Teacher Perceptions of STEM Curriculum Integration and Application:

A Qualitative Study

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Abstract

Science, technology, engineering, and mathematics (STEM) education reforms have steadily increased since the 1980s. Legislators, education policymakers, and corporate leaders have shifted the focus to demand the production of increased numbers of STEM-literate graduates. The problem is a lack of consensus on the definition of STEM education, which contributes to the absence of an integrated and consistent STEM curriculum in U.S. public schools. A gap exists in literature regarding the perceptions of teachers and administrators related to STEM education in Georgia public schools. The study explored teacher perceptions of STEM education and a cohesive integrated curriculum. Constructivist learning theory and social cognitive learning theory provided the theoretical framework for the study. Key research questions explored administrator and teacher perceptions regarding uniform STEM curriculum as well as perceived obstacles to implementing STEM curriculum changes in Georgia public schools. Through a basic qualitative methodology, 16 teacher participants and three administrator participants were surveyed. All participants were current teachers or administrators at a STEM-certified and top-ranked Georgia high school. Questionnaire responses and document analysis results were coded using an inductive thematic analysis framework. Results indicated teachers and administrators held a predominantly positive view of STEM education, yet attempts to define and conceptualize STEM were basic and incongruous. Teachers also indicated a need for additional professional development to improve feelings of efficacy implementing STEM initiatives.

Keywords: STEM education, STEM perceptions, integrated STEM education, integrated curriculum, STEM curriculum, basic qualitative
Dedication

This dissertation is dedicated to my wife, April. Without her, this work would not have been possible. The support you have given me throughout this journey is more appreciated than you will ever know.
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Chapter 1: Introduction

Reforms to science, technology, engineering, and mathematics (STEM) education have been in high demand since the mid-1980s (Burrows et al., 2018). Pressure has steadily increased from educational stakeholders to produce graduates who are proficient in STEM subjects (Scherer et al., 2019). Occupations in the STEM fields, particularly science and engineering, were projected to grow by 18.7% in the 10-year period between 2010 and 2020; comparatively, all other occupations were only expected to grow by a projected 14% (National Science Board, 2014).

A vast majority of literature and studies concerning STEM education identify a serious dilemma across the United States and in other countries where the definition of STEM education remains unclear and educators feel ill equipped to effectively implement STEM education initiatives in the classroom (English, 2016; LaForce et al., 2016). There exists a lack of consensus as to the definition of STEM education and an absence of a clear plan for developing and implementing a STEM curriculum in U.S. public schools (J. Brown, 2012; El Nagdi et al., 2018; English, 2016; LaForce et al., 2016; Roehrig et al., 2021). Further study into the perceptions of teachers and administrators regarding the definitions of STEM and its integration into existing curriculum can aid policymakers and educators in advancing STEM education initiatives. The following sections present the background of the problem, purpose of the study, theoretical framework, scope and delimitations, limitations, and definitions of terms associated with the research study.

Background of the Problem

The roots of modern STEM education can be traced back to the 1870s when Washington University professor Calvin Woodward required his students to integrate principles of science
and engineering with mathematics principles, which marked a shift in mindset emphasizing curricular connections between disciplines (Sanders, 2009). Following World War I, economic prosperity in the United States was marked by a period of rapid discovery and invention, which inspired a movement to improve science and mathematics education to encourage students toward engineering careers (Burrows et al., 2018; Sanders, 2009). World War II further increased the need for an engineering-proficient workforce as the development of airplanes, submarines, bombs, and high-tech equipment increased (Burrows et al., 2018; Sanders, 2009).

Discoveries made during World War II would become the catalyst for interest and scientific discoveries in space travel (Burrows et al., 2018). The 1950s saw the space race between the United States and the Soviet Union, ultimately resulting in the Soviet Union’s successful launch of Sputnik I in October 1957 (Burrows et al., 2018). The National Aeronautics and Space Administration (2018) was created in October 1958 as the United States’ response to the space race and commitment to be the first to launch a man into space. The National Defense Education Act of 1958 funded student enrollment in science and engineering pathways of higher education and further enhanced public interest in science and engineering careers (Burrows et al., 2018).

A wave of education reform began with the 1983 National Commission of Excellence in Education report *A Nation at Risk*. The controversial report highlighted a critical disconnect in U.S. K–12 public education (Burrows et al., 2018). The resulting focus on integrated materials and practices would further develop into modern STEM. Continued concern that U.S. students were lagging behind global competitors saw the publication of numerous additional reports, bills, and grants by government and private agencies in an attempt to bring awareness to the need for STEM-literate graduates (Bernstein, 2019).
Defining STEM

As evidenced by the historical perspective, the STEM movement has been ongoing for decades, with numerous federal and state calls for increased student proficiency in STEM subjects and increased efforts to bolster student interest in STEM careers (LaForce et al., 2016). Despite continuing efforts and initiatives, a solid definition of STEM education remains undecided, making it difficult for schools to implement effective STEM programs. Unclear parameters, disparity in definitions, and lack of research into teacher perceptions toward integration compound the problem (El Nagdi et al., 2018; English, 2016).

To achieve effective STEM reform, teachers and administrators need to first understand what STEM education means and why STEM literacy is vital to the economy. Although some organizations have attempted to hone the definition, STEM education continues to be a largely ambiguous term with multiple interpretations and perspectives (El Nagdi et al., 2018; English, 2016). R. Brown et al. (2011) reported on a 2010 study created and conducted by Illinois State University STEM Education and Leadership graduate students that found, among 200 teachers and administrators interviewed, only half of the teachers and less than half of the administrators could define STEM education, and only 75% of respondents believed STEM education was important.

STEM remains a vague acronym, often defined only by the subjects it includes. STEM education and STEM literacy will require more concrete definitions to form and implement cohesive curriculum reforms. Even with the lack of definition, STEM programs continue to multiply, each providing its own interpretation of STEM education and further confusing the problem by contributing to a lack of a consistent and unified approach.
STEM Literacy

Similar to the difficulties seen in defining STEM education, the term STEM literacy is also met with some degree of ambiguity. Margot and Kettler (2019) and Thibaut, Ceuppens, et al. (2018) defined STEM literacy as the awareness of the roles the STEM subjects play in modern society, along with a familiarity and ability to apply at least fundamental concepts from each of the disciplines. Martin-Paez et al. (2018) stated STEM literacy is the capacity to identify and apply knowledge from the STEM disciplines to resolve problems that are not solvable by a monodisciplinary approach. The disparity of definitions to STEM education and STEM literacy only serves to complicate and hinder the integration of effective STEM education initiatives.

A gap in the literature was identified as minimal research has explored how administrators’ and teachers’ beliefs influence the implementation of integrated STEM in the classroom setting. STEM is more than an acronym, but until educators, policymakers, and stakeholders can agree on what STEM is and how STEM education should be taught, confusion and ineffectual efforts may continue to pervade the education system. This study filled the gap by exploring the perceptions of administrators and teachers regarding STEM education and integrated STEM efforts.

Statement of the Problem

The problem was a lack of consensus on the definition of STEM education, which contributes to the absence of an integrated and consistent STEM curriculum in U.S. public schools (English, 2016; Roehrig et al., 2021). STEM education reform is a national issue; for the United States to remain globally competitive and meet the need for increased numbers of STEM-literate graduates, a uniform definition of STEM needs to be developed and cohesive curricular changes need to be implemented (Scherer et al., 2019; Wang et al., 2011). Despite more than 2
decades of research supporting the need for quality STEM education, educators still lack the supports necessary to implement effective and lasting changes that would result in a uniform STEM curriculum (Kelley & Knowles, 2016; LaForce et al., 2016).

A gap exists in literature exploring how teachers’ and administrators’ perceptions about STEM affect the implementation of integrated STEM initiatives. Teacher and administrator attitudes and understandings play a pivotal role in the success of any curricular changes and innovations (Kelley et al., 2020). Ill-defined terminology and ambiguous conceptualizations of STEM education can significantly hinder the adoption of curricular changes and negatively impact the production of STEM-oriented graduates (Kelley & Knowles, 2016; Kelley et al., 2020).

**Purpose of the Study**

The purpose of this basic qualitative study was to explore the perceptions of teachers and administrators regarding the definition of STEM education and developing and integrating a uniform STEM curriculum at the Georgia public high school level. A basic qualitative study allowed for thorough investigation of participant perceptions and in-depth understanding of associated thoughts and feelings without the need to focus on a single underlying theory (Kennedy, 2016; Patton, 2015). Basic qualitative research also allowed for the use of multiple aspects from each of the distinct qualitative designs, while maintaining an outward focus on participant thoughts, feelings, and perceptions (Bellamy et al., 2016).

The study contributed to the knowledge base by exploring Georgia teacher and administrator perceptions regarding STEM education and the potential for a uniform STEM curriculum. The target population was 15–25 teachers and three administrators in a STEM-certified Georgia high school. Through the use of thick, rich descriptions in detailing the results,
the reader may determine whether the findings of this study are transferable to other populations, contexts, and situations across the state of Georgia (Roberts et al., 2019). This study filled the gap by providing an analysis of teacher and administrator definitions of STEM education as well as an understanding of perceptions regarding STEM curriculum integration.

**Significance of the Study**

Research supports the positive impact STEM education has on increasing student interest in STEM majors and careers (Kelley et al., 2020). However, the United States continues to lag behind global competitors in science and technology innovation and has decreasing numbers of STEM-minded graduates (Marksbury, 2017; Wang et al., 2011). STEM education remains an unfocused and imprecise concept with educators who feel ill equipped to effectively implement STEM curriculum changes (El Nagdi et al., 2018; English, 2016).

By exploring the understandings and perceptions of teachers and administrators, this study can begin to close the gap and understand what obstacles may contribute to the lack of developing a uniform integrated STEM curriculum. If unified definitions of STEM education and its associated terms can be agreed on, policymakers can begin to provide the guidelines and support necessary for teachers to embrace integrated STEM initiatives.

**Research Questions**

Questions exploring the complex phenomena of perception and interpretation were essential to this basic qualitative study (Crotty, 1998). Qualitative questioning focuses on attributing meaning to the personal experiences and opinions of the participants (Patton, 2015). The following research questions guided this basic qualitative research study:

Research Question 1: What are administrator and teacher perceptions regarding STEM education and integrated STEM curriculum?
Research Question 2: What obstacles, if any, do teachers and administrators perceive to implementing a uniform curriculum in Georgia STEM high school courses?

**Theoretical Framework**

Constructivist learning theory (Vygotsky, 1978) in combination with social cognitive theory (Bandura, 1977) provided the framework for this study. Modern constructivist learning theory combines the views of both Vygotsky and Piaget and states the environment and lived experiences, including interactions and collaboration, are essential to the formation of knowledge (Stipanovic & Pergantis, 2018). Social interactions and experiences integrate with existing knowledge, and new understandings are then created (Stipanovic & Pergantis, 2018).

Cornerstones of most STEM education initiatives are collaboration and experiential learning, making STEM activities inherently constructivist (Yenmez et al., 2021). Constructivism aligns with the research questions by allowing participants to describe and explain personal experiences and derive meaning from their perceptions (Hatisaru et al., 2019; Stipanovic & Pergantis, 2018).

Social cognitive theory, introduced by Bandura in 1977, is based on theories of social learning and behavior modeling. Learning under social cognitive theory takes place in a social setting and is attributed to individual observed behaviors and social interactions (Bandura, 1977). The STEM classroom provides a rich social environment in which students can interact and observe to create new knowledge.

Under the lenses of constructivist and social cognitive theories, educator attitudes and perceptions toward STEM education and integration efforts can significantly impact student achievement (Bandura, 1977; Kelley et al., 2020). The intersection of these two theories lies in the belief that social interaction is necessary to facilitate full cognitive development and that meaning is attributed to and derived from these interactions. A more in-depth description of the
Theoretical framework is provided in Chapter 2.

**Definitions of Terms**

Defining key terms can add precision to a study and enhance readability and understanding for the reader. This section provides context to the use of the key terms throughout the study. Key terms used throughout the research are as follows.

**Common Core State Standards (CCSS).** The Common Core State Standards (CCSS) are a government initiative that provides for a consistent and clear understanding of what students are expected to know in mathematics and English language arts. The CCSS lack any depth or guidelines in the areas of science, engineering, and technology (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010).

**Inquiry-Based Learning.** Inquiry-based learning is a student-centered learning approach whereby students engage in the learning process by asking questions, gathering data and evidence, synthesizing new knowledge, and evaluating the outcome. Existing knowledge is utilized to form a deeper understanding of the subject material (Archer-Kuhn et al., 2020).

**Interdisciplinary Integration.** Interdisciplinary integration is an integration approach whereby two or more disciplines are interconnected in such a way that they are difficult to separate or distinguish from one another. Teaching goes beyond theme or problem to cut across individual subject areas, creating a seamless learning environment (Roehrig et al., 2021).

**Multidisciplinary Integration.** Multidisciplinary integration is an integration approach whereby each separate discipline is still identifiable within the curriculum but connections are made using real-world scenarios (Roehrig et al., 2021). Disciplines are taught side by side with a connecting theme, but each discipline has separate overall objectives (Martin-Paez et al., 2018).

**Next Generation Science Standards (NGSS).** The Next Generation Science Standards
(NGSS) are a government initiative that sought to fill the gaps in the CCSS related to science, technology, and engineering. The NGSS define performance expectations required for students to demonstrate proficiency in the various science and engineering disciplines (El Nagdi et al., 2018).

**Problem-Based Learning.** Problem-based learning is a teaching/learning strategy whereby students are presented with a specific problem and must use knowledge and skills they already possess in addition to material they are learning to solve real-world problems (Akcanca, 2020). Multiple strategies and solutions may result from this student-centered approach.

**Professional Development.** Professional development refers to the comprehensive and concentrated education initiatives aimed at enhancing teacher knowledge and quality of practice to increase student engagement and achievement (Bush et al., 2020).

**Transdisciplinary Integration.** Transdisciplinary integration is an integration approach whereby teaching centers around real-world problems and not individual disciplines. Real-world issues are analyzed in the context of social, economic, political, international, and environmental concerns (Roehrig et al., 2021).

**21st-Century Skills.** Twenty-first-century skills refer to the learning and integration of life, career, and technology skills necessary for success in a continuously growing technological world (Stauffer, 2020).

**Assumptions**

Assumptions are aspects of research that are beyond the control of the researcher, cannot be eliminated from the study, and are considered true by those who read the research (Creswell & Creswell, 2018). Several assumptions existed within this study due to the nature of the research methodology and instrumentation. First, it was assumed the participants would respond
to the questionnaire and submit documents for analysis willingly and with a commitment to true and accurate responses. Another assumption was the respondents were able to provide firsthand knowledge of individual personal experiences. All respondents were teachers teaching a STEM discipline or within the STEM Academy of the research site, thereby giving them applicable and relevant knowledge to complete the questionnaire and provide requested documentation.

