1-17. https://doi.org/10.1186/s40594-019-0201-4

Wäschle, K., Gebhardt, A., Oberbusch, E. M., & Nückles, M. (2015). Journal writing in science: Effects on comprehension, interest, and critical reflection. *Journal of Writing Research*, *7*(1), 41–64. https://dx.doi.org/10.177239/jowr-2015.07.01.03

Weinberg, P. (2017). Mathematical description and mechanistic reasoning: A pathway toward STEM integration. *Journal of Pre-College Engineering Education Research (J-PEER)*, *7*(1), 90-107. https://doi.org/10.7771/2157-9288.1124

Yildirim, B., & Türk, C. (2018). Opinions of secondary school science and mathematics teachers on STEM education. *World Journal on Educational Technology: Current Issues*, *10*(1), 52–60. https://eric.ed.gov/?id=EJ1170368

APPENDIX A:

Interview Guide 1: Focused Life History

In the first interview, the interviewer's task is to put the participants' experience in context by asking them to tell as much as possible about themselves considering the topic up to the present time.

1. Topic – Educational background leading into the teaching profession
    a. High school experiences
    b. College experiences
    c. Traditional/non-traditional path into education
2. Topic – Past influential life experiences
    a. Family influences that made an impact on the participant
    b. Social influences that made an impact on the participant
    c. Other influences not mentioned
3. Topic – Educational focus or association with STEM
    a. Previous experience with science courses as a student
    b. Previous experience with math courses as a student
    c. Previous experience with engineering courses/exploratory courses as a student
4. Topic – Defining approach to technology throughout life
    a. Examples of technology use growing up (ages 5-10)
    b. Examples of technology use growing up (ages 11-15)
    c. Examples of technology use growing up (ages 16-22)

APPENDIX B:

Interview Guide 2: Details of the STEM Program

The purpose of the second interview is to concentrate on the specific details of the participants' present lived experience in the STEM program. When reconstructing these details, the search is for facts and not opinions.

1. Topic – School culture
    a. Describe general school culture of all students
2. Topic – STEM program culture
    a. STEM culture in your classroom
    b. STEM culture within the school
3. Topic – Goals of the STEM program – strategy of achievement
    a. Goals within your discipline/classroom
    b. Goals within the program
4. Topic – Role associated with the STEM program
    a. Topics taught / peers collaborated with
    b. Impact on achieving program goals within classroom
5. Topic – Interactions with curricular planning
    a. Describe a good curricular planning session from your perspective
    b. What makes collaborative planning successful?
6. Topic – Defining success in the STEM program
    a. Success in your classroom
    b. Success in the school STEM program

APPENDIX C:

Interview Guide 3: Reflection on the Meaning of the STEM Program

The purpose of the third interview is to reflect on the connections between the participants' lived experiences and their interactions within the STEM program. This interview will involve an examination of an understanding of how each participant arrived where they are professionally. This reflection will better develop an understanding of each participants meaning they have crafted around their work.

1. Topic – Reflection on the connections between work and life
    a. Intellectual connections
    b. Emotional connections
2. Topic – Factors in life bringing you to your current situation (reflection on topic #2 from Interview Guide 1)
3. Topic – Making sense of present experiences within their context (reflection on Interview Guide 2)
4. Topic – How did past experiences lead you to where you are today professionally? (reflection on Interview Guide 1)
5. Topic – Closing reflections/remarks

APPENDIX D:

IRB Approval

Institutional Review Board (IRB)
For the Protection of Human Research Participants

PROTOCOL EXEMPTION REPORT

Protocol Number: 03786-2021 **Responsible Researcher(s):** Jonathan Garner

Supervising Faculty: Dr. Rudo Tsemunhu

Project Title: *Portraits of a Rural Georgia High School STEM Program.*

INSTITUTIONAL REVIEW BOARD DETERMINATION:

This research protocol is **Exempt** from Institutional Review Board (IRB) oversight under Exemption **Category 2**. Your research study may begin immediately. If the nature of the research project changes such that exemption criteria may no longer apply, please consult with the IRB Administrator (irb@valdosta.edu) before continuing your research.

ADDITIONAL COMMENTS:

- *Upon completion of this research study, all collected data must be securely maintained (locked file cabinet, password protected computer, etc.) and accessible only by the researcher for a minimum of 3 years. At the end of the required time, collected data must be permanently destroyed.*
- *Exempt protocol guidelines **permit** recording of interviews for the sole purpose of creating an accurate transcript. Exempt protocol guidelines **prohibit** the collection and/or sharing of interview recordings. Upon creation of an accurate transcript all recordings are required to be permanently destroyed/deleted from recording devices.*
- *The researcher must read aloud the research consent statement at the start of each recorded interview session. A copy of the research consent statement must be provided to participants. The researchers reading of the consent statement, and the participant's verbal confirmation of understanding and willingness to participate, must be included in the recording – and permanent transcript.*
- *Under exempt protocol guidelines signed consent is not obtained. The research consent statement provides participants with all required information necessary to make an informed participation decision.*

☒ ***If this box is checked, please submit any documents you revise to the IRB Administrator at irb@valdosta.edu to ensure an updated record of your exemption.***

Elizabeth Ann Olphie 03.19.2021
Elizabeth Ann Olphie, IRB Administrator

Thank you for submitting an IRB application.
Please direct questions to irb@valdosta.edu or 229-253-2947.

Revised: 06.02.16