ABSTRACT

BOAKYE, CHRISTIAN. Teacher Perspectives on Interdisciplinary STEM Education in Special Education: A Phenomenological Case Study. (Under the direction of Dr. Denson).

This study sought to understand the lived experiences and perspectives of special education teachers regarding interdisciplinary STEM education using a phenomenological case study qualitative design. The study took place in a rural district in the Southeast region of the United States of America. The participants included six special education teachers with diversity in years of experience, educational degrees, background, and ethnicity. Data collection centered around semi-structured interviews and a STEM classroom observation. Data analysis focused on a coding process to interpret the interview data.

Findings suggest that special education teachers find the integration of STEM education within specially designed instruction increases student engagement and motivation. However, there are a number of challenges that make implementation difficult, such as time, lack of resources, lack of professional development, lack of follow-up, and lack of a strategic implementation plan.

Teachers' Perspectives on Interdisciplinary STEM Education in Special Education: A Phenomenological Case Study.

By Christian Boakye

A dissertation submitted to the Graduate Faculty of North Carolina State University in partial fulfillment of the requirements for the degree of Doctor of Education

Technology Engineering Design

Raleigh, North Carolina

2025

APPROVED BY:

Dr. Cameron Denson, Chair	Dr. Tamecia Jones
Dr. Aaron Clark	Dr. Jai Jackson

DEDICATION

I dedicate this work, first and foremost, to God Almighty, whose grace, wisdom, and unwavering presence have guided me through this journey. His strength sustained me during the most challenging times, and His blessings have made this achievement possible.

To my wife, Dr. Faith Boakye, your love, patience, and support have been my anchor. Thank you for standing beside me, believing in me even when I doubted myself, and being my source of strength throughout this process.

To my children, Asher, Ian, Jaxon, Ziva, may this work serve as a reminder that perseverance, faith, and hard work can lead to the fulfillment of dreams.

To my parents, who have been my greatest source of inspiration, love, and encouragement. Your sacrifices, prayers, and unwavering belief in my abilities have given me the foundation to pursue my dreams. This accomplishment is as much yours as it is mine.

To my siblings, Robert, Linda & Stanley, extended family, small group, and dear friends, your constant encouragement, prayers, and words of support have been invaluable. Thank you for always pushing me forward and celebrating every milestone with me.

To the educators and students in special education, especially those dedicated to making interdisciplinary STEM education more inclusive, this work is for you. Your passion and commitment inspire meaningful change, and I hope this research contributes to your efforts in making learning accessible for all.

Finally, to all those who have supported, guided, and uplifted me along this journey, I dedicate this dissertation as a testament to the power of faith, resilience, and unwavering support.

With deepest gratitude and love,
Chris Boakye
2025

ACKNOWLEDGMENTS

First and foremost, I give all glory, honor and praise to the Lord God Almighty, who has been my strength, guide, and source of wisdom throughout this journey. Without His grace, favor, and endless mercies, I would not have reached this milestone. Through every challenge, He provided me with perseverance, clarity, and resilience, and for that, I am eternally grateful. I extend my heartfelt gratitude to my advisor, Dr. Cameron Denson, for his unwavering support, invaluable mentorship, and continuous encouragement. His guidance has been instrumental in shaping my research and fostering my growth as a scholar. His constructive feedback and belief in my work have been deeply appreciated throughout this process.

I am also profoundly grateful to my dissertation committee members, Dr. Aaron Clark, Dr. Tamecia Jones, and Dr. Melvin Jackson, for their insightful feedback, expertise, and support. Their dedication to academic excellence has helped refine my study and push me toward new levels of intellectual rigor. Not forgetting Dr. Soonhye Park, who has been phenomenal in her responses and helping me get to the finish line.

A special thank you to the educators who participated in this study – their willingness to share their experiences, insights, and challenges has been the heart of this research. Their dedication to interdisciplinary STEM education in special education is inspiring, and I hope this study contributes to their important work.

To my family and friends, words cannot fully express my appreciation for your unwavering love, patience, and encouragement. To my parents, whose sacrifices and prayers have shaped me into the person I am today, I owe you my deepest gratitude. To my wife, Dr. Faith Boakye, your steadfast support, patience, and understanding have meant the world to me. Thank you for being with me every step of this journey.

I also extend my appreciation to my colleagues and peers, who provided motivation, shared valuable insights, and encouraged me through this challenging yet rewarding journey. Your camaraderie and support have been an invaluable part of this experience.

Finally, I recognize the countless mentors, teachers, and supporters who have influenced my academic and personal growth along the way. Every conversation, word of encouragement, and act of kindness has contributed to my success.

This dissertation is not just a culmination of my academic work but also a testament to the faith, love, and support I have received from so many. To everyone who has been part of this journey, I extend my sincerest thanks.