**Scope and Delimitations**

This research study included 16 teachers and three administrators from a top-ranked suburban Georgia high school. The research site has a dedicated STEM Academy, attendance to which is application based. A primary objective of the study was to answer the research questions based on perceptions and personal experiences of teachers and administrators regarding STEM education and integrated STEM curriculum. A delimitation of this study was the decision to conduct research at a single STEM-certified high school as opposed to multiple locations. This decision was made in the interest of time and convenience. For this study, the target population was purposively selected based on meeting the inclusion criteria. Creswell and Creswell (2018) stated purposive sampling in qualitative research allows researchers to select participants from whom the most useful information can be garnered. The results of the research are potentially transferable as the study provided thick, rich descriptions of data to convey findings that allow the reader to determine whether the content is transferable to other contexts (Roberts et al., 2019). Additionally, while education level and years of service were not considered in the participant inclusion criteria, they were included in the questionnaire and were assessed for similarities and patterns when determining results.

**Limitations**

Difficulties or restraints within a study are identified as limitations (Creswell & Creswell,
The research took place in a single STEM-certified institution in the state of Georgia and was limited to a maximum of 25 teacher participants and three administrator participants. Participation was voluntary, which resulted in the final sample size being a limitation of the study. Additional limitations of this study included time constraints and availability of research participants at the school site. Data and results are potentially transferable; however, transferability may be limited due to the use of a single research site and dependence on the lived experiences of teachers and administrators in that setting. Credibility and dependability of research results was achieved through triangulation and careful documentation throughout the research process. As an integral part of the qualitative research process, the researcher presented a potential for bias. Given the potential for researcher bias to enter the study, random sampling minimized the potential for preexisting relationships to influence sampling decisions (Merriam & Tisdell, 2016). Bracketing, the process by which researchers identify and set aside personally held beliefs, also helped to minimize the potential for researcher bias (Emiliussen et al., 2021).

Chapter Summary

Despite decades’ worth of rhetoric and government calls to action regarding STEM education and the increasing need for graduates choosing STEM pathways and careers, little consensus exists as to exactly what STEM education entails and how it should be integrated and taught in U.S. public schools (Kelley et al., 2020; Marksbury, 2017; Wang et al., 2011). The purpose, significance, and design of this study sought to advance the body of knowledge relating to teacher and administrator perceptions of STEM education and its integration into existing high school curricula. Working through the lens of constructivist and social cognitive theory, this study explored the thoughts, perceptions, and interpretations of teachers and administrators, which may in turn affect student interest and achievement in STEM subjects and later choices.
regarding STEM careers (Kelley et al., 2020). The following chapter includes a comprehensive literature review exploring the theoretical framework for the study, related research, the need for integration, integration strategies, professional development, and teacher self-efficacy, all with respect to STEM education and curriculum change initiatives.
Chapter 2: Literature Review

The Bureau of Labor Statistics (2020) projected that by 2029, jobs in STEM-related occupations will increase by 8% compared to a projected 3.4% increase in non-STEM-related occupations. Despite this significant increase in workforce needs, the U.S. educational landscape is plagued by a disorganized approach to STEM education and an ill-defined conceptualization of what STEM education is or should look like. The problem is a lack of consensus on the definition of STEM education, which contributes to the absence of an integrated and consistent STEM curriculum in U.S. public schools. The purpose of this basic qualitative study was to explore the perceptions of teachers and administrators regarding the definition of STEM education and developing and integrating a uniform STEM curriculum at the Georgia public high school level.

Literature and documentation defining a uniform curriculum plan for the integration and application of STEM standards in Georgia public schools is sparse at best. The findings of this study may help school officials and policymakers to define STEM education from a teacher perspective as well as provide background to assist in future curriculum initiatives. The study was built on constructivist and social cognitive theories as a theoretical framework.

This review of the literature presents the history and challenges facing the implementation of a STEM curriculum. The review further advances how teacher preparedness and feelings of self-efficacy affect the implementation of STEM education at the classroom level. A gap in the literature has been identified regarding teacher and administrator definitions and perceptions of STEM education and curriculum. The literature review is divided into the literature search strategy, theoretical framework, subtopics related to STEM education, teacher perception and efficacy, curriculum development, a counterargument, and conclusions. The
conclusions summarize the literature review and align with the purpose of the study.

**Literature Search Strategy**

Supporting resources for this study were researched using databases through the American College of Education Library, including EBSCOhost, ProQuest, ERIC, SAGE Journals, and Academic Search Complete. Scholarly peer-reviewed journal articles were also located through the Directory of Open Access Journals, Google Scholar, and direct access to journal websites. Searches were conducted utilizing keywords commonly associated with STEM education and STEM curriculum, including *STEM, STEM curriculum, STEM integration, STEM education, STEM reform, STEM literacy,* and *STEM crisis.* Research was focused primarily on studies and articles published between 2017 and 2022. Some older studies and publications were included to preserve validity and support the historical context of the subject. A minimum of 76% of articles reviewed had publication dates between 2017 and 2022, and a minimum of 50% were peer reviewed.

**Theoretical Framework**

Constructivist learning theory (Vygotsky, 1978) along with social cognitive theory (Bandura, 1977) of learning made up the theoretical framework upon which this study was built. These theories provided the lens through which results were analyzed. Constructivist learning theory states the environment and lived experiences contribute to a person’s knowledge and provide the platform upon which new knowledge is built (Mohammed & Kinyo, 2020). Constructivism is based on the foundational thought that collaboration, interaction, and engagement are essential to student learning (Xu & Shi, 2018). Through the lens of constructivism, meaning can be attributed to the perceptions and understandings of the educators involved, while providing support for the purpose of the study, which was to explore and
understand those perceptions.

Modern constructivist theory is a blend of multiple constructivist approaches but is most often associated with Piaget’s cognitive constructivist theory and Vygotsky’s social constructivist theory (Stipanovic & Pergantis, 2018). Cognitive constructivism, as defined by Piaget, centers on the individual. Students strive to make sense of the world around them by developing personal understanding of social, mental, and physical experiences (Stipanovic & Pergantis, 2018). Vygotsky’s viewpoint emphasized the importance of society, culture, and language, forming the social constructivist paradigm (Stipanovic & Pergantis, 2018; Vygotsky, 1978). According to Vygotsky (1978), social interactions provide a vital component in student learning. The primary belief is that students learn from each other and as part of larger social and cultural contexts (Stipanovic & Pergantis, 2018). Underlying the social constructivist viewpoint is the notion that new experiences are integrated with existing knowledge and that knowledge is transferred through dialogue with others (Vygotsky, 1978). Constructivist theory aligns with STEM-integrated curriculum initiatives through the use of problem-based learning, collaboration, and the connection of learning to personal experience. Yenmez et al. (2021) stated integrated STEM activities are inherently constructivist. Therefore, constructivism supported the research questions.

Social cognitive theory was first discussed by Bandura in 1977 but was based on prior theories of social learning and modeling behaviors. According to social cognitive theory, learning takes place in social settings and is attributed to observed behaviors and interactions with the learner’s environment (Bandura, 1977). Bandura’s theory states portions of knowledge gained can be attributed to or affected by the learner’s observations of social interactions, and would suggest educator perceptions of self-efficacy, as well as attitude toward STEM education
could affect student achievement (Bandura, 1977; Kelley et al., 2020). Proponents of Bandura’s theory propose learning occurs in social settings with a dynamic interaction between people, behavior, and environment (Khudzari et al., 2019). Social cognitive theory aligned with the study as the integrated STEM classroom provides the social environment through which students can interact, observe, and interpret new information.

Social cognitive theory and constructivism worked together to form the theoretical framework of this study. Knowledge is constructed through experiences, integrating new knowledge with existing knowledge. Observation and collaboration provide the lens through which the learning occurs. Additionally, teachers’ perceptions of STEM education can affect feelings of self-efficacy and subsequently impact student learning.

Figure 1 illustrates the intersection of constructivist theory and social cognitive learning. While the theories hold some differing views on the nature of student learning and knowledge construction, they intersect in three key areas that give context to this study. Both theories state knowledge is constructed through experience and existing knowledge is integrated with new knowledge. Social interactions are also viewed as vital to the student learning process. Finally, learning is foremost a cognitive process involving thinking, remembering, and problem solving in the formation of knowledge.

**Research Literature Review**

Since the mid-1980s, the demand for students well versed in STEM subjects has been at the top of the education reform agenda. Regardless of the push for STEM reform, billions of dollars allocated toward STEM initiatives, and the knowledge that STEM is vital to maintaining an economic edge, the United States continues to fall behind global competitors in science and technology innovation (Marksbury, 2017; Wang et al., 2011). While there appears to be a general
understanding of how to teach STEM, little has been done to create a uniform method for integrating STEM in curricula (Morrison & Bartlett, 2009).

Figure 1

*Theoretical Framework*

To understand the subject, earlier research needs to be investigated. The following literature review provides an overview of the literature pertaining to STEM education and STEM reform. The review details what have been identified as effective and ineffective strategies of integrating STEM into curriculum, while highlighting the disorganized approach and lack of clear definition of many of the key aspects. The gap in literature pertaining to teacher conceptualizations and perceptions of effective STEM practices is also highlighted through comparison of extant literature.

STEM remains a vague acronym, often defined only by the subjects it includes. STEM
education and STEM literacy will require more concrete definitions to form and implement cohesive curriculum reforms. Even with the lack of definitions, STEM programs continue to multiply, each providing its own interpretation of STEM education and further confusing the problem by contributing to a lack of a consistent and unified approach.

**STEM Literacy**

The term *STEM literacy* is met with a great degree of ambiguity within the education field. Margot and Kettler (2019) and Thibaut, Ceuppens, et al. (2018) defined *STEM literacy* as the awareness of the roles STEM subjects play in modern society, along with a familiarity and ability to apply at least fundamental concepts from each of the disciplines. Martin-Paez et al. (2018) stated *STEM literacy* is the capacity to identify and apply knowledge from the STEM disciplines to resolve problems that are not solvable by a monodisciplinary approach. Utilizing these definitions, *STEM literacy* can be defined as the ability to identify, apply, and integrate STEM concepts in the context of real-world problems and their solutions. Teacher perceptions related to the integration of STEM concepts can provide important context as to why integration is not happening to a higher degree; however, previous research is sparse.

**Qualitative Studies Relevant to Teacher Perceptions of STEM Integration**

Three qualitative research studies were located that specifically explored STEM education strategies and teacher perceptions of success or barriers to integration that related closely to the present study’s purpose and research questions. One study (Ryu et al., 2019) utilized a grounded theory approach and studied preservice teachers enrolled in an integrated STEM teaching methods course. Semi-structured interviews were conducted with the six study participants, and artifacts generated by participants were utilized. The study found preservice teachers’ motivations for selecting STEM activities and content were related to the teachers’ own
experiences, personal interests, and disciplinary focus. Participants also identified several challenges to implementing integrated STEM, including school culture, limited content knowledge, and absence of role models (Ryu et al., 2019).

The second study, conducted by Wang et al. (2020), used a qualitative case study design to better understand teachers’ beliefs and practices as viewed through an interdisciplinary approach. A significant limitation of the study was the exclusion of administrators from the participant pool, leaving a significant gap in the data. Wang et al. (2020) found the teachers attributed the success or failure of collaborative efforts to team size, teaching goal, and collaboration structure. Individual teacher beliefs of what STEM integration meant and should look like played an important role, indicating greater success could be achieved if everyone were working under the same definitions.

The third study was most closely related to the research questions and purpose of the present study. El-Deghaidy et al. (2017) conducted a basic qualitative study to explore teachers’ views on STEM education as well as the factors they attributed to STEM integration success. The study was conducted in a Saudi Arabian middle school and included focus groups and interviews with 21 teachers. The results of the study showed the teachers cited a variety of internal and external factors as constraints to effective STEM integration. Lack of equipment, large class sizes, lack of time, student concerns about assessments, lack of pedagogical content knowledge, and lack of curricular focus on STEM activities contributed to teachers’ predisposition toward teacher-centered pedagogies (El-Deghaidy et al., 2017). Although not conducted in the United States, El-Deghaidy et al.’s findings suggest common identifiable challenges that lead to teacher-centered approaches and could have important implications for the status of current impediments to integration in Georgia STEM programs.
The remainder of extant literature surrounding the topics of STEM integration involved attempts to define the various strategies and zero in on strategies that have proven most effective in terms of student achievement. The literature showed a disjointed landscape with multiple definitions of key concepts as well as a lack of exploration into teacher and administrator perceptions of what works in practical contexts. The following subsections explore what has been established in the field of STEM education as well as what is still unclear.

**STEM Integration Strategies**

As with many areas of STEM terminology, *STEM integration* is somewhat ill defined, with multiple possible definitions depending on the scholar. While a solid definition is not forthcoming, the majority of literature reinforces the need for an integrated approach to STEM education. Integrating the disciplines can support a more cohesive and less fragmented experience for learners. Investigation has revealed that traditional teaching methods approach the individual disciplines in a largely isolated manner and make it necessary for students to form connections across the disciplinary boundaries, whereas more explicit explanation and reasoning would be beneficial (Kelley & Knowles, 2016; Roehrig et al., 2021).

Studies by Martin-Paez et al. (2018) and Roehrig et al. (2021) demonstrated the existence of three primary approaches to integration of the STEM disciplines: multidisciplinary, interdisciplinary, and transdisciplinary. The primary differences in the three approaches include the degree of interaction individuals have outside a single disciplinary community, the degree of integration between the bodies of knowledge within the disciplines, and the presence of a common topic or theme to drive the collaboration (Klaassen, 2018). The level of integration increases from no integration in a disciplinary approach to total integration in a transdisciplinary approach. The distinctions and recommendations of how to approach the various levels of
integration could assist teachers in their efforts to adopt increasingly integrated approaches and move toward a student-centered curricular approach. The research of Martin-Paez et al. (2018) further supports the existence of multiple ideas of what STEM education is and how it should be implemented. Several authors’ theoretical definitions and conceptualizations of the integration levels are discussed as follows.

**Multidisciplinary**

The first approach to integration is a multidisciplinary approach. Under this approach, each separate discipline would still be identifiable within the curriculum, but connections would be made by utilizing a real-world scenario (Roehrig et al., 2021). Disciplines are taught side by side with a connecting theme, but each discipline has separate overall objectives and offers its own knowledge toward solving the problem (Martin-Paez et al., 2018). Roehrig et al. (2021) used a multiple-case study design to explore teacher implementation of integrated STEM and found the level of integration achieved was predominantly multidisciplinary, with only minor curriculum changes intended to accomplish the integration initiative. Under this approach, information is shared but not truly integrated, and students are expected to form connections through the use of their own unique knowledge and experiences. Separate teachers still teach the individual disciplines to students, but the teachers are expected to collaborate with one another and approach the respective subject material from a common problem-based approach. The reality under this approach is that teachers may want to include other disciplines in lessons, but the ultimate goal remains to deepen the understanding of their own discipline (Roehrig et al., 2021).

**Interdisciplinary**

The next integration approach is interdisciplinary. In an interdisciplinary approach, the
disciplines would be difficult to distinguish from one another as two or more of the disciplines are interconnected beyond theme or problem and teaching would cut across the individual subject areas (Roehrig et al., 2021). Students are able to make meaningful connections that assimilate concepts and allow for an understanding of the material that is applicable to reality (Martin-Paez et al., 2018). A theoretical analysis by Helmane and Briška (2017) defined the interdisciplinary approach as educators organizing curriculum around common themes across disciplinary boundaries. Roehrig et al. (2021), Martin-Paez et al. (2018), and Helmane and Briška (2017) agreed interdisciplinary integration requires an organizational structure that supports and promotes collaboration that can be difficult given the current disciplinary structure of most education systems.

**Transdisciplinary**

The most difficult level of integration to achieve is transdisciplinary. Under a transdisciplinary approach, teaching centers on real-world problems and not individual subject areas. Real-world issues are analyzed in the context of social, economic, political, international, and environmental concerns (Roehrig et al., 2021). Transdisciplinary approaches help students to understand not only how a concept works but also why. Nadelson and Seifert (2017) discussed the concept of information synthesis, a merging of the traditional disciplines to better meet the needs of 21st-century citizens. Transdisciplinary education starts with the problem to be solved and brings the required knowledge from each discipline to bear in devising a solution, and there may be many possible solutions to each problem. Transdisciplinary integration is touted by some as the best approach to combining the seemingly disparate information received through traditional teaching models (Nadelson & Seifert, 2017). This approach, however, is difficult as it is not in line with the education system’s fixation on disciplinary curriculum content and
measurable assessments. Learning is often divided into systematized and structured segments by discipline, which are not easily broken down, to allow for adoption of a transdisciplinary approach.

**Additional Strategies**

In addition to the three primary integration strategies, Thibaut, Knipprath, et al. (2018) suggested STEM integration is inextricably linked with the theory of constructivism. Construction of knowledge takes place through interaction with others and in the context of solving real-world problems. By combining constructivism with other evidence from prior research, Thibaut, Knipprath, et al. (2018) presented a framework for integrated STEM education. The framework includes five elements: integration of content, problem-based learning, inquiry-based learning, design-based learning, and cooperative learning. Learning is grounded in authenticity, cooperation, and connection between learning objectives.

English (2016) argued the STEM disciplines do not exist in isolation in the real world and should not be approached as such in teaching practices. The consensus among scholars is that any integration strategy is better than continuing to treat the subjects as disconnected silos, with no one strategy being superior. In fact, Roehrig et al. (2021), Martin-Paez et al. (2018), and Nadelson and Seifert (2017) found integration to be a continuum along which the degree of integration can vary from disciplinary to transdisciplinary depending on the curricular context. Dare et al. (2018) supported this notion with findings from a phenomenological case study that showed differing degrees of integration are common depending on the support teachers receive in bringing multiple disciplines into the classroom.

Discipline-specific skills are still necessary to build cognitive strength to comprehend STEM educational content. Singular concepts (such as algebraic functions) should still be taught
to students as foundational information to be utilized later for problem-based learning strategies and to solve complex ill-structured problems (Nadelson & Seifert, 2017). All three approaches are intended to support student abilities to make connections across the STEM disciplines and improve STEM literacy (Nadelson & Seifert, 2017).

**The Importance of Collaboration**

In addition to and as an integral part of the three primary integration strategies, cooperation and collaboration within schools are believed to be cornerstones of effective STEM integration (R. Brown et al., 2012). Margot and Kettler (2019) suggested cross-disciplinary approaches and deviation from conventional techniques should be the basis of STEM reform. In a similar study, Bell (2016) found an interdependent and cooperative curriculum was necessary for students to achieve true STEM literacy. To apply acquired knowledge to real-world problems and remain globally competitive, students should be able to develop and understand the relationships between the disciplines that occur when the disciplines work together to present cohesive views connecting principles (English, 2016; Slavit et al., 2016). However, none of the aforementioned studies approached the research from the standpoint of teacher perceptions, nor did they attempt to provide a cohesive or uniform definition of the key STEM conceptual terms.

What have previously been approached as silos and disciplines independent of one another should now become one metadiscipline; but many secondary grade teachers perceive significant barriers to the implementation of cross-curriculum programs (Scherer et al., 2019). This barrier is likely the result of a lack of professional development programs and supports to aid teachers in integrating content beyond primary content specialties. Collaboration becomes essential in a system with an established structure of segregated disciplines. M. Gardner (2017) conducted a phenomenological study and found that educators, with few exceptions, receive no
significant instruction outside their content specialty; this lack of professional development and formal education makes it difficult for teachers to embrace STEM education without collaboration. Nadelson and Seifert (2017) supported this result in their comprehensive literature review and reiterated that, by the very nature of the present design, the U.S. education system does not support integrated curricular structures. Bybee (2010) proposed a timeline of action whereby new teaching standards, certification requirements, and supplemental supports may aid in integrating the STEM disciplines; but his model requires a progressive change over a decade or more, and neither legislation nor local reforms have taken any action toward this end. Research points to several challenges to integration as possible reasonings behind this lack of action (Dare et al., 2018; Firat, 2020; Hodges et al., 2016; Ryu et al., 2019; Thibaut, Ceuppens, et al., 2018; Wang et al., 2011).

**Challenges to Integration**

While integration of the STEM disciplines is agreed to be the most beneficial approach for student achievement and understanding, the majority of current curriculum models still approach the subjects with little or no association between them. Ryu et al. (2019) conducted a qualitative study that suggested this disconnect between theory and practice has been attributed to numerous factors, including cost, time, teacher lack of knowledge, feelings of inefficacy, and lack of commitment to STEM initiatives. Thibaut, Ceuppens, et al. (2018), through a systematic literature review, also found implementing integrated approaches can require a significant restructuring of curriculum; this implementation requires significant funding as well as time. STEM education lessons often involve the use of additional resources, materials, and technology, which can involve a substantial investment by schools to implement effectively (Thibaut, Ceuppens, et al., 2018). Although not directly linked to Georgia school systems, the research
conducted by Ryu et al. (2019) and Thibaut, Ceuppens, et al. (2018) highlighted the significant challenges that can hinder effective implementation of integrated STEM. The current structure of the Georgia school curriculum would necessitate a significant overhaul, which could be both costly and time consuming.

In addition to the cost and time associated with such curriculum overhauls are the challenges associated with staff. Teacher lack of knowledge can present a huge hurdle to STEM integration. Ryu et al. (2019) found conventional models of teacher education and training result in limited knowledge of disciplines outside their primary focus. STEM subjects are often taught individually with little crossover, and content specialists (such as biology or mathematics) encounter difficulty in creating integrated STEM activities while fulfilling the requirements of the curriculum (Dare et al., 2018; Hodges et al., 2016; Wang et al., 2011). This difficulty results in a lack of confidence, which has been found to be in part a result of inadequate support, low feelings of self-efficacy crossing disciplinary lines, and lack of STEM-related professional development opportunities. Lack of development of competencies in other disciplines goes hand-in-hand with feelings of inefficacy. Teachers may have the desire to implement integrated STEM content and strategies in their classrooms but lack the pedagogical knowledge to do so. Wang et al. (2011), following a qualitative case study, stated one of the greatest challenges facing elementary and secondary STEM education is a lack of guidelines and models for educators to follow. This aligns with the previously discussed studies of Dare et al. (2018) and Hodges et al. (2016) stating that teachers require additional support and professional development to feel comfortable embracing integrated STEM initiatives. Further research could indicate whether these findings could also explain the lack of cohesive integrated STEM approaches plaguing the Georgia education system.
Teachers who lack the commitment required to effectively implement integrated STEM are also less likely to do so. Lack of commitment can result from feelings that STEM is not a necessary or worthwhile use of time. For teachers to invest the time and effort, they should strongly believe that STEM is best for their students (Firat, 2020; Thibaut, Ceuppens, et al., 2018).

Perhaps the most troublesome reason that efforts to implement integrated STEM are lacking in the education system, and a cornerstone of this study, is the absence of consensus as to what STEM should look like in practice (Thibaut, Ceuppens, et al., 2018). As demonstrated thus far, an abundance of opinions exists regarding the definition and application of STEM and all its components. Without a well-defined agreement on the fundamental aspects of STEM education, the way forward will continue to be unclear (English, 2016). Several strategies exist that may aid teachers in achieving deeper levels of integration across disciplines, including problem-based learning, inquiry-based learning, and a focus on well-defined sets of curricular standards such as the NGSS and CCSS.

**Real-World Connections**

Real-world connections and problem-based learning form the basis of the primary integration strategies (multidisciplinary, interdisciplinary, transdisciplinary). As Thibaut, Ceuppens, et al. (2018) revealed, real-world problems are not fragmented and comprised of separate disciplines, they are complex and interrelated issues that cut across disciplines. Since the 1980s, numerous initiatives and strategies have been discussed and implemented as ways to help students make these connections and increase proficiency in skills associated with successful STEM learning. The increasing awareness of the importance of specific skills and knowledge to future success was first discussed in the context of 21st-century skills, later
followed by government initiatives in establishing common standards for the mathematics and science disciplines. Studies and literature support the problem-based learning approach as an effective method for developing and achieving the established skills and proficiencies of these initiatives (Akcanca, 2020; Thibaut, Ceuppens, et al., 2018).

21st-Century Skills

Twenty-first-century skills are core components of STEM education. The U.S. government passed the No Child Left Behind Act of 2001 (2002), which included, among other things, a goal that all students be technologically literate by the end of eighth grade. In response to this federal education reform initiative, numerous entities began to develop frameworks for achieving technological literacy and succeeding in a continuously growing technological world. In 2002, the Partnership for 21st Century Skills developed the P21 framework, which would become one of the leading frameworks for defining the skills necessary to interact and work in today’s world. The P21 framework consists of skills in three categories: life and career skills; learning and innovation skills; and knowledge, media, and technology skills.

Stauffer (2020) further defined and broke down these categories. Learning and innovation skills include the four C’s: critical thinking, creativity, collaboration, and communication. Life and career skills are broken down into flexibility, leadership, initiative, productivity, and social skills. Finally, knowledge, media, and technology skills are grouped under the heading of literacy skills and include information, media, and technology literacy (Stauffer, 2020). Akcanca (2020) used a correlational survey to demonstrate that STEM education and its related diverse approach to learning can hold the key to acquiring these 21st-century skills. The constructivist portion of this study’s framework supports students becoming active participants in the learning process whereby knowledge is constructed rather than simply conveyed, a primary component of
21st-century skills acquisition.

**Common Core State Standards**

Following the federal-level reform of the No Child Left Behind Act of 2001, the CCSS Initiative was created in 2010 through cooperation of the National Governors Association Center for Best Practices and Council of Chief State School Officers (2010). The CCSS provided for a consistent and clear understanding of what students are expected to know in mathematics and English language arts. The adoption of the CCSS by a majority of states marked a turning point; however, the standards lacked any real depth in the areas of science, technology, and engineering.

**Next Generation Science Standards**

As a solution to the deficiency of the CCSS, the National Research Council, National Science Teachers Association, and American Association for the Advancement of Science created the NGSS (NGSS Lead States, 2013). While maintaining alignment with the CCSS, the NGSS sought to increase interest in the sciences as well as define the performance expectations required for students to demonstrate proficiency in the various science and engineering disciplines (El Nagdi et al., 2018). The STEM education movement has been developing concurrently with the CCSS and NGSS. As teachers and school officials attempt to create curricula and learning opportunities aligned with the CCSS and NGSS, integrated STEM education offers cross-curricular opportunities through which to make these connections and foster development of 21st-century skills. These educational strategies can aid in the formation of uniform and cohesive approaches to STEM curriculum development.

**Problem-Based Learning**

Problem-based learning has emerged as one of the preeminent methods of teaching
students to utilize their knowledge in solving real-world problems (Akcanca, 2020). Through the student-centered approach of problem-based learning, students identify and solve the problem by applying the knowledge and skills they already possess with what they are currently learning (Bell, 2016; Hatisaru et al., 2019; Thibaut, Ceuppens, et al., 2018). Students become better equipped to confront and solve real-world problems when able to utilize knowledge from differing disciplinary outlooks. Building feelings of self-efficacy through the use of problem-based learning in the STEM subjects can lead to increased student interest in STEM careers (M. Gardner, 2017). Additionally, teacher perceptions of STEM usefulness have been shown to have a significant impact on student achievement and student self-efficacy (K. Gardner et al., 2019).

The origin of problem-based learning approaches can be traced back to 1969 and the McMaster University School of Medicine in Canada (Servant-Miklos, 2019; Thomassen & Stentoft, 2020). Thomassen and Stentoft (2020) supported the position the problem-based learning model presents an approach to allow students to recognize and realize the ways in which the various disciplines and knowledge work together to confront the complexities and uncertainties of real-world practice. Teachers are thus tasked with developing suitable and robust problems that fit the context and objectives of the course. Lectures are limited under a problem-based approach and teachers act primarily as facilitators to the learning process (Servant-Miklos, 2019).

Mann et al. (2021) further conceptualized an approach to problem-based learning that can be broken down into three primary principles: a learning approach, a social approach, and a content approach. The learning approach uses well-crafted problems to support identification of the problem, analysis, and crafting of an appropriate solution. The social approach ties back to constructivism and social learning theories as it states learning is a process of social dialogue and
communication through self-directed learning and collaboration. Lastly, the content approach
focuses on integration of information across subjects to solve the problem (Mann et al., 2021).

Integrating problem-based learning strategies can prove problematic in practice. Teachers
are often hesitant to embrace teaching models that are outside their training and comfort level
(M. Gardner, 2017). Holmlund et al. (2018), using a qualitative concept-mapping case study,
concluded focused professional development becomes an essential element to allow teachers
opportunities to develop knowledge outside specialized disciplinary lines and strategies for
realizing problem-based learning implementation.

**Inquiry-Based Learning**

Another popular student-centered approach to teaching is inquiry-based learning. Inquiry-
based learning is a pedagogical approach whereby students engage in the learning process by
asking questions, gathering data and evidence, synthesizing new knowledge, and evaluating the
outcome (Archer-Kuhn et al., 2020). During the inquiry process, students utilize existing
knowledge in the construction of new knowledge, resulting in deeper understanding of subject
material. Lindeman (2020), through an action research study, found inquiry-based learning with
elementary-age children fosters the processing of experiences and encourages deeper learning.
Rather than acting as receptacles for information, students co-construct knowledge and teachers
act as facilitators.