With gratitude and humility,
Chris Boakye
2025

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

CHAPTER I: INTRODUCTION

Over the last decade, Science, Technology, Engineering, and Mathematics (STEM) has found its way into every facet of education. A consensus-driven definition of STEM education provided by Tsupros, Kohler, and Hallinen (2009) states:

> "STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy."

Integrating STEM education into special education is a growing area of interest, particularly within interdisciplinary frameworks. STEM education is essential in equipping students with the skills required for success in an increasingly technological and problem-solving-oriented workforce (Mutohhari et al., 2021). It emphasizes hands-on, inquiry-based learning to foster critical thinking, collaboration, and problem-solving skills (National Research Council, 2011). In contrast to transdisciplinary approaches, where subjects are fully merged, interdisciplinary STEM education seeks to preserve the integrity of each discipline while encouraging the collaboration and integration of content across them. This method mirrors the genuine nature of resolving problems in the workplace, where distinct and specialized knowledge from different fields is frequently employed in concert to tackle multifaceted and stubborn difficulties (Bybee, 2013).

K-12 STEM education has often been touted as a remedy for the world's workforce skills gap, purportedly leading to larger numbers of graduates with the critical and creative thinking skills necessary to operate the technologically advanced infrastructures of the present and future

(Larson & Miller, 2011). A solution to the STEM skills gap seems previously inconceivable in light of our understanding of computational thinking and the forces pushing for humanity to think, act, and operate interdisciplinarily. Interdisciplinary STEM education integrates knowledge from related fields, enabling students to grasp how science, technology, engineering, and mathematics intersect to address real-world problems (Sanders, 2008). This reflects the professional world in which experts work collaboratively across various fields while keeping intact their specific types of expertise (Holmlund et al., 2018). An approach like this encourages the sort of thinking and skills that are vital for being successful in the workforce today – essentially, the sort of stuff that is in the error reports for the last 50 years of science education (Bybee, 2013).

On the other hand, special education concentrates on meeting the varied needs of students with disabilities, using customized teaching strategies (Bryant et al., 2019). Advocating for the education of students with disabilities in general education settings, inclusive education requires innovative solutions that meet the diverse learning needs of all students (McLeskey et al., 2018). The integration of interdisciplinary STEM education in special education provides unique opportunities to engage students with disabilities. It gives them accessible and meaningful learning experiences that encourage collaboration, creativity, and critical thinking (Woolverton, 2021).

Special education offers a wealth of chances and a handful of challenges that interdisciplinary teams must address. Hands-on, inquiry-based learning in these settings often necessitates a greater allotment of resources (including assistive technologies) and well-planned, team-delivered, differentiated instruction to achieve the effect of meeting a class full of diverse learning needs (Abels, 2014). Nonetheless, the prospective advantages comprise heightened student engagement, keen motivation, and improved learning results (Israel et al., 2013). Interdisciplinary STEM education is not merely a means to improve the quality of STEM education for all students. It is also a way to promote equity and inclusion in STEM fields. For too long, STEM disciplines have not been accessible to many students from different demographic backgrounds. Simplistic views of accessibility have failed to consider the kinds of barriers that individuals with disabilities face (Heumann & Gibbons, 2014). Not forgetting, historically, individuals with disabilities have been underrepresented in STEM careers, and providing them with accessible STEM education could address this gap (McCollough & Ramirez, 2012).

Problem Statement

Although the expansion of research on STEM education has occurred in recent years, there remains a poor grasp of how special education teachers modify interdisciplinary STEM curricula to address the varied needs of their students. This is particularly true for those who specialize in curricula and instruction in STEM areas (McCollough & Ramirez, 2012). Special education teachers often face unique challenges in implementing interdisciplinary approaches due to limited resources, inadequate training, and the complexity of meeting individualized learning needs (Szwed & Bouck, 2013; Marino, 2009). This study seeks to investigate these challenges and uncovers the pathways that special education teachers take to make STEM education accessible to students with disabilities. The study's fundamental purpose is to fill an important gap in literature concerning the integration of interdisciplinary STEM education in special education settings (McDonald, 2016; Mohamad Hasim et al., 2022).

Purpose of the Study

This phenomenological case study aims to investigate the lived experiences, perspectives, and attitudes of special education teachers who implement interdisciplinary STEM curricula. Phenomenology is concerned with capturing the essence of participants' experiences, making it a suitable approach for understanding how special education teachers perceive and navigate the integration of STEM content in their classrooms (Moustakas, 1994). STEM curriculum itself is phenomenally complex and its delivery in the special education classroom requires navigation of both the integrated content and pedagogical labyrinths in order to achieve the curriculum goals set forth for educators in the National Research Council's Framework for K-12 Science Education (National Research Council, 2012). This study aims to illuminate both the perceived benefits and challenges of interdisciplinary STEM education in special education settings by focusing on how these educators integrate content across distinct STEM disciplines – science, technology, engineering, and mathematics – while addressing the diverse needs of their students.