Archer-Kuhn et al. (2020) and Correia and Harrison (2020) found inquiry-based learning
can happen at any level along a spectrum from structured to open inquiry, with guided inquiry
somewhere in between. Structured inquiry involves the teacher identifying the problem and
providing extensive guidance to facilitate student questioning. Open inquiry, at the other end of
the spectrum, is characterized by the students identifying the problem and developing questions,
with very little guidance from the instructor. Archer-Kuhn et al. (2020) and Correia and Harrison (2020) agreed implementation of inquiry-based learning strategies should start at the structured end of the spectrum and work progressively toward open inquiry to develop student autonomy and self-efficacy.

One of the most widely used and discussed inquiry-based learning models is the 5E learning cycle. Created by the Biological Sciences Curriculum Study, the 5E model comprises five steps: engage, explore, explain, elaborate, and evaluate (Bezen & Bayrak, 2020). Working from constructivist theory, Bezen and Bayrak (2020) posited the 5E model generates student interest in a topic and encourages students to investigate and question around the topic, explain the newly discovered or gained knowledge, and make connections to already-known information and solve real-world problems. The evaluation phase of the model pertains to teacher evaluation that student understanding has been achieved (Bezen & Bayrak, 2020; Siwawetkul & Koraneekij, 2018).

Asking relevant questions and engaging in active discussion support construction of knowledge by allowing students to associate the newly acquired information with existing constructs (Archer-Kuhn et al., 2020). At its highest level, inquiry-based learning can be self-regulated and lead to increased critical thinking skills. Encouraging students to learn through seeking knowledge, active investigation develops deeper understanding and problem-solving skills (Correia & Harrison, 2020).

Further inquiry is needed to explore the relationships between teacher perceptions and the various learning approaches that have been shown beneficial to student learning. Several barriers to implementation of these student-centered approaches have been identified and are discussed in the following subsections. Development and implementation of cohesive and uniform curricular
approaches to student instruction could also affect teacher perceptions of their efficacy and feasibility with practical classroom application.

Teacher Perception and Efficacy

Teacher perceptions of self-efficacy can have a strong influence on student self-efficacy and cognitive achievement (Kelley et al., 2020). Implementation of integrated STEM initiatives depends in part on teacher perceptions, and alterations of attitude can positively affect teachers’ practices (Bell, 2016; Thibaut, Knipprath, et al., 2018). Margot and Kettler (2019) discussed several perceptions teachers express toward their ability to facilitate student STEM learning. The supports perceived to be most beneficial are professional development, pedagogical strategies, instructional reforms to improve content knowledge, district support of additional collaboration time, and an open means of communication between teachers and district leaders. Teachers place great value on STEM education and its positive student achievement outcomes but lack confidence in their ability to effectively implement cross-curricular STEM initiatives (Margot & Kettler, 2019). Increased teacher confidence can directly affect student learning outcomes. K. Gardner et al. (2019) also found that all participants in the mixed-methods professional development study experienced increases in feelings of self-efficacy, which in turn had a positive impact on classroom practices.

One contradictory study was discovered and is worth noting. Following a qualitative action research study, Bozkurt-Atlan and Ercan (2016) found teachers’ perceptions of the necessity of STEM education changed to the negative after having conducted STEM-related activities with their classes. Prior to the study, teachers believed STEM education was essential for student achievement in the core disciplines of science, technology, engineering, and mathematics; however, after completing STEM-related activities, the teachers no longer believed
STEM was necessary in relation to the core disciplines but believed it was vital to improving student creativity, problem-solving skills, and technology utilization skills (Bozkurt-Atlan & Ercan, 2016).

Research has shown that teachers mostly believe STEM education will have positive effects on student learning (Firat, 2020). While teacher attitudes toward student learning in the individual STEM disciplines are well documented, little research has explored how teachers’ and administrators’ beliefs influence the implementation of integrated STEM in their teaching. Policies and procedures being implemented to shape the K–12 education system are being formed with little to no input from teachers and administrators (Firat, 2020; Shernoff et al., 2017). Understanding teacher perceptions regarding preparation and professional development can provide this critical insight into the causes for the lack of STEM integration.

**Teacher Preparation and Professional Development**

The primary purpose of professional development is to enhance quality of teaching for increased student achievement. Education institutions and teachers are facing intense pressure to integrate STEM concepts. Teacher and administrator experience and background highly influence the classroom environment and subsequent success or failure of STEM initiatives. The radical departure from traditional teaching methodologies makes some teachers hesitant to adopt integrated STEM practices. Bush et al. (2020), M. Gardner (2017), and Shernoff et al. (2017) researched the topic using qualitative studies and agreed many teachers only receive training in a single discipline and develop few strategies that enable them to implement cross-curricular concepts. Professional development regarding STEM is especially important because of the complex aspects involving technology and engineering concepts not typically included in teacher preparation processes (Bush et al., 2020).
Despite the push for integrated STEM education, teachers have little opportunity to participate in integrated STEM professional development. Disciplinary curricular models across the country also contribute to the difficulty teachers face in implementing integrated STEM (Dare et al., 2018). Continuing professional development can provide an avenue for teachers to supplement their knowledge toward STEM integration skills and initiatives. Shernoff et al. (2017) discussed several ways to improve in-service teacher training toward STEM integration. Through their research, the most commonly suggested methods were implementing integrated STEM training and providing exemplars of effective integrated STEM lessons that could be used to model initiatives (Shernoff et al., 2017). Additionally high on the list were observations of fellow educators successful in integrating STEM concepts and creation of a supportive teacher community (Shernoff et al., 2017).

Central to improving preservice teacher education are the need for an integrated multidisciplinary approach, more practical classroom experience, and more rigorous training in the science and mathematics disciplines. K. Gardner et al. (2019), through a mixed-methods study, found superficial or basic STEM professional development did not result in statistically significant STEM content knowledge gains. Furthermore, vital to the success of STEM initiatives is that teachers understand the components and goals of the NGSS and 21st-century skills. According to Shernoff et al. (2017), the monodisciplinary structure of teacher education programs is completely inadequate and needs to be entirely reorganized to support integrated STEM education.

The ill-defined nature of STEM education contributes to the continued struggle to integrate STEM concepts into existing curricula. Limited understanding of what STEM is and represents adds to a lack of strategies and supports for teachers to truly understand what STEM
should look like in the classroom (Dare et al., 2018). Dare et al. (2018) stated teachers lack the necessary training to balance the various aspects of STEM education while maintaining student engagement and facilitating the connections especially pertaining to science and engineering content. Collaborative and administrative support were shown to be important factors when determining the success of integrated STEM initiatives (El-Deghaidy et al., 2017).

**Counterargument**

While the majority of available research and literature supports the need for STEM education reforms and corroborates the fact existing STEM initiatives are ineffectual, differing opinions exist. Counter to the majority of expert opinions, Charette (2013, 2014), Anft (2013), and Berghel (2015) believed the STEM crisis to be a myth. These experts believe data and statistics have been skewed or misinterpreted to show a lack of STEM-literate graduates and a shortage of STEM-qualified workforce where none exists. Charette argued the issue lies not in graduates pursuing STEM degrees but in those graduates later choosing employment in professions that do not utilize those degrees.

Anft (2013) and Charette (2013) agreed STEM should include more than the four core disciplines. The overarching belief of this argument is that including the arts and humanities will help students learn how to learn, improve creativity, and expand students’ abilities to interact effectively with other people, ultimately producing a more well-rounded and overall valuable scholar (Anft, 2013; Charette, 2013). Berghel (2015) posited the overwhelming push for additional funding and increased numbers of STEM professionals in the labor pool relate back to money. Academic institutions want additional funding, and industry wants more supply than demand to drive down salaries. Regardless of the differing opinions, all three dissidents agreed STEM is still important and relevant, just not a crisis as many experts and research suggest.
Other literature abandons the dispute that a shortage in the STEM workforce does not exist and focuses instead on the necessity of balancing the push for STEM and the pursuit of liberal arts and social science degrees. Shamir (2020) and Newton (2019) believed, to ensure lucrative career opportunities for the future, liberal arts and humanities degrees are the way to go. STEM careers can ensure job opportunities and high earnings early on, but by the time a graduate enters the peak earning years, liberal arts degrees have caught up and, in some cases, surpassed the STEM degree earners. Besides, part of the argument is the ongoing nature of STEM skills development. Technology and computer science knowledge change rapidly and require increasing commitments to continued education over the long term (Newton, 2019; Shamir, 2020).

Conclusions

The majority of research supports a lack of effective implementation of STEM initiatives despite more than 2 decades of rhetoric. The lack of a cohesive approach is due to many factors, primarily the inability to agree on common definitions of STEM education, STEM literacy, and STEM integration, as well as a lack of conceptual frameworks to facilitate educator efforts (Kelley & Knowles, 2016; LaForce et al., 2016). A general sense of confusion pervades the educational landscape, with the result being little to no practical advice on the implementation of integrated STEM education reform within existing curricula (Dare et al., 2018). Teacher attitudes and perceptions have been positively correlated with STEM student achievement (Kelley et al., 2020); understanding teacher perceptions could prove a vital first step to the success of any STEM integration programs or efforts.

Gap in the Literature

A gap in the literature was identified as minimal research has explored how
administrators’ and teachers’ beliefs influence the implementation of integrated STEM in the classroom setting. STEM is more than an acronym, but until educators, policymakers, and stakeholders can agree on what STEM is and how STEM education should be taught, confusion, negativity, and ineffectual efforts may continue to pervade the educational landscape. This basic qualitative research study was conducted and analyzed under the theories of constructivism and social cognitive learning to align with the purpose of exploring and understanding teacher and administrator perceptions toward STEM and the integration of STEM curriculum.

Chapter Summary

A thorough review of the literature revealed a need for a qualitative study of teacher and administrator perceptions regarding STEM education and the implementation of integrated STEM curriculum. Teachers and administrators play a significant role in the success of curricular innovations such as student-centered learning strategies proven effective in STEM education. Research demonstrates a shift in the U.S. education system calling for more and improved integrated STEM education initiatives. STEM education, STEM literacy, and STEM integration remain ill defined, which hinders the adoption of STEM curriculum changes by teachers and educational organizations.

Constructivist and social cognitive theories guided this study and provided the lens through which results were analyzed. Integrated STEM curriculum, through the use of student-centered learning models such as problem-based learning, inquiry-based learning, and student collaboration, aids student engagement and connection of the learning material to personal experience, which aligns with constructivist philosophy (Yenmez et al., 2021). Social constructivist theory gives context to the integrated STEM classroom’s social environment, which fosters student interaction, observation, and interpretation of new information (Khudzari
et al., 2019). This study contributed to closing the gap in literature regarding teacher and administrator perceptions of integrated STEM education and the definitions of the various STEM terminologies. The following chapter explains the research methodology, data collection process, and analysis for this study.
Chapter 3: Methodology

Although evidence suggests occupations in the STEM fields are growing rapidly, the United States continues to fall behind the global competition in terms of STEM-literate graduates (Marksbury, 2017; Wang et al., 2011). This disparity may be partly due to educators who feel ill equipped to implement an integrated STEM curriculum in the classroom effectively. The problem is a lack of consensus on the definition of STEM education, which contributes to the absence of an integrated and consistent STEM curriculum in U.S. public schools. The purpose of this basic qualitative study was to explore the perceptions of teachers and administrators regarding the definition of STEM education and developing and integrating a uniform STEM curriculum at the Georgia public high school level. The following research questions guided this basic qualitative research study:

Research Question 1: What are administrator and teacher perceptions regarding STEM education and integrated STEM curriculum?

Research Question 2: What obstacles, if any, do teachers and administrators perceive to implementing a uniform curriculum in Georgia STEM high school courses?

The following sections discuss the research design and rationale, the role of the researcher, and research procedures. Data analysis, reliability and validity, and ethical considerations also are included in this chapter. A summary concludes and brings together the aforementioned elements.

Research Design and Rationale

Qualitative research focuses on understanding people’s perceptions, interpretations, and meanings attributed to personal experiences. This study methodology was based on the theory that people construct knowledge in an ongoing manner and that how individuals interact with
others and the environment affects the perception of experiences (Crotty, 1998). A qualitative approach was best to answer the research questions to explore and describe the perceptions and experiences of administrators and teachers regarding STEM curriculum. Research that calls for understanding experiences and interactions with the social world is best served by a qualitative methodology (Merriam & Tisdell, 2016). Under the umbrella of qualitative research are numerous distinctive approaches a researcher may utilize, one of which is basic qualitative research. Basic qualitative research does not follow a prescribed outline and does not fall within the traditional boundaries of other established designs such as phenomenology or grounded theory (Kahlke, 2014; Merriam & Tisdell, 2016). According to Merriam and Tisdell (2016), basic interpretive qualitative design is the most common qualitative research type in applied fields of practice, such as education.

A basic qualitative study was appropriate to investigate thoroughly and gain an in-depth understanding of the problem of this study; without the limitations of a specific qualitative methodological approach, truly interpretive research can be accomplished (Kennedy, 2016). Given the research questions were based on participant perceptions, basic qualitative research was appropriate as various aspects from each of the distinct qualitative designs can be used as needed (Kennedy, 2016; Patton, 2015). Unlike grounded theory, which would have focused on establishing an underlying theory based on the phenomenon, basic qualitative research had the benefit of understanding and interpreting the participants’ thoughts, perceptions, and feelings while maintaining an outward focus (Bellamy et al., 2016).

The main benefit of a basic qualitative design is permitting general qualitative concepts, such as constructivism and phenomenological underpinnings, while allowing for the incorporation of elements from the other established methodologies (Kahlke, 2014).
Phenomenology alone would not suffice as this study sought to understand the perceptions of participants and the processes surrounding the phenomenon; phenomenology does not explore processes (Patton, 2015). Quantitative research would have been inappropriate as it would have been limited to numerical data and would have relied on numerical analyses. In contrast, a qualitative study can emphasize rich descriptions and phrasing to interpret themes and underlying feelings (Patton, 2015).

Data were collected through use of a questionnaire and document analysis. A questionnaire was selected as the primary data collection instrument due to practical time constraints and participants’ anticipated accessibility. Other qualitative designs requiring observation over an extended period would not have been feasible.

**Role of the Researcher**

The role of the researcher was that of an observer-participant. As observer-participants, researchers interact closely with participants, often resulting in an insider’s identity; participants are aware of a researcher’s presence and role (Patton, 2015). I had a professional relationship with many of the prospective participants but no supervisory position. Due to a preexisting professional relationship, ethical issues such as coercion, undue influence, and research data protection were of paramount concern. Special care was taken during the informed consent process to ensure each participant understood inclusion is voluntary and would not affect employment. No social conversations were exchanged during distribution or collection of questionnaires and documents, to control bias and preserve the validity and reliability of data. No discussions about results occurred prior to conclusion of the study.

**Research Procedures**

Qualitative research provides an in-depth look at an experience to understand the
participants’ perceptions. The following subsections describe the research procedures of the study. The intended population, sample, instrumentation, and data collection procedures are detailed.

**Population and Sample Selection**

The target population was a purposively identified subset of 65 teachers and administrators at the research site. A top-ranked STEM-certified Georgia high school was chosen as the research site for this study. The research site has a highly selective and sought-after certified STEM Academy pathway in addition to a regular college preparatory curriculum. A letter requesting permission to conduct research at the site, including questionnaires and document analysis, was delivered to the school principal. A signed letter of approval was received (see Appendix A) granting permission to complete research contingent on Institutional Review Board (IRB) approval.

All teachers within the STEM disciplines in addition to teachers within the STEM Academy, regardless of discipline, were included in the target population. All administrators at the research site were also included in the target population. The target sample size was 15–25 teachers and three administrators purposively selected from the target population. Any teachers under the direct supervision of the researcher were excluded from participation. Purposive and deliberate selection of participants based on qualities or qualifications that the participants possessed was appropriate for this study, as qualitative research necessitates selecting participants from whom the most information and insight can be gained (Etikan et al., 2016; Patton, 2015).

To be eligible, teachers had to be teaching in a STEM pathway as part of the STEM Academy at the research site. All administrators were eligible because of involvement in
decision-making activities at a STEM-certified school. Age, race, and gender were not factored into eligibility. The target sample of 15–25 teachers and three administrators was randomly selected from the eligible target population and was approached via school-assigned email addresses and allowed to participate voluntarily. Given the potential for researcher bias to enter the study, random sampling minimized the potential for preexisting relationships to influence sampling decisions (Merriam & Tisdell, 2016). Informed consent documents were attached to the email or delivered in person, and signed consent was required prior to participation in the study. The email invitation to participate (see Appendix B) and informed consent (see Appendix C) are included. Failure to provide signed informed consent documents or failure to answer all questions resulted in exclusion from the study. Participants were also reminded of relevant informed consent factors prior to completion and collection of questionnaire responses and documents for analysis.

**Instrumentation**

This study utilized two data collection methods to facilitate triangulation of results: questionnaire and document analysis. Basic qualitative research often uses multiple data collection instruments, such as questionnaires and document analysis, to gather data (Denzin, 1978; Patton, 2015). All data collection instruments included in this study aligned with the research questions by allowing for richly descriptive interpretation of participant perceptions.

**Questionnaire**

For the initial questionnaire portion of the research, an existing research instrument was located in the 2013 dissertation of an East Tennessee State University doctoral student (Turner, 2013). The questionnaire was initially designed as a quantitative research survey to explore the perceptions of northeast Tennessee educators in connection with STEM education and served as
the basis for the instrumentation of this study. The original survey consisted of 20 binary-response questions and was reviewed for validity by additional members of the original researcher’s academic community (Turner, 2013). A permission letter (see Appendix D) was emailed to Turner. An email granting permission to reproduce, alter, and use the survey instrument toward the goals of the present research was obtained (see Appendix E). Survey questions were reworded to produce an open-ended questionnaire for this study. The questionnaire is included as Appendix F; all questionnaire items were transferred into Google Forms for the administration of the questionnaire to participants. Creswell and Creswell (2018) stated data gathered from qualitative studies are richly descriptive and comprise primarily words used by participants; an open-ended questionnaire to obtain the participants’ thoughts and perceptions was the most appropriate design to align with the research questions.

**Document Analysis**

Document analysis was also completed and used in the triangulation of the data with questionnaire responses. The triangulation of data across multiple sources contributed to reliability (Creswell & Creswell, 2018). All teacher participants were asked to submit a lesson plan that reflected the integration of two or more STEM disciplines within the STEM Academy. Submissions were lesson plans only and did not include any student work. Document analysis is a type of qualitative research instrumentation wherein provided documents are interpreted to give additional insight and meaning to a participant’s views on the phenomenon (Merriam, 2002). In this study, analysis of lesson plans formed a picture of the practical application of integration principles and a representation of the teachers’ conceptualizations of integrated STEM.

**Data Collection**

Following IRB approval (see Appendix G), data were collected in several ways. The
instruments utilized were a questionnaire and document analysis. The open-ended questionnaire was delivered to participants through Google Forms. Google Forms is a password-protected tool that allows for creating and analyzing surveys and questionnaires (Lindsay, 2016). Data were prepared for coding and analysis by downloading directly from Google Forms into Microsoft Excel and NVivo. Google Forms organizes responses individually and in summary format, requiring no preparation for data analysis aside from downloading the response files. For the document analysis portion of the research, participants were asked to provide a lesson plan demonstrating the integration of two or more of the STEM disciplines. The documents could be submitted in electronic or hard-copy format at each participant’s discretion.

To aid in maintaining participant confidentiality, a number was assigned to each participant upon receipt of informed consent. Subsequent questionnaire responses and submitted lesson plans were coded with the respective participant’s number and all names were removed. Participant names and corresponding numbers were maintained in a password-protected Microsoft Excel file and were known only to the researcher. All electronic data were stored on a secure, password-protected computer. All informed consent documents, researcher notes, and any hard-copy data were stored in a locked filing cabinet. Data will be maintained in a secure state for the mandated 3-year period and then destroyed in a manner that would prevent reconstruction (Office for Human Research Protections, 2018).

Participants were able to exit the study at any time; in such cases, data collected prior to participant departure were deleted or destroyed prior to data analysis. Due to the low-risk nature of this study, no debriefing or participant follow-up after completion of the research was necessary. Participants were provided with an email address through which questions could be submitted at any time during or after completion of the study.
Data Analysis

Data were coded and analyzed using an inductive thematic analysis framework. Thematic analysis involves identifying, analyzing, and interpreting themes within qualitative data (Braun & Clarke, 2006). Thematic analysis was appropriate for this study as it enabled a wide variety of information to be systematically analyzed to interpret and understand observations, perceptions, and thought processes (Boyatzis, 1998; Braun & Clarke, 2006). Braun and Clarke (2006) offered the following six steps regarding the thematic analysis of qualitative data: “familiarize oneself with the data, generate initial codes, search for themes, review themes, define and name themes, [and] produce the report” (p. 887).

Questionnaire responses and participant-provided documents were reviewed thoroughly, familiarity with all data was established, and initial notes were made (Braun & Clarke, 2006; Patton, 2015). The coding process was started by downloading the participant responses into NVivo. NVivo is a data analysis tool that allows for the organization, identification, and analysis of themes across sets of qualitative data. Initial codes were constructed from interesting or informative portions of the raw data using researcher notes and the NVivo auto-coding function; these codes were organized and subsequently manipulated using NVivo. Initial codes were grouped to form initial themes. A theme is an outcome of coding and analysis, a pattern; themes identify the meaning of a set of data (Braun & Clarke, 2006; Saldaña, 2016). Thematic analysis in NVivo was used to discover critical themes correlated with the findings, literature review, and theoretical framework. Content of the data guided coding and theme development. Data were again reviewed to support (or not) the identified themes; themes were collapsed or expanded where applicable to ensure internal homogeneity and external heterogeneity within and between themes (Braun & Clarke, 2006; Patton, 2015). Identified themes were then refined, defined (for
what they are as well as what they are not), and analyzed (Braun & Clarke, 2006). Lastly, final
synthesis of the themes ensured all aspects of the data set were represented, and a final report of
the findings was created.

**Reliability and Validity**

Reliability and validity are important concepts in any research design. *Reliability* is the
concept that outcomes would remain the same if the study were to be repeated; the dependability
of research results, and whether or not a study can be repeated (Carcary, 2009). *Validity* deals
with the credibility or trustworthiness of the data and analyses. The interpretive nature of
qualitative research requires careful attention to reliability and validity (Carlson, 2010).

Voluntary participation by all research subjects was the first step in ensuring reliability and
validity. Participants who volunteer for inclusion in a study without coercion are more likely to
provide truthful and accurate information (Kilinc & Firat, 2017).

Credibility, dependability, and confirmability were established through use of triangulation, and careful documentation throughout the research process. Triangulation is the
process of collecting data through the use of multiple instruments or methods (Patton, 2015). The
research involved the use of a questionnaire and document analysis for triangulation of the data.
Throughout the research process, vigilant documentation, from data collection through data
analysis and interpretation, contributed to the reliability and validity of the research and
subsequent analyses and conclusions (Carcary, 2009). Careful attention to all of the
aforementioned processes ensured the integrity of the research.

The findings of this study are potentially transferable; findings may be applicable to other
populations, contexts, or situations (Roberts et al., 2019). Transferability was established in this
study by providing thick, rich descriptions of data to convey findings and allow the reader to
know whether the content is transferable to other contexts. Thick description is a technique that
provides detailed and robust descriptions of the data and experiences during data collection
(Roberts et al., 2019).

**Ethical Procedures**

All research involves ethical considerations, particularly research involving human
subjects. Human subjects’ protection in both qualitative and quantitative research should be of
paramount concern during the research process. Since the inception of *The Belmont Report* by
the National Commission for the Protection of Human Subjects of Biomedical and Behavioral
Research (1979), the principles of respect for persons, beneficence, and justice have been
considered the standard to which all research involving human subjects has been held. This study
followed all federal guidelines and received IRB approval (see Appendix G).

All participants received an informed consent document as part of the initial invitation to
participate in the study (see Appendix B). Informed consent forms detailed the purpose of the
study, voluntary nature of the study, expected procedures, anticipated risk, and commitment to
confidentiality (see Appendix C). A signed informed consent document was required from each
participant prior to inclusion in the study.

Research documents and data were kept strictly confidential and safeguarded
appropriately. Digital data were maintained on a password-secured computer with password-
protected files. All hard-copy documents and data were kept in a locked safe or filing cabinet for
the duration of the research. All research documentation and data will be destroyed after 3 years
(Office for Human Research Protections, 2018).

Researching in one’s workplace can be ethically challenging. As such, any participants
presenting a conflict of interest were excluded from the study. All other participants were made
aware through informed consent that participation in the study is voluntary and that no action, direct or indirect, can be taken for refusal to participate. As an added measure, all participants were reminded of the continued voluntary nature of participation prior to completion of the questionnaire and document collection and were allowed to exit the study at any time. For any participants who chose to exit the study prior to completion, all research data pertaining to those participant were deleted or destroyed prior to analysis and omitted from the study.

Chapter Summary

Through a basic qualitative design, this study explored the perceptions of administrators and teachers regarding a uniform STEM curriculum. A basic qualitative research design was appropriate for this study as it allowed for analysis of participant perceptions, opinions, attitudes, and beliefs. Research design and rationale, role of the researcher, research procedures, data analysis, reliability and validity, and ethical procedures were addressed.

The following chapter includes an in-depth discussion of data collection, data analysis, and research results. Further discussion of how data were coded and organized into themes for analysis is included. Chapter 4 also includes results of the data collected, which were used to address the research questions.
Chapter 4: Research Findings and Data Analysis Results

STEM education reform remains a topic of great interest at local as well as national levels. The need for STEM-literate graduates is expected to increase, and it is imperative the United States makes the changes necessary to meet this growing demand to remain globally competitive (National Science Board, 2014; Scherer et al., 2019). Despite this obvious need, STEM education is poorly defined and no national or state guidelines exist to assist in a uniform implementation of STEM curricular standards or goals. The problem is a lack of consensus on the definition of STEM education, which contributes to the absence of an integrated and consistent STEM curriculum in U.S. public schools (English, 2016; Roehrig et al., 2021). The purpose of this basic qualitative study was to explore the perceptions of teachers and administrators regarding the definition of STEM education and obstacles to integrative STEM practices at the Georgia public high school level.

The study was conducted in a suburban Georgia high school. This research site was chosen due to its status as a top-ranked Georgia high school (as ranked by the Georgia Department of Education) with a highly sought-after certified STEM Academy pathway in addition to a regular college preparatory curriculum. The following research questions guided this qualitative study:

Research Question 1: What are administrator and teacher perceptions regarding STEM education and integrated STEM curriculum?

Research Question 2: What obstacles, if any, do teachers and administrators perceive to implementing a uniform curriculum in Georgia STEM high school courses?

Data collection, data analysis, and results are discussed in the following sections. The reliability and validity of the study, including principles of credibility, transferability,
dependability, and confirmability, are then addressed. A brief summary recaps the findings to the research questions and provides a transition to the final chapter of this study.

**Data Collection**

All participants were teachers who, at the time of the study, were part of a STEM pathway associated with the STEM Academy at the research site or were administrators at the research site. Following IRB approval, an invitation to participate (see Appendix B) was distributed to eligible participants; informed consent forms (see Appendix C) were collected during the subsequent 2-weeks. Following informed consent, participants were given an additional 2-week window within which to complete the questionnaire and lesson plan submission.

The invitation to participate was sent to eligible participants through school-assigned email addresses as an attached document. Respondents choosing to participate were required to submit the signed informed consent form prior to being provided the link to the questionnaire. The questionnaire (see Appendix F) was administered via a link to Google Forms that was emailed to participants. The questionnaire contained 18 open-ended questions and a request for submission of a sample integrated STEM lesson plan for analysis. Of 65 potential participants, 19 informed consent forms were obtained, and all 19 participants completed the questionnaire, providing a 100% response rate. Fourteen of the 19 participants submitted a lesson plan for analysis, providing a 74% response rate. Of the five participants who did not submit a lesson plan, three were administrators and were not expected to provide a lesson plan. The two teacher participants who did not submit a lesson plan were still included in the study as the informed consent advised that participants could refuse to answer any question for any reason. Neither participant indicated a desire to leave the study entirely and simply failed to submit a lesson plan.
No deviations from the data collection plan presented in Chapter 3 occurred. One participant reached out directly to the researcher for clarification on the submission format of the sample lesson plan. No other additional communication took place with participants, and no unusual or significant circumstances were encountered during data collection.

**Data Analysis**

Qualitative research allows for exploration of perceptions, opinions, and experiences of participants to gain insight into a specific problem or phenomenon (Crotty, 1998; Merriam & Tisdell, 2016). This research was conducted to identify teacher and administrator perceptions regarding STEM education and implementation of STEM curriculum in Georgia high schools. A basic qualitative approach was used to facilitate the use of general qualitative concepts such as constructivism and phenomenological underpinnings, while allowing for the incorporation of elements from the other established methodologies (Kahlke, 2014).

Questionnaire responses from all 19 participants were collected electronically through the use of Google Forms. All lesson plans were also collected in electronic format through direct email response and/or through the Google Forms document upload option. An inductive approach was used for data analysis. A student academic license to NVivo software was purchased and used to generate initial auto-codes for the data set. The data were then reviewed by hand, and auto-codes were manually expanded and collapsed to generate codes and subcodes from which themes began to emerge. This approach followed the steps to thematic analysis set forth by Braun and Clarke (2006): becoming familiar with the data, generating initial codes, compressing codes into axial themes, reviewing themes, defining and naming themes, and producing the report.
Lesson plans were coded beginning with a thorough review of all plans. The plans were then sorted by integration level demonstrated through component disciplines and cross-cutting concepts. Thematic analysis of the lesson plans involved reading and rereading as well as keeping detailed and reflective notes through each iteration. Themes began to emerge and were refined throughout the process. Identified themes were checked in correlation to the coded themes identified through the questionnaire data. Final themes and subthemes were named and defined.

The final phase of analysis was to produce the report of findings, including selected passages of participant data to support each theme and relate back to the guiding research questions. Data collection, organization, coding, and analysis are vital steps of the thematic analysis process. All data collected were included and analyzed to ensure a higher level of understanding relating to the research questions. Open coding followed by axial coding helped to identify the central themes in the data and formulate the results discussed in the following sections.

**Participant Characteristics**

The participant sample consisted of 19 teachers and administrators at a suburban high school in Georgia. Of the 19 participants, three (15.8%) were administrators and 16 (84.2%) were teachers. Additionally, participant education was broken down according to level of advanced degree, with all participants holding a master’s degree or higher; 47.4% held a master’s degree, 42.1% a specialist’s degree, and 10.5% a doctorate. Participants’ years of experience varied and are depicted in Figure 2. The majority of participants (42%) fell in the 6–10 years of experience range, followed by 21% in the 21–25 years of experience range. The breakdown of participants’ years of experience is depicted in Figure 2. Demographic information, such as
gender and age, was not collected as additional breakdown of results along these demographics was deemed outside the scope and goals of this research.

Figure 2

Participants’ Years of Experience

Results

Following the thematic analysis process outlined by Braun and Clarke (2006), initial codes were generated for data, then the data were reviewed for emerging themes and recoded. This process took several iterations, and five overarching themes were eventually named and defined: Conceptualization of STEM Education, Significance of STEM Education, Implementation of STEM in Existing Curriculum, District/School Support for STEM Education, and Obstacles to STEM Implementation and Integration. Findings from the questionnaire and document analysis were triangulated to build validity. The following five themes and associated subthemes were identified from the questionnaire and document analysis data.

Theme 1: Conceptualization of STEM Education

A central objective of the research was to identify participant perceptions of STEM education. One of the emergent themes to come from the data was a wide range of
conceptualizations surrounding the meaning of STEM education as well as discrepancy in the primary goals regarding student learning. These subthemes along with the corresponding key phrases (codes) that were used to define them are depicted in Table 1.

Table 1

Major Theme 1, Subthemes, Key Phrases

<table>
<thead>
<tr>
<th>Major theme</th>
<th>Subtheme</th>
<th>Key phrases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptualization of STEM education</td>
<td>STEM acronym</td>
<td>• Science, technology, engineering, and mathematics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Integration of two or more disciplines</td>
</tr>
<tr>
<td></td>
<td>STEM skills</td>
<td>• 21st-century skills</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Communication</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Collaboration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Critical thinking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Inquiry-based learning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Problem-based learning</td>
</tr>
<tr>
<td></td>
<td>STEM achievement</td>
<td>• Well rounded</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Higher performing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Advanced achievement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Balanced education</td>
</tr>
<tr>
<td></td>
<td>Career implications</td>
<td>• Changing technology</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Global workforce</td>
</tr>
</tbody>
</table>

STEM Acronym

Participants were asked to define STEM education in their own words. Through analysis of the responses, 14 of the 19 participants (73.6%) primarily defined STEM directly or indirectly through use of the STEM disciplines and the STEM acronym. Additionally, 11 of the 19 participants (57.9%) were able to identify that STEM involved the integration of two or more of
the related disciplines to form cross-cutting concepts and facilitate critical thinking and problem-solving abilities. Only one of the three administrators, Participant 1, went beyond the use of the acronym and defined STEM as “using critical thinking skills to solve problems in science, technology and math and conducting research in these areas for innovation.”

**STEM Skills**

Of the 19 participants, 11 referenced real-world problem solving or critical thinking skills as primary definition components. Participant 3 responded, “STEM allows students to develop critical thinking and communication skills as well as other transportable skills needed to be successful in the workplace. Using inquiry-based learning gives STEM students the fundamentals to face real-world obstacles.” Thirteen of the 19 participants referred to specific 21st-century skills, such as communication, collaboration, leadership, and technology proficiency.

**STEM Achievement**

The next most frequent codes under the conceptualization of STEM education theme pertained to student achievement. Participant responses believed STEM instruction results in a more well-rounded student and exposure to more academically challenging problems and material. Advanced achievement in the core subjects of science, technology, and mathematics was also singled out as resulting in higher performing and all-around balanced students. Eighty-six percent of respondents included some aspect of student achievement or balanced educational experience to their definition. Participant 2 defined STEM as follows: “STEM Education allows students to fully engage and provides a well-rounded education, which helps the students develop skills to use in the real world.”
**Career Implications**

One of the driving forces behind the push for STEM education reform has been to remain globally competitive regarding changing technology and engineering innovation. Eight participant responses referenced career implications. Five participant definitions were centered solely on students becoming part of the global workforce.

**Theme 2: Significance of STEM Education**

The theme of significance emerged from the coded data with two associated subthemes of real-world problem-solving skills and career opportunities. NVivo provided the ability to auto-code by intended participant sentiment, with breakdowns of *very positive, moderately positive, neutral, moderately negative*, and *very negative*. All auto-coded sentiments were reevaluated by hand to ensure tone was accurately interpreted by the software. Sixty-seven participant responses were coded *positive* or *negative* in tone, with 71.6% of coded responses falling in the *positive* end of the spectrum, indicating most participants viewed STEM initiatives with some degree of positivity. Subthemes and key phrases for this major theme are depicted in Table 2.

**Real-World Skills**

Real-world problem solving and inquiry-based learning strategies are cornerstones of integrated STEM education (Thibaut, Ceuppens, et al., 2018). Under the theme of significance, 70.5% of all coded responses related to learned STEM (21st-century) skills such as real-world problem solving, critical thinking, evidence-based learning, communication, and creativity.Participant 10 stated, “STEM education encourages students to be active learns [sic] in their school and community. It provides them real world application problems to research and solve.”
Table 2

*Major Theme 2, Subthemes, Key Phrases*

<table>
<thead>
<tr>
<th>Major theme</th>
<th>Subtheme</th>
<th>Key phrases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significance of STEM education</td>
<td>Real-world skills</td>
<td>• Problem solving</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Inquiry-based learning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Critical thinking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Communication</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Creativity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Evidence-based learning</td>
</tr>
<tr>
<td>Career opportunities</td>
<td></td>
<td>• STEM careers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Future jobs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Global workforce</td>
</tr>
</tbody>
</table>

From the questionnaire responses, 78.9% of respondents believed they implemented problem-based learning at least once a week. This sentiment was supported through triangulation with the lesson plans provided. Document analysis of the participant lesson plans showed a strong participant inclination to include real-world, problem-based learning strategies. Eleven of the 14 lesson plans (78.6%) demonstrated problem-based learning and involved at least one reference to a real-world scenario.

*Career Opportunities*

The second most frequently coded category of responses related to career opportunities afforded by STEM education. Considering the projected trend of STEM-related occupations, a focus on the importance of STEM education was to be expected. Participants 5 and 6 stated, “Most future jobs will require a level of expertise in technology and/or science” and “More and more jobs are being created that connect in some way to a STEM field,” respectively.
Theme 3: Implementation of STEM in Existing Curriculum

While participant responses to questionnaire items indicated the teachers believed they were doing well at integrating STEM concepts, analysis of the lesson plans indicated primarily multidisciplinary approaches to integration. Lessons were easily separated into their component disciplines, and integration of principles was superficial. The plans showed little evidence of deeper integration of the STEM concepts and skills beyond cursory integration of disciplinary principles. Table 3 breaks down the subthemes associated with the major theme as well as the associated key phrases (codes) used to define the subthemes.

Table 3

Major Theme 3, Subthemes, Key Phrases

<table>
<thead>
<tr>
<th>Major theme</th>
<th>Subtheme</th>
<th>Key phrases</th>
</tr>
</thead>
</table>
| Implementation of STEM in existing curriculum | Integration level     | • Problem solving  
                                      |                        | • Hands-on learning  
                                      |                        | • Multidisciplinary  
                                      |                        | • Interdisciplinary  
                                      |                        | • Transdisciplinary  
                                      | STEM instruction and concepts | • Core concepts  
                                      |                        | • Robotics  
                                      |                        | • Programming  
                                      |                        | • Inquiry  
                                      |                        | • Investigation  
                                      |                        | • Problem solving  
                                      |                        | • Cross-curricular connections  
                                      |                        | • Real-world application  |

Integration Level

Triangulation with document analysis supported that teachers were not practicing transdisciplinary integration of STEM principles; 11 of 14 lesson plans (79%) maintained an
overall focus on the specific discipline for which they were written. As an example, the lesson plan submitted by Participant 7 approached a chemistry concept with only cursory inclusion of middle school-level mathematical processes, no inclusion of technology, and no link to engineering, representing only a multidisciplinary level of mathematics integration. Three lesson plans (21%) demonstrated an interdisciplinary integration level. One of these lessons was a physics lab activity integrating science concepts and complex mathematics. This lesson, submitted by Participant 18, included review of the mathematics skills in addition to learning the science concepts. Both disciplines were still easily distinguished but were combined into a cohesive real-world application allowing students to make connections between the skills. None of the lesson plans indicated a transdisciplinary level of STEM integration. Figure 3 demonstrates the breakdown of integration level as determined through questionnaire responses and document analysis.

**Figure 3**

*STEM Lesson Plan Integration Level*
**STEM Instruction and Concepts**

Responses indicated a subtheme surrounding perceptions of what constitutes a STEM concept. Among the responses were the four primary STEM disciplines of science, technology, engineering, and mathematics, as well as robotics, programming, inquiry, investigation, and problem solving. Many participants identified that STEM instruction required cross-cutting strategies and cross-curricular connections. Participant 14 stated, “I teach a STEM course where students engage in cross-curricular projects between engineering and medical courses. Students also do culminating unit projects that encourage real-world application of course concepts.” Of 97 references under Theme 3, 32% of participant responses pertained to this subtheme of STEM instruction and STEM concepts.

**Theme 4: District/School Support for STEM Education**

Several questionnaire items related directly to perceptions of professional development, access to school assets, preparedness, and how well current conditions support student learning of 21st-century skills. Responses to specific questionnaire items were coded to determine sentiment and were found to be predominantly positive, with 25 specific references in the positive end of the scale and eight in the negative end of the scale. An example of a very positive participant response came from Participant 19: “I feel extremely prepared [sic] to implement STEM instruction within my classroom.” Conversely, Participant 2 expressed, “It’s great if the student is in the STEM academy, but outside that, some teachers have never been taught about STEM.” The theme of district/school support for STEM education emerged from the data and contained three subthemes of professional development, STEM-based courses, and educator proficiency in STEM concepts. The major theme, subthemes, and key phrases are depicted in Table 4.
Table 4

*Major Theme 4, Subthemes, Key Phrases*

<table>
<thead>
<tr>
<th>Major theme</th>
<th>Subtheme</th>
<th>Key phrases</th>
</tr>
</thead>
<tbody>
<tr>
<td>District/school support for STEM education</td>
<td>Professional development and proficiency</td>
<td>• Teacher interest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Certification levels</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Professional development</td>
</tr>
<tr>
<td></td>
<td>STEM-based courses</td>
<td>• Integration strategies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Inquiry-based learning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Technology implementation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Cross-cutting concepts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Engineering practices</td>
</tr>
</tbody>
</table>

*Professional Development and Proficiency*

Professional development opportunities \((n = 17)\) was the most common subtheme among teachers and administrators relating to district and school support. Some participants felt professional development opportunities were available or could be made available depending on teacher interest. Several participants also noted some STEM programs are certified by local, state, and national agencies and are therefore required to maintain a set degree of professional development. Other programs are limited only to specific training offered during preset professional development days. Participant 16 stated, “I have not participated in STEM professional development, but I am sure if I wanted or needed any support, my administrator would be happy to find resources and training for me.” Conversely, Participant 6 stated, “Honestly, I felt kind of thrown into the deep in [sic] the first time I taught the STEM ELA [English language arts] course. . . . STEM/English curriculum needs to be developed on the state and county levels.”
**STEM-Based Courses**

The school district has not significantly pushed for increased STEM initiatives and instruction. With the growing emphasis on STEM from the county level, many participants believed district support was geared toward courses with a STEM focus or STEM basis. Of the 45 responses associated with district support, 11 were related to STEM-based courses, particularly courses in the four core STEM disciplines. One of the teacher participants, Participant 16, indicated,

> Because [school] is STEM certified, STEM education is on the forefront of how we plan and implement lessons especially in the STEM coursework. Furthermore, the entire science curriculum in the state of Georgia and in [county] is based on crosscutting concepts and engineering practices, both of which are critical components of a true STEM education.

**Theme 5: Obstacles to STEM Implementation and Integration**

From the completed questionnaires, 35 responses and phrases were coded as obstacles to implementation and integration of STEM education in the current curricular landscape of Georgia public high schools. These responses were further categorized into three subthemes: student motivation, teacher proficiency, and insufficient time, listed in order of significance. Table 5 provides a breakdown of the key phrases used in coding to identify the major theme and subthemes.
Table 5

**Major Theme 5, Subthemes, Key Phrases**

<table>
<thead>
<tr>
<th>Major theme</th>
<th>Subtheme</th>
<th>Key phrases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obstacles to STEM implementation and integration</td>
<td>Student motivation</td>
<td>• Student disinterest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Minority students</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Female students</td>
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<tr>
<td>Teacher proficiency</td>
<td></td>
<td>• Teacher allotments</td>
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<td></td>
<td></td>
<td>• Teacher preparation</td>
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<td></td>
<td></td>
<td>• Teacher buy-in</td>
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<td>Insufficient time</td>
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<td>• Lack of teaching time</td>
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<tr>
<td></td>
<td></td>
<td>• Depth of integration</td>
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<td></td>
<td></td>
<td>• Maintenance of state standards</td>
</tr>
</tbody>
</table>

**Student Motivation**

Data from the questionnaire responses revealed a concern among participants regarding student motivation and continued student interest in the STEM fields, especially beyond the K–12 years. Two participants noted a concern for stimulating interest and involvement of more females and minorities in STEM programs. Another participant believed students are not exposed to enough diversity of STEM professions, which could reduce student motivation to enter and continue with a STEM-related pathway. Sixty-three percent of participant responses related to student motivation and continuation within STEM programs and career pathways. When ranking the top three challenges to STEM education in Georgia, Participant 17 stated, “Student attitudes and interests: There seems to be an overall student disinterest in STEM.”

**Teacher Proficiency**

One of the most frequently coded themes under the theme of obstacles to STEM
implementation was teacher proficiency and allotments. Participant statements indicated an inadequate allotment of teachers to fill the required STEM education roles within the research site. Several teachers also specifically mentioned lack of teacher preparation as a significant obstacle to STEM implementation. When asked to rank the top three obstacles facing STEM education in Georgia, Participant 1 stated “not enough teachers” as the top response. Additionally, Participant 2 stated the top challenge was “educating teachers about STEM and how to do it in the classroom,” while Participant 3 ranked “teacher buy-in” as the second most significant challenge. Nine of the 19 participants (47%) referenced teacher proficiency or lack of adequate staffing in some capacity within their questionnaire responses.