STEM education with an interdisciplinary focus teaches students to integrate knowledge and thinking from several distinct fields of study in order to solve the kinds of problems that demand solutions in the real world. It is not an education where each field of study is taught in isolation and where the students never see or understand the connections among the subjects they are learning (Larson & Miller, 2011). This approach is especially beneficial in special education, where students frequently gain from hands-on or experiential, inquiry-based learning that pushes them toward solving problems and working collaboratively (Scruggs et al., 2008). Yet, even as interdisciplinary strategies grow in popularity within mainstream educational spaces, the teaching of special education students seems largely untouched by these sometimes transformative ideas. The ways in which they are implemented (or not) in special education classrooms remains an understudied area. McCollough and Ramirez (2012) highlighted this gap in research.

Teachers in special education have a distinct set of obstacles when it comes to tailoring STEM curricula to satisfy the demands of students with disabilities. Those difficulties may stem from inadequate access to materials, scant professional development, and a dearth of teamwork between special and general education instructors (Szwed & Bouck, 2013). Additionally, the varied demands of learners with disabilities frequently call for distinctly tailored instructional strategies. These may include differentiated instruction or the use of assistive technologies to render STEM content both accessible and meaningful (Marino, 2009). By exploring how special education teachers navigate these challenges, the study seeks to identify strategies that support the successful implementation of interdisciplinary STEM education in diverse learning environments. It is vital to understand the perceptions and approaches of special education teachers regarding interdisciplinary STEM education because the beliefs and practices of these teachers have a direct impact on the learning outcomes of their students. (Pajares, 1992).

Efficacy of teachers – the belief in one's ability to affect student learning, has been shown to be both impactful and beneficial. The impacts and benefits manifest in both quality of instruction and in student success at the level of achievement (Tschannen- Moran & Hoy, 2001). In interdisciplinary STEM education, teacher confidence in the integration of diverse content and in the adaptation of that content for students with disabilities seems to be a good predictor of that teacher's likelihood to implement effective instructional practices that promote engagement and learning among all students (Asghar et al., 2017). The findings of this study will provide insights into the practical application of interdisciplinary STEM education in special education settings. The study will also contribute to the broader dialogue on inclusion and equity in STEM education by looking at the strategies special education teachers use to adapt the content of the STEM disciplines. Individuals with disabilities historically have not been well represented in the STEM workforce. The National Science Foundation (2015) reports that only 0.5% of the individuals in their survey who received a bachelor's degree in a STEM field also reported having a disability. So therefore, ensuring students with disabilities have access to high-quality STEM education is critical for addressing this disparity (McCollough & Ramirez, 2012). Ultimately, the study aims to inform professional development programs and curriculum design initiatives that support special education teachers in delivering interdisciplinary STEM content, thereby fostering a more inclusive and equitable STEM learning environment for all students.

Significance of the Study

This research has significant implications for teaching and learning, policy formation, and future research. The central focus is to present special education teachers' perspectives on interdisciplinary STEM education. Much of the existing research on STEM education has been conducted in general education contexts (Corlu et al., 2014; Honey et al., 2014; Shernoff et al., 2017), leaving a critical gap in understanding how STEM integration functions in special education settings.

Interdisciplinary STEM education offers unique advantages in special education by maintaining discipline-specific content while fostering knowledge transfer across subjects. This approach supports students with disabilities by engaging them through hands-on, inquiry-based learning that facilitates access to abstract concepts via multisensory experiences (Scruggs et al., 2008). Furthermore, interdisciplinary STEM education equips students with essential collaboration, problem-solving, and critical thinking skills necessary for post-graduation success (Asghar et al., 2017).

Despite these benefits, special education teachers face considerable challenges in implementing interdisciplinary STEM curricula. Limited access to resources, technology, and lab spaces creates significant barriers (Szwed & Bouck, 2013). Additionally, many special education teachers lack confidence in teaching STEM due to insufficient professional development (McDonald, 2016). Addressing these challenges requires dedicated professional development programs that equip teachers with the necessary skills to modify STEM content for diverse learners and foster collaboration between special and general education teachers (Mohamad Hasim et al., 2022). Understanding how special education teachers perceive and implement interdisciplinary STEM curricula will help identify effective strategies while uncovering potential barriers to its successful enactment.

Interdisciplinary STEM education in special education settings holds transformative potential, yet it remains an underexplored area in educational research. By examining how special education teachers implement interdisciplinary STEM curricula, this study aims to contribute meaningful insights into both practice and policy. The findings will have broad implications across several key areas, including educational practice, professional development, policy and curriculum development, and equity and inclusion.

Educational Practice

Findings from this study will provide special education teachers with effective instructional strategies for implementing interdisciplinary STEM curricula in diverse classrooms. By identifying how hands-on, inquiry-based learning can be adapted to accommodate students with disabilities, this research ensures that STEM instruction is both meaningful and accessible.