**Insufficient Time**

Participants expressed a concern regarding the lack of time available to adequately teach STEM content. Several participants noted insufficient time to delve deeply into STEM content while still covering all material required for success on state standardized testing in science. Participant 4 stated, “Time to implement STEM lessons and still cover necessary standards or having enough time in one 50-minute class period to implement a full STEM lesson.” Seven of the 19 participants referenced time as a challenge to implementation and successful depth of integration.

**Findings in Relationship to Research Question 1**

From the data collected and analyzed, teachers and administrators have an inadequate conceptualization of what constitutes STEM education. Many participants defined STEM education in terms of only the four core subjects. While a fair number of participants also referenced skills, achievement goals, and career implications, the definitions were wide-ranging and noncohesive, supporting the literature that states no solid definition exists among educators.
Without a cohesive definition, each educator can interpret STEM education differently and students may not receive a consistent educational experience.

Teachers and administrators expressed opinions primarily in support of STEM education and recognizing its significance in terms of real-world problem-solving abilities and career opportunities. Most participants believed they were successful in implementing integrated STEM with their current curriculum and attempted to include regular discussions about STEM-related career choices. Triangulation of the questionnaire data with the document analysis indicated integration of STEM concepts occurs, but only at a surface level, indicating much room for growth and improvement toward deeper levels of integration (e.g., interdisciplinary, transdisciplinary).

Participants’ perceptions of district/school support of integration strategies held a predominantly positive tone. Most respondents felt prepared and proficient with STEM education content and techniques; however, the majority of respondents failed to expand on STEM education beyond the four core disciplines, completely missing the components related to 21st-century skills. Sixty-seven participant statements were coded according to sentiment (positive tone or negative tone), and 72% believed the current climate of STEM education in the state of Georgia to be positive and encouraging of higher achievement, particularly in the science and mathematics disciplines.

While participant perceptions were predominantly positive, several negative sentiments were of note and stood out to the researcher. Regarding meeting the needs of 21st-century learners, Participant 2 stated,

I do not believe they [Georgia] are effectively meeting the needs of students across their time in education. While they [students] may receive high-quality STEM education in
one grade band or a handful of courses, it is not continuous across their K–12 education. Similarly, Participant 15 expressed concerns about how much application is actually STEM and not just verbiage: “STEM is a topic of discussion in my district a lot, but I’m not sure how many of the academies are actual STEM academies or just a rebranding of the math, science, and CTAE [Career, Technical, and Agricultural Education] departments.” Finally, when asked about the status of STEM education in Georgia, Participant 13 stated, “They are on the right path, but most schools need more money and flexibility to implement the programs on the level needed.”

**Findings in Relationship to Research Question 2**

Participants were asked to list and rank the three most important challenges facing STEM education in the state of Georgia. The most common subtheme was student motivation. Encouraging students to pursue STEM courses and, ultimately, STEM-related careers remains a major challenge to the implementation of STEM programs and reform. Participant 16 stated, “Keeping the students motivated without them feeling overwhelmed.” Likewise, Participant 17 stated,

Student attitudes and interests: There seems to be an overall student disinterest in STEM. I think the STEM fields are viewed by students as hard and there is little education about the diversity of STEM careers available in the workforce.

The second most commonly occurring subtheme was teacher preparation and proficiency. Contrary to the findings for Research Question 1, which indicated most of the respondents felt prepared and proficient in their implementation of STEM strategies, over half of respondents listed teacher professional development or teacher support as a top challenge. Demonstrating this sentiment, Participant 2 responded, “Educating teacher [sic] about STEM and how to do it in the classroom” as the number one challenge facing STEM education in Georgia.
Last was the subtheme of insufficient time. Just over one third of participants expressed a concern with the amount of time available for implementing in-depth STEM instruction, especially when done in conjunction with state standards unrelated to STEM instruction. Participant 4 stated “time to implement STEM lessons and still cover necessary standards or having enough time in one 50-minute class period to implement a full STEM lesson” as one of the top three challenges facing STEM instruction.

**Reliability and Validity**

*Credibility* in qualitative research refers to a study’s internal validity, or the confidence that can be placed on the accuracy of the findings (Korstjens & Moser, 2018). When the results accurately represent the participant data and a correct interpretation of participant views, results have credibility. Credibility was established in this study through the use of triangulation and persistent observation. Persistent observation is the identification of elements most relevant to the problem, coding, analysis, and recoding until final analysis provides the intended depth of insight (Korstjens & Moser, 2018). Failure of two teacher participants to submit lesson plans for analysis presents a potential threat to the credibility of the research findings, which is addressed further in the limitations section of Chapter 5.

**Transferability**

Findings of this study are potentially transferable to other contexts and settings, specifically other large suburban schools in the southeastern United States. Transferability of this study is established by providing thick, rich descriptions of data to convey the findings to allow the reader to determine whether the content is transferable. Thick description provides detailed and robust descriptions of the data and experiences during data collection (Roberts et al., 2019). Including descriptions of the context of the data also aids the reader in determining
transferability (Korstjens & Moser, 2018). While not intended to be generalizable at large, this study facilitates an understanding at the high school level and in a regional context.

**Dependability and Confirmability**

A key aspect of reliability for qualitative research is the principle of *dependability*, or trustworthiness of the research. Dependability of the study was maintained through triangulation of the data and careful researcher notes to establish an audit trail. *Confirmability* of the research is the degree to which the study results reflect the participant views and not the bias or personal interests of the researcher (Christenbery, 2017). To aid in maintaining confirmability, reflexivity was routinely performed during review and analysis of the data. All data and results were carefully documented and maintained, and researcher bias was minimized through bracketing. Data were also continually checked and rechecked for accuracy to increase confirmability of the study.

**Chapter Summary**

The goal of this basic qualitative study was to gain deeper insight into the perceptions of teachers and administrators regarding STEM education and integrated curriculum. Emergent themes were developed based on participant responses to the questionnaire as well as document analysis of teacher lesson plans. Data were presented in the form of tables, and quotations from participant responses were included to support the emergent themes. Research Question 1 found an overall positive teacher and administrator outlook on the nature and climate of STEM education. Teacher and administrator definitions of STEM education were primarily superficial, with a small percentage of respondents including transdisciplinary wording and concepts. Pertaining to Research Question 2, participants believed student motivation, teacher proficiency and preparation, and insufficient time were significant challenges facing STEM education in
The final section of this dissertation is the discussion section, presented in the following chapter. Included in this discussion are detailed descriptions of results, interpretations, and outcomes. Limitations of the study as well as recommendations for future research also are presented.
Chapter 5: Discussion and Conclusion

The purpose of this basic qualitative study was to explore the perceptions of teachers and administrators regarding the definition of STEM education and integrative STEM practices at the Georgia public high school level. The goal of the research was to understand teacher perceptions related to STEM integration as well as perceived obstacles to implementing STEM curricular initiatives. Teacher and administrator attitudes can play a significant role in the success of curricular innovations and initiatives (K. Gardner et al., 2019). By exploring the understandings and perceptions of teachers and administrators, this study highlighted perceived obstacles that may help leaders and policymakers in developing a uniform integrated STEM curriculum.

Research Question 1 explored teacher and administrator perceptions regarding STEM education and integrated STEM curriculum. Themes that emerged for the first research question were conceptualization of STEM education, significance of STEM education, implementation within existing curriculum, and district/school support for STEM education. Findings indicated a wide range of conceptualizations of what constitutes STEM education, and while the majority of respondents recognized the importance of STEM education and support STEM initiatives, significant challenges and concerns existed.

Research Question 2 examined the obstacles teachers and administrators perceived to implement a uniform curriculum across Georgia high school courses. The most common themes to emerge were student motivation, teacher preparation, and insufficient time. The theme of inadequate teacher preparation and lack of professional development opportunities stood in contrast to the responses related to Research Question 1 that indicated the majority of respondents felt prepared and proficient in STEM content and strategies.

The following sections present research findings and interpretations, limitations, and
Findings, Interpretations, Conclusions

Results from this research revealed teacher and administrator perceptions about STEM education and integrated STEM education initiatives. Four major themes emerged in correlation to Research Question 1. These themes indicated an overall lack of consensus as to the meaning of STEM education. The majority of respondents relied on the STEM acronym and disciplines as a main component of the definition. While a lack of uniform definition compounds the issues surrounding STEM education reform, data analysis reflected most teachers and administrators value STEM education as a way to produce well-rounded students prepared to pursue competitive technology and engineering careers and become successful global citizens.

While a majority of respondents indicated feelings of proficiency and effectiveness at integrating STEM concepts with existing curriculum, document analysis revealed the majority of respondents were only integrating STEM concepts at a basic multidisciplinary level. Through responses to multiple questionnaire items, teachers indicated predominant feelings of efficacy and proficiency in implementing STEM concepts. However, when directly questioned on challenges and obstacles to STEM implementation, more than half of respondents listed professional development as a key obstacle. This result indicates the superficial level of integration is likely a direct result of the deficiency in fully conceptualizing the meaning of STEM education and lack of practical support and strategies for implementation.

Findings in Comparison to Literature

The findings of this study further validate and expand on the knowledge presented in Chapter 2. Themes emerging from the data were compared to the extant literature and are
discussed as follows. Findings in contrast to or beyond the knowledge of the existing literature are noted.

**STEM Literacy, STEM Education, and STEM Integration**

The complex components and related definitions of STEM education, STEM literacy, and STEM integration were presented in Chapter 2. The literature demonstrated the multiple definitions of the STEM-related terms among scholars (Dare et al., 2018; English, 2016; Helmane & Briška, 2017; Martin-Paez et al., 2018; Nadelson & Seifert, 2017; Roehrig et al., 2021; Thibaut, Knipprath, et al., 2018). Results of the study supported the literature by indicating teachers and administrators lack consensus on a definition of STEM education and exhibit only basic levels of integration.

**Teacher Preparation and Efficacy**

Questionnaire and document analysis showed the teachers felt capable of integrating STEM concepts but also indicated a lack of professional development and practical supports as a top challenge. Ryu et al. (2019) highlighted similar findings that point to a disconnect between theory and practice. Especially at the high school level, teachers are usually educated and trained in a specific disciplinary area. As a result, teachers can understand the importance of cross-disciplinary concepts while acknowledging their own knowledge is limited by current models of teacher preparation and often does not extend beyond their specific discipline, making genuine transdisciplinary integration extremely difficult if not impossible under the present educational structure.

**Lack of Consensus**

Perhaps most important, the results of this study corroborated the findings of Dare et al. (2018); English (2016); Roehrig et al. (2021); Thibaut, Ceuppens, et al. (2018); and Thibaut,
Knipprath, et al. (2018) that stated the abundance of opinions and definitions regarding STEM education and its application only serve to compound the issue and perpetuate an unclear path forward in STEM education reform. Multiple definitions and conceptualizations have resulted in multiple methods of integration and implementation. Without uniform curricular goals, educators can feel capable of implementing STEM education principles while having no real impact on student achievement or acquisition of 21st-century skills.

Findings in Context of Theoretical Framework

The study explored the perceptions of teachers and administrators regarding STEM education and integrated STEM curriculum in the state of Georgia. The theoretical framework for this study was a combination of constructivist learning theory (Vygotsky, 1978) and social cognitive theory (Bandura, 1977). These pivotal learning theories intersect in the belief that social interaction is necessary to facilitate full cognitive development and that meaning is attributed to and derived from these social interactions.

Interactions with teachers as well as peers can have a profound impact on student learning. Teacher perceptions can also have a significant impact on student achievement and student self-efficacy (K. Gardner et al., 2019). By understanding teacher perceptions and perceived obstacles to implementing STEM education, policymakers can work to correct misconceptions and negative feelings, thereby effecting positive change in student outcomes. Students are likely to mirror the behaviors and attitudes of teachers and peers; facilitating an environment in which STEM education is valued and rigorously pursued by the faculty will result in students who value and strive for STEM content knowledge as well (K. Gardner et al., 2019).

In addition to providing perspective regarding the impact teacher perceptions can have on
student achievement, the theoretical framework highlighted the importance of experiential learning. By embracing STEM learning models such as problem-based learning and inquiry-based learning, teachers can positively impact student achievement. The theoretical framework provided the context through which this study showed a need for development and implementation of cohesive and uniform curricular approaches to student instruction as well as the importance of fostering positive teacher and administrator perceptions through interactions and continued professional development.

Conclusions

While not generalizable due to the nature of this qualitative research, when viewed against the theoretical framework and existing literature, the findings of this study give rise to several conclusions. Teachers and administrators view STEM education as necessary for students to pursue STEM-related occupations and gain key 21st-century skills. While the majority of respondents felt adequate at implementing integrated STEM concepts, actual levels of integration were superficial at best. This study, combined with the existing body of literature, points to the underlying disconnect between perceived importance and actual implementation being due to a lack of cohesive definition as well as a lack of defined curricular standards.

Limitations

Three primary limitations apply to this study. First, the study focused on a single large suburban high school in Georgia. The limited sample population gives rise to some concern for the transferability of the findings. Transferability refers to how well the findings can be applied to similar environments and populations (Roberts et al., 2019). The research remains potentially transferable through the use of thick, rich descriptions of data allowing the reader to determine the level of transferability based on specific context.
The second limitation relates to availability of research participants. Informed consent forms and initial questionnaire communications were conducted during summer break for the research site and extended into the teacher preplanning period for the starting school year. With an adjusted or expanded data collection time frame, additional participants may have been able to respond.

Finally, the study lacks generalizability due to the nature of the qualitative design. Adding a layer of data collection in the form of interviews and member checking could improve the richness and depth of information. While the findings of this research were triangulated using both questionnaire responses and document analysis, interviews coupled with member checking of transcripts and researcher notes would have provided an added opportunity to explore and clarify participant feelings and perceptions.

**Recommendations**

Recommendations for future research and changes in practice are grounded in the themes that emerged from the data analysis and findings. The push for STEM education expansion and reform continues to be a national and international issue. A disconnect remains between theory and practice, which is further compounded by obstacles both real and perceived. Following are the recommended changes in practice and further research that are supported by the findings.

Results indicated the lack of a uniform and consistent definition of STEM education perpetuates difficulties in implementation of STEM curricular initiatives and changes. The primary recommendation is the consensus on and adoption of a detailed and uniform definition to STEM education, STEM literacy, and integrated STEM curriculum. Ideally, the formation and dissemination of this definition should take place on a national level, but adoption at any level (school, district, state) would be an improvement and would pave the way for continued change.
Based on this research, teachers also perceived obstacles to integrated STEM education, including a lack of professional development and practical supports. Teachers should be provided with added professional development opportunities related to STEM education to foster and maintain feelings of proficiency and preparedness. Additionally, ensuring adequate time for collaborative activities will allow teachers to share their knowledge, skills, and ideas, creating a more cohesive and uniform experience for STEM students. Allowing for an increase in peer observation, especially of teacher leaders, would also help educators to envision and understand what best-practice STEM integration should look like.

Recommendations for further research include an expanded participant sample and use of a quantitative or mixed-methods study to provide statistical analysis relating teacher perceptions and student achievement. As noted in the limitations section of this chapter, the small and narrowly focused participant sample potentially limited the transferability of the study results. A broader participant pool, from several schools within the same district or several schools across districts, should provide a greater degree of transferability as well as a more comprehensive picture of STEM education for the state of Georgia. Future research should avoid the use of a solely quantitative methodology as a qualitative element provides in-depth exploration of beliefs and perceptions that a strictly quantitative approach may not provide (Creswell & Creswell, 2018).

Future research should focus on the obstacles identified through the second research question of this study. Whether merely perceived or actual, obstacles to implementing and effectively exercising integrated STEM curriculum can have a significant impact on the effectiveness of STEM programs and reform. Exploring the identified obstacles in more detail can help administrators and policymakers to enact changes that will mitigate the impact on
Much of the existing literature also hinges on the underlying assumption that STEM education results in STEM-literate graduates and, ultimately, choices of STEM-related careers (J. Brown, 2012; El Nagdi et al., 2018; English, 2016; Kelley et al., 2020; LaForce et al., 2016; Roehrig et al., 2021). Additional research tying STEM education with STEM literacy and choice of university major could prove interesting and beneficial to policymakers. Results of this research could be further synthesized with additional research to indicate connections between teacher perceptions at the high school level and students’ choice of STEM or non-STEM majors in higher education.

**Implications for Leadership**

Based on existing literature combined with the results of this study, several implications for leadership emerge. STEM education positively impacts student interest in STEM majors and careers (Kelley et al., 2020). By exploring the understandings and perceptions of teachers and administrators, leaders can begin to understand perceived benefits and challenges regarding STEM education and integrated STEM curriculum at a practical level. If unified definitions of STEM education and its associated terms can be determined, policymakers can begin to provide the guidelines and support necessary for teachers to embrace integrated STEM initiatives. Further, by attempting to understand what obstacles may contribute to the lack of developing a uniform integrated STEM curriculum, educational leaders can start to create solutions that will improve STEM reform initiatives locally and worldwide.

This study indicates teachers and administrators understand the necessity and value in developing and implementing STEM content. However, results also point to a disconnect between theory and practice coupled with problems in conceptualization of exactly what STEM
content should look like. Leadership efforts should be centered on equipping teachers with the necessary skills and training to integrate STEM content at a transdisciplinary level.

The present structure of teacher education and preparation programs focuses on single-discipline specialization and rarely includes complex technology or engineering concepts. This lack of training leaves teachers ill prepared to effectively implement cross-disciplinary teaching and learning strategies. Restructuring of teacher preparation programs, as well as access to meaningful professional development opportunities, may be necessary and would require support of leadership at all levels in addition to significant sources of funding.

Leaders at the local (school) level are often unable to enact meaningful change due to district- and state-level standards, leaving teachers feeling pressed for time and attempting to teach STEM concepts without definitive guidelines. Educational leaders need to focus on a cohesive definition of STEM education as well as the development of uniform curricular standards to be followed. Without a groundbreaking shift in teacher education, it becomes imperative that leaders allow for adequate professional development and collaboration through which teachers can learn the content knowledge and skills necessary to teach at a transdisciplinary level. The findings of this study have the potential to further inform how educational leaders and schools approach teacher education, creating positive social change by ensuring educational professionals are adequately prepared to teach transdisciplinary STEM concepts.

**Conclusion**

This qualitative study focused on teacher and administrator perceptions regarding the definition of STEM education and developing and integrating a uniform STEM curriculum at the Georgia public high school level. Results indicated the teachers and administrators held opinions
largely in support of STEM education and recognized the significance of STEM to future careers and economic success. However, results also indicated the teachers wanted additional professional development and practical supports to help integrate STEM with existing curriculum. This disconnect demonstrates the primary conclusion that the lack of consensus regarding definition results in inconsistent and superficial integration of STEM concepts. Time was also noted as a significant perceived obstacle to implementing effective in-depth STEM instruction.

Educational leaders could use the results of the study to identify and solve the perceived obstacles to integrated STEM education. Implications include the necessity for a comprehensive and uniform definition of STEM education and development of uniform STEM standards that could be used by educators at all levels. Future research focused on student achievement related to STEM curricular initiatives and students’ ultimate interest in STEM-related careers could provide additional information to Georgia educators and policymakers to continue implementing effective STEM education reform.
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Appendix A

Site Permission Letter

October 7, 2020

Dear Mr. Ruggiero:

This letter is to serve as my written permission for you to interview teachers and administrators at [redacted] as a doctoral candidate at American College of Education (ACE). The information will be used in your dissertation: Teacher Perceptions of STEM Curriculum Integration and Application: A Qualitative Study.

Sincerely,

[Redacted]
Appendix B

Invitation to Participate

Date: June 16, 2021

Dear Perspective Participant,

I am a doctoral student at American College of Education. You are invited to participate in a dissertation research study. The research concerns teacher perceptions of STEM curriculum integration and application. The purpose of this basic qualitative study will be to explore, understand, and describe the perceptions and experiences of teachers and administrators with regard to the definition of STEM education and developing and integrating a uniform STEM curriculum.

Responses and data will be collected through an electronic questionnaire and document analysis.

Your participation in the study is completely voluntary. If you wish to withdraw from the research at any time, you may do so by contacting me using the information below.

I may publish the results of this study; however, I will not use your name nor share identifiable data you provided. Your information will remain confidential. If you would like additional information about the study, please contact the following:

Principal Investigator: Angelo Ruggiero
Email: angelo.ruggiero3188@my.ace.edu
Phone: 770-855-3012

Dissertation Chair: Dr. Wendy Reisinger
Email: wendy.reisinger@ace.edu

If you are interested in participating in the study please review, sign, and send back the attached informed consent document.

Thank you again for considering this dissertation research opportunity.

Angelo Ruggiero
Appendix C

Informed Consent

Prospective Research Participant: Read this consent form carefully and ask as many questions as you like before you decide whether you want to participate in this research study. You are free to ask questions at any time before, during, or after your participation in this research.

Project Information

Project Title: Teacher Perceptions of STEM Curriculum Integration and Application: A Qualitative Study

Researcher: Angelo Ruggiero
Organization: American College of Education
Email: angelo.ruggiero3189@my.ace.edu Telephone: 770-855-8012

Researcher’s Dissertation Chair: Dr. Wendy Reisinger
Organization and Position: American College of Education, Dissertation Coordinator
Email: wendy.reisinger@ace.edu

Introduction
I am Angelo Ruggiero, and I am a doctoral candidate student at American College of Education. I am doing research under the guidance and supervision of my Chair, Dr. Wendy Reisinger. I will give you some information about the project and invite you to be part of this research. Before you decide, you can talk to anyone you feel comfortable with about the research. This consent form may contain words you do not understand. Please ask me to stop as we go through the information, and I will explain. If you have questions later, you can ask them then.

Purpose of the Research
The purpose of this basic qualitative study will be to explore, understand, and describe the perceptions and experiences of teachers and administrators in a top-ranked Georgia high school with regard to the definition of STEM education and developing and integrating a uniform STEM curriculum. Information collected could help schools make informed decisions about the development and implementation of STEM curriculum.

Research Design and Procedures
The study will use a qualitative methodology and basic qualitative research design. An 18 item open-ended questionnaire will be disseminated to specific participants within Lassiter High School. The study will be comprised of 15-25 participants, randomly selected, who will participate in a questionnaire, and document analysis. Each participant will be asked to submit a lesson plan which they feel demonstrates integrated STEM curriculum in their classroom.

Participant selection
You are being invited to take part in this research because of your experience as an educator who can contribute much to the field of STEM Education, which meets the criteria for this study. Participant selection criteria: educators must currently teach in a STEM pathway as part of the STEM Academy at Lassiter High School.

© 2020 American College of Education
Voluntary Participation
Your participation in this research is entirely voluntary. It is your choice whether to participate. If you choose not to participate, there will be no punitive repercussions and you do not have to participate. If you select to participate in this study, you may change your mind later and stop participating even if you agreed earlier.

Procedures
I am inviting you to participate in this research study. If you agree, you will be asked to answer an 18 item electronic questionnaire through Google Forms and provide a sample lesson plan demonstrating integrated STEM curriculum in your classroom. The type of questions asked will range from general demographic information to direct inquiries about the topic of STEM Education and Curriculum.

Duration
The electronic questionnaire should take approximately 15-20 minutes to complete. The lesson plan may be submitted at your convenience.

Risks
The researcher will ask you to share your personal and professional views regarding STEM education and STEM curriculum. If at any time you feel uncomfortable discussing a question or topic, you do not have to answer or take part in the discussion if you choose not to. You do not have to give any reason for not responding to any question. All information obtained throughout this research will remain confidential.

Benefits
While there will be no direct financial benefit to you, your participation is likely to help us find out more about implementing STEM curriculum. The potential benefits of this study will help schools in making informed decisions regarding development and implementation of STEM curriculum.

Reimbursement
You will receive no reimbursement for participation in this study.

Confidentiality
I will not share information about you or anything you say to anyone outside the research team. During the defense of the doctoral dissertation, data collected will be presented to the dissertation committee. The data collected will be kept in a locked file cabinet or encrypted computer file. Any information about you will be coded and will not have a direct correlation, which directly identifies you as the participant. Only I will know what your number is, and I will secure your information.

Sharing the Results
At the end of the research study, the results will be available for each participant. It is anticipated to publish the results so other interested people may learn from the research.

Right to Refuse or Withdraw
Participation is voluntary. At any time, you wish to end your participation in the research study, you may do so without repercussions.
Questions About the Study
If you have any questions, you can ask them now or later. If you wish to ask questions later, you may contact Angelo Ruggiero. This research plan has been reviewed and approved by the Institutional Review Board of American College of Education. This is a committee whose role is to make sure research participants are protected from harm. If you wish to ask questions of this group, email IRB@ace.edu.

Certificate of Consent
I have read the information about this study, or it has been read to me. I acknowledge why I have been asked to be a participant in the research study. I have been provided the opportunity to ask questions about the study, and any questions have been answered to my satisfaction. I certify I am at least 18 years of age. I consent voluntarily to be a participant in this study.

Print or Type Name of Participant: __________________________

Signature of Participant: __________________________

Date: __________________________

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily. A copy of this Consent Form has been provided to the participant.

Print or type name of lead researcher: Angelo F. Ruggiero

Signature of lead researcher: __________________________

Date: __________________________

Principal Signature __________________________

Date: __________________________

PLEASE KEEP THIS INFORMED CONSENT FORM FOR YOUR RECORDS.
Appendix D

Request for Permission to Use Instrument

October 8, 2020

Dr. Kristin Turner
Santa Rosa Beach, FL

Dear Dr. Turner:

My name is Angelo Ruggiero and I am a doctoral candidate at American College of Education (ACE) writing to request permission to use instrument Northeast Tennessee Educators’ Perception of STEM Education Implementation. This information will be used for my dissertation research related to Teacher Perceptions of STEM Curriculum Integration and Application: A Qualitative Study. The purpose of the basic qualitative study will be to explore, understand, and describe the perceptions and experiences of teachers and administrators in a top-ranked Georgia high school with regard to the definition of STEM education and developing and integrating a uniform STEM curriculum.

Important Contacts for this study include:

Principal Investigator: Angelo Ruggiero
E-mail: Angelo.Ruggiero@cobbk12.org
Phone: 770-855-8012

Dissertation Chair: Dr. Elizabeth Johnson
E-mail: Elizabeth.Johnson@ace.edu

Thank you for your attention to this issue and prompt response. I appreciate your time and consideration of my request.

Regards,

Angelo F. Ruggiero
Appendix E

Email Granting Permission of Instrument Use

From: Xiuyu Turner
To: Angelo Ruggiero
Subject: Email Granting Permission of Instrument Use

Hi Angelo,

I am a current doctoral candidate working on my dissertation at the American College of Education on STEM Education and Curriculum. I would like to seek your permission to utilize your survey instrument for my study. I would alter it slightly to meet the needs of my research. I can send you a formal request letter, but wanted to start with an email to introduce myself first. My personal email is raymond.brinkley@umflint.edu, which is the one I use for school.

Thank you in advance for your time.

Angelo Ruggiero
Appendix F

Questionnaire

STEM Curriculum Questionnaire

1. What is your position at Lassiter High School?
2. How many years of experience do you have within this role?
3. What is the highest level of advanced degree that you hold?
4. Why do you perceive a need for STEM education?
5. In your own words, define STEM education:
6. To what extent has "STEM Education" been a topic of discussion in your district and/or school?
7. Some schools and districts have implemented programs and courses focused on STEM education. Does your school have programs which integrate core concepts of STEM?
8. To what degree do you implement/observe STEM instruction in the classroom setting?
9. How often do you implement/observe inquiry-based, problem solving activities in the classroom setting?
10. How has STEM resulted in the ability to spend more time teaching the related fields?
11. How is technology used throughout your STEM program as a tool to facilitate research, investigation and design?
12. What professional development opportunities around STEM education are regularly provided to teachers in your school?
13. Do you have adequate access to STEM assets (libraries, agencies, professionals, museums, etc)? Please explain.
14. The unique characteristics of STEM education may require the use of alternative instructional techniques for effective instruction of STEM concepts. What instructional techniques do you utilize?
15. How prepared do you feel for the implementation of STEM instruction/curriculum in your classroom/school?

16. In a nine-week period, how often are you able to integrate discussions that help students become aware of STEM careers?

17. How are the current conditions of STEM education in Georgia meeting the needs of 21st Century Learners?

18. In your opinion, what are the 3 most important challenges facing STEM education?

Please rank your top 3 most important challenges with 1 being the greatest.
Appendix G

IRB Approval

June 16, 2021

To: Angelo Ruggiero
   Wendy Reisinger, Dissertation Committee Chair

From: Institutional Review Board
       American College of Education

Re: IRB Approval

"Teacher Perceptions of STEM Curriculum Integration and Application: A Qualitative Study"

The American College of Education IRB has reviewed your application, proposal, and any related materials. We have determined that your research provides sufficient protection of human subjects.

Your research is therefore approved to proceed. The expiration date for this IRB approval is one year from the date of review completion, June 16, 2022. If you would like to continue your research beyond this point, including data collection and/or analysis of private data, you must submit a renewal request to the IRB.

Our best to you as you continue your studies.

Sincerely,

Tiffany Hamlett
Chair, Institutional Review Board