Professional Development

The study will contribute to professional development initiatives by identifying the specific challenges and support needs of special education teachers. Tailored, targeted professional development programs can empower educators with the necessary skills to adapt STEM content and collaborate with general education teachers, thereby improving instructional quality and promoting greater inclusion in STEM fields.

Policy and Curriculum Development

Findings from this study will provide policymakers and curriculum designers with evidence-based recommendations for enhancing STEM education accessibility for students with disabilities. By identifying the challenges special education teachers encounter, this research offers strategies for improving curriculum flexibility, increasing resource allocation, and fostering inclusive STEM instruction.

Equity and Inclusion

This research contributes to broader efforts aimed at increasing equity and inclusion in STEM education. Historically, individuals with disabilities have been underrepresented in STEM careers (McCollough & Ramirez, 2012). By providing students with disabilities access to high-quality interdisciplinary STEM education, educators can help bridge the gap in STEM participation and create a more inclusive workforce.

Research Questions

The main research question guiding this study is:

- What are the lived experiences and perspectives of special education teachers regarding interdisciplinary STEM education?

To further explore specific elements of the overarching inquiry, the study will be directed by the following sub-questions:

1. What do special education teachers perceive as the benefits of interdisciplinary STEM education for students with disabilities?
2. What challenges do special education teachers face in implementing interdisciplinary STEM education?
3. What strategies do special education teachers use to adapt interdisciplinary STEM content for students with disabilities?

Overview of Methodology

This study utilizes a phenomenological case study methodology to investigate the perspectives and lived experiences of special education teachers who implement interdisciplinary STEM education. Such a qualitative methodology is particularly well-suited for this research because it affords an in-depth view of the participants' experiences and the contextualized nuances of interdisciplinary STEM education in special education environments (Creswell & Poth, 2018). This study seeks to capture the complexity of integrating STEM disciplines into classrooms filled with diverse learners through semi-structured interviews, classroom observations, and document analysis.

This study employs a qualitative approach to explore the lived experiences of special education teachers in implementing interdisciplinary STEM curricula. A phenomenological case study methodology (Creswell & Poth, 2018; Moustakas, 1994) was chosen to capture the perceptions, challenges, and instructional strategies used by these educators.

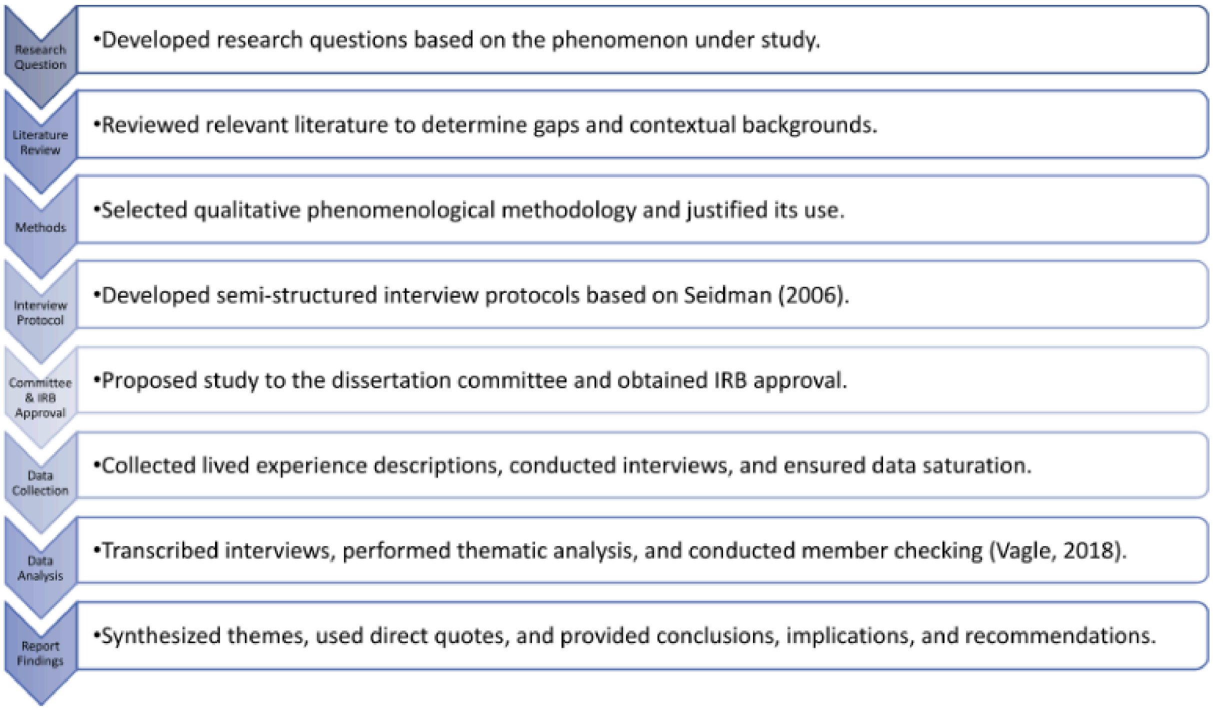
The study relies on purposeful sampling (Patton, 2015) to select participants – special education teachers with direct experience in interdisciplinary STEM instruction. Semi-structured interviews

(Seidman, 2006) were conducted via video conferencing to gather insights on participants' experiences, instructional practices, and perceived challenges. The interviews were designed to capture participants' backgrounds, their approaches to interdisciplinary STEM teaching, and their reflections on accessibility and student engagement.

In addition to interviews, classroom observations (Merriam & Tisdell, 2016) were conducted to analyze real-time instructional strategies and student interactions with STEM content. Document analysis (Bowen, 2009) was intended to be employed to examine instructional materials, lesson plans, and resources used by special education teachers to implement interdisciplinary STEM education. However, none of the teachers submitted or produced any documents during the interviews nor in the google folder provided to each participant. When the researcher asked about any documents, participants noted that the lesson plans were integrated with the general education lesson plans (yet still did not produce or share) or that their lesson plans did not document any STEM education integration.

Data analysis was conducted using thematic analysis (Braun & Clarke, 2006), following a whole-part-whole approach (Vagle, 2018; van Manen, 2016). The researcher initially conducted a broad review of interview transcripts to identify emerging themes, followed by a detailed, line-by-line analysis to refine categories and patterns within the data. To ensure trustworthiness, member checking (Birt et al., 2016) was used, allowing participants to verify interpretations of their statements. Data triangulation (Patton, 2015) across interviews, observations, and document analysis further enhanced the study's credibility and reliability.

Figure 1.1 *Graphical representation of the research design*



Theoretical and Conceptual Framework

This study employs a theoretical and a conceptual framework to explore the implementation of interdisciplinary STEM education in special education settings comprehensively. Using both frameworks is essential because each offers distinctive insights into different facets of the educational process, shedding light on the well-researched aspects of STEM education and special education, while offering a glimpse into the not-so-well-known areas of interdisciplinary STEM education in special education. Together, they inform a rounded understanding of how STEM education can serve well the diverse population of students with disabilities.

A theoretical framework explains how learning occurs, offering a foundation for instructional design. Constructivist Learning Theory, which serves as the theoretical backbone of this study, emphasizes that students actively construct knowledge when they have the kinds of hands-on, inquiry-based experiences that we provide in our courses. Primary theorists for the constructivist learning theory include Jean Piaget (1970) and Lev Vygotsky (1978). This theory aligns with interdisciplinary STEM education, wherein students merge concepts from several disciplines to undertake problem-solving and apply those concepts to real-world situations. Active learning, collaboration, and critical thinking, core elements of STEM education – are supported by constructivism (Learn, 2000). The theory helps make sense of student interaction with interdisciplinary STEM content and of teacher facilitation of student learning in that content using the approach often referred to as inquiry driven.

A conceptual framework, in contrast, provides practical strategies for applying theoretical principles in real-world settings. This study adopts Universal Design for Learning (UDL) as the conceptual framework because it offers a clear and structured approach to designing learning environments that are inclusive and accessible to all students, including those with disabilities (Meyer, Rose, & Gordon, 2016). UDL ensures that instructional strategies align with student needs by offering multiple means of engagement, representation, and expression (CAST, 2018). While the Constructivist Learning Theory explains how students build knowledge, UDL provides practical, effective strategies to ensure equitable access to learning for all students. This makes interdisciplinary STEM education more inclusive and enables diverse learners, especially students with disabilities to fully participate in their education.

Constructivist Learning Theory

Constructivist Learning Theory emphasizes the active engagement of learners with content rather than the passive receipt of information (Piaget, 1970; Vygotsky, 1978). This is especially pertinent for STEM education, in which students take knowledge from multiple disciplines and apply it to solve intricate problems. In special education, constructivist strategies make abstract STEM concepts accessible through real-world applications and hands-on learning.

The Zone of Proximal Development (ZPD) as articulated by Vygotsky highlights scaffolding—an educational technique that centers on the provision of guidance and support that decreases as the learner's independence increases (Vygotsky, 1978). In the ZPD, the teacher and the student work together in the domain of what is not yet mastered and where independence is on the horizon. This is especially relevant to STEM education, where complex interdisciplinary content demands not just horizontal transfer but also vertical thinking. Indeed, the types of problems presented in STEM content require more than surface-level understanding. They demand sustained inquiry and the types of interdisciplinary, life-realizing problem-solving skills that direct students not just to a solution, but also to a way of envisioning the world (and their place in it) as whole.

Piaget's Cognitive Development Theory states that students build their comprehension from direct interaction with their surroundings (Piaget, 1970). In interdisciplinary STEM environments, this translates to engaging students in all manner of experiments, collaborative projects, and research-based endeavors so that they might construct a better and more refined understanding of the phenomena under study.

Constructivist approaches align with interdisciplinary STEM education by fostering collaborative learning, where students work together to tackle challenges. For students with disabilities, constructivist methods help break down barriers to STEM participation by encouraging multisensory and hands-on learning (Mastropieri & Scruggs, 2010).

Universal Design for Learning (UDL) Framework

The Universal Design for Learning (UDL) framework, created by CAST, makes sure that all kinds of students learn in a good way in all kinds of places. (Meyer, Rose, & Gordon, 2016). UDL moves the direct focus from changing the way instruction is given to students with disabilities to a more general way of changing the design of curricula to better fit all students. UDL is structured around three guiding principles:

1. Multiple Means of Engagement – Incorporates diverse instructional strategies such as hands-on activities, digital tools, and gamified learning experiences to sustain student motivation.
2. Multiple Means of Representation – Provides STEM content through varied formats (visual, auditory, interactive) to ensure accessibility for all learners.
3. Multiple Means of Expression – Allows students to demonstrate understanding through different modalities, such as presentations, digital projects, and hands-on demonstrations (CAST, 2018; Meyer et al., 2014).

UDL holds particular significance for interdisciplinary STEM education, as it helps to remove participation barriers via flexible ways of providing instruction. For students in special education, accessible opportunities for STEM learning promote increased engagement and development of important skills and knowledge. (Rapp & Arndt, 2012)

Integration of Theories

By integrating Constructivist Learning Theory with Universal Design for Learning (UDL), this study establishes a strong foundation for analyzing how interdisciplinary STEM education can be effectively implemented in special education settings. Whereas constructivist principles emphasize active, inquiry-based learning, encouraging students to engage with STEM content in meaningful ways, UDL ensures accessibility by removing barriers, making interdisciplinary STEM curricula inclusive for diverse learners. Together, these frameworks guide this study's analysis of special education teachers' strategies, challenges, and best practices in adapting interdisciplinary STEM education (Bybee, 2013; McDonald, 2016; Mohamad Hasim et al., 2022). These will also inform the study's research design, data interpretation, and recommendations for inclusive STEM instruction, ensuring that interdisciplinary STEM education is both effective and accessible for students with disabilities.

Definition of Key Terms

To provide clarity and consistency throughout this study, it is essential to define the key terms used in exploring interdisciplinary STEM education in special education. These definitions serve as a foundation for understanding the core concepts and processes that guide the research and analysis. These terms are specific to this study.

Interdisciplinary STEM Education

Interdisciplinary STEM education refers to an educational approach that encourages the integration of science, technology, engineering, and mathematics (STEM) disciplines while maintaining the distinct boundaries of each subject. In this model, students are encouraged to draw connections between the disciplines and apply knowledge from multiple fields to solve complex, real-world problems (Bybee, 2013; Webb, 2013). Unlike transdisciplinary approaches, where subjects are fully merged, interdisciplinary learning allows for the preservation of disciplinary integrity while promoting collaboration across fields (National Research Council, 2011; Czerniak & Johnson, 2014). This method reflects how STEM disciplines function in professional settings, where experts from various fields work together to address multifaceted challenges (Honey et al., 2014).

Special Education

Special education refers to instructional practices and programs designed to meet the unique needs of students with disabilities. This includes individualized education plans (IEPs), specialized teaching methods, and accommodations aimed at providing equitable access to education (McLeskey et al., 2013; Turnbull et al., 2020). Special education services support students with a wide range of disabilities, including cognitive, physical, emotional, and learning disabilities, ensuring that they receive the necessary resources and instruction to succeed academically alongside their peers (Friend et al., 2010; Heward, 2000). The goal of special education is to provide students with disabilities the same opportunities for success as their non-disabled peers by creating individualized and inclusive educational environments (Gargiulo & Metcalf, 2010).

Inclusive Education

Inclusive education is an approach to teaching and learning that ensures students with disabilities are educated alongside their typically developing peers in general education settings. This model promotes equal access to educational opportunities, fostering an environment where students of all abilities can participate fully in classroom activities with appropriate support and accommodations (Eredics, 2018; Ainscow, 2020). Inclusive education is grounded in the belief that all students, regardless of their abilities, should have the opportunity to learn in an environment that values diversity and promotes social inclusion (McLeskey et al., 2013; Friend & Cook, 1992). The philosophy of inclusion emphasizes that education systems should be responsive to the diverse learning needs of all students, aiming to remove barriers, specially regarding implementation of STEM within specially designed instruction that prevent students with disabilities from participating fully in the classroom (Florian, 2014; Gargiulo & Metcalf, 2010).

Conclusion

This study has been introduced, and a foundational understanding has been provided, along with the background and problem statement; the purpose; the research questions; the significance; and the guiding theoretical frameworks. This research is essential in bridging the gap between interdisciplinary STEM education and its application in special education. It highlights the STEM complex of the lived experiences of teachers in special education settings.

The objective of the study is to derive insights that will illuminate best practices, mold the professional development of educational personnel, and influence the sort of policies that will enable the effective integration of STEM disciplines for students with disabilities.

The study will also examine in detail the environment of special education and the challenges that teachers in that environment undergo. It will investigate the strategies those teachers use to overcome the kinds of challenges that are altogether too common in special education. In the end, then, it will examine in detail a group of teachers in a quite specific environment.

The rest of the document has the following structure. A literature review forms the content of chapter two. Its purpose is to demonstrate the existence of a gap in the relevant literature and to provide sufficient justification for the proposed study to exist. Chapter three addresses how this study is designed and what methods will be used to answer the research questions.The fourth chapter presents the findings of the proposed study. Instead of discussing the findings as they relate to the individual research questions, I present the results as themes. Finally, chapter five contains the essence of the proposed study and the discussion of what the results mean.

CHAPTER II: LITERATURE REVIEW

This chapter examines pertinent literature on the implementation of interdisciplinary STEM education in settings for special education. Its key aim is to provide a clear and comprehensive understanding of the theoretical, empirical, and practical foundations that underwrite this line of research. The chapter is arranged into several key sections that cover the theoretical and conceptual bases of the study. Each key section of the chapter is divided into subsections and thereby presents relevant literature in a manner that is accessible. The first key section covers the theoretical and conceptual frameworks of the study. The next key section is on the role of interdisciplinary STEM education in K-12 schools. Followed by the application of STEM education for students with disabilities, the challenges faced by special education teachers, the role of teacher perspectives and professional development, and the impact of assistive technologies and inclusive education.

This review serves to establish a setting for the study's research question. It shines a much-needed spotlight on an underexplored area that the researcher believes is essential to consider if one is to adapt interdisciplinary STEM education to meet the needs of students with disabilities. While there has been significant progress in integrating STEM education into general K-12 settings, there remains a critical gap in understanding how special education teachers implement interdisciplinary STEM curricula and the barriers they encounter in doing so. This gap highlights the need for the current study, which seeks to investigate special education teachers' perspectives, strategies, and experiences with interdisciplinary STEM education.

Even with the expanding focus on inclusive education and the ever-growing push for fields like STEM, not a whole lot of research has been done to figure out just how special teachers are adapting this push for inclusive curricula to suit the needs of the students in their classrooms. We focused on that potential gap in this study by investigating the lived experiences of special education teachers who have been working at the frontline of this STEM push.

The main research question guiding this study is:

- What are the lived experiences and perspectives of special education teachers regarding interdisciplinary STEM education?

To further explore specific elements of the overarching inquiry, the study will be directed by the following sub-questions:

1. What do special education teachers perceive as the benefits of interdisciplinary STEM education for students with disabilities?
2. What challenges do special education teachers face in implementing interdisciplinary STEM education?
3. What strategies do special education teachers use to adapt interdisciplinary STEM content for students with disabilities?

To answer these questions, the literature review is structured around these central topics: interdisciplinary STEM education; constructivist learning theory; the Universal Design for Learning; implementing STEM education in special education; teacher perspectives; professional development; assistive technology; and inclusion and equity in STEM education. This chapter helps set the context for what follows by synthesizing the research across these areas to get a better sense of how interdisciplinary STEM education might be served up to students with disabilities.

Interdisciplinary STEM Education

Interdisciplinary STEM education (English, 2016; Roehrig et al., 2021) is an integrated instructional approach that melds science, technology, engineering, and mathematics into a coherent, unified whole. Unlike multidisciplinary approaches, where subjects are taught separately in silos but aligned with a common theme, or transdisciplinary approaches, where subject boundaries are fully dissolved, interdisciplinary STEM education maintains the distinctiveness of each discipline while promoting connections between them (National Research Council, 2011). This framework allows learners to visualize the complementary nature of the various STEM disciplines that form their core knowledge and skills and to see the disciplines working in concert to solve multifaceted challenges (Larson & Miller, 2011).

The route to 21st-century accepted critical thinking, creativity, collaboration, and problem-solving skills is through interdisciplinary STEM education (Bybee, 2013). These skills are simply vital in the modern complex and dynamic world. STEM fields are increasingly converging in real-world contexts, including engineering, biotechnology, and environmental science (Honey et al., 2014). The reason is simple: these disciplines interact, and they apply interdisciplinary thinking to solve the practical problems of our age. For instance, a project in which students create a sustainable energy solution could demand that they apply mathematical principles to figure energy requirements, draw on scientific knowledge to comprehend renewable energy sources, and muster technological and engineering skills to develop and test their creation.

The National Research Council (2011) underscores the significance of interdisciplinary STEM education in readying students to be the kinds of critical thinkers and innovators who can confront the interdisciplinary global issues of the 21st century. These challenges – ranging from climate change to advances in artificial intelligence – require an understanding of how science, technology, engineering, and mathematics intersect in professional practice. As a result, interdisciplinary STEM education promotes deeper learning and helps students develop the analytical and creative skills needed to thrive in a rapidly evolving economy (Bybee, 2013).

Interdisciplinary STEM education has been shown to not only enhance students' problem-solving abilities but also to increase engagement and motivation, particularly when students perceive the content as being relevant to the real world. (Larson & Miller, 2011). Students are encouraged to think critically, collaborate effectively, and approach problems from multiple perspectives when they work on interdisciplinary projects that reflect how professionals operate in the STEM fields. (National Research Council, 2011). This correlates with the increasing focus on 21st-century skills like collaboration, communication, and adaptability, which employers in diverse industries are placing a premium on (Bybee, 2010).

Interdisciplinary STEM education is especially important in special education settings because it promotes active, hands-on learning that can engage students with diverse needs. Students with disabilities often benefit from pedagogic strategies that promote hands-on, investigative learning, as this helps to make abstract concepts more concrete and accessible (Scruggs et al., 2008).

STEM in Special Education

STEM education in special education conditions presents both challenges and prospects. Students with disabilities typically need to have their teaching tailored – in other words differentiated. Historically, students with disabilities have been underrepresented in STEM fields due to barriers such as accessibility, engagement, and equity (McCollough & Ramirez, 2012).

Addressing these challenges is crucial for creating an inclusive STEM education that prepares all students for the workforce. Addressing these challenges requires thoughtful integration of STEM curricula in ways that meet the diverse needs of students with disabilities while providing them with the same opportunities to succeed as their non-disabled peers.

One of the main challenges in putting into practice STEM education for students with disabilities is the necessity for differentiated instruction. Students with disabilities often have a tough time grasping the abstract concepts that form the backbone of STEM fields. For instance, students whose main cognitive strength lies in rote memorization may not perform well on complex, multi-step mathematical problem solving, just as students who are unable to move their hands cannot work with physical models and prosthetics. To address these challenges, special education teachers must employ a range of instructional strategies, including Universal Design for Learning (UDL), which emphasizes multiple means of engagement, representation, and expression to ensure that all students can access and interact with STEM content (Meyer, Rose, & Gordon, 2016). Moreover, scaffolding is frequently employed to decompose intricate tasks into a series of constituent subtasks, each suitably graded in difficulty, that together enable the student to perform the overall task (Wood, Bruner, & Ross, 1976).

Opportunities for growth and innovation exist in the field of STEM education for students with disabilities, even when the challenges are taken into account. Research has shown that students with disabilities often thrive in inquiry-based, hands-on learning environments, where they can engage with real-world problems and develop critical thinking skills (Scruggs et al., 2008). Interdisciplinary STEM education gives students with disabilities the opportunity to meaningfully and relevantly apply their knowledge in ways that are meaningful and relevant to their daily lives (McCollough & Ramirez, 2012). For example, students who take part in STEM projects that require them to design technologies that are accessible to people with disabilities, or to solve environmental challenges, might feel more motivated to engage with the content, as it directly relates to their lived experiences.

Additionally, inclusive STEM education can and should create an environment in which the social and communication skills of students with disabilities can flourish. Most STEM activities require collaboration and teamwork, providing students with opportunities to work with their peers in a shared problem-solving environment (Friend & Cook, 1992). This promotes not only academic learning but also the development of important social skills, such as communication, negotiation, and cooperation, which are essential for success both in school and beyond (Rapp & Arndt, 2012). Classrooms of inclusive STEM, where students both with and without disabilities work together, also help break down social barriers and cultivate a sense of belonging among all students (Klimaitis & Mullen, 2021).

Theoretical and Conceptual Frameworks

This study incorporates both a theoretical and conceptual framework to ensure a comprehensive understanding of the integration of STEM education in special education classrooms. The theoretical framework provides a foundation based on established educational theories, guiding the interpretation of findings. Meanwhile, the conceptual framework maps out the key relationships among instructional strategies, student engagement, and learning outcomes, offering a structured approach to analyzing the data. These frameworks provide a comprehensive foundation for comprehending this multitiered form of education. Employing both types of frameworks is essential, as they offer complementary perspectives that address different aspects of the research problem (D’amour et al., 2005). The theoretical framework explains how learning occurs and offers a lens for understanding how students construct knowledge, while the conceptual framework provides a practical guide for applying these theories in educational settings, particularly for students with disabilities.

Theoretical frameworks are extremely important. They are based on well-established theories that explain fundamental processes of learning and cognition. This study has as its theoretical basis Constructivist Learning Theory, which stresses the enacted role of students in the construction of knowledge from experience, reflection, and interaction with their environment (Piaget, 1970; Vygotsky, 1978). This theory is particularly relevant to STEM education, which involves hands-on, inquiry-based learning that encourages students to engage deeply with content and solve real-world problems. By grounding the study in constructivist principles, this framework helps explain how students with disabilities can benefit from engaging in active learning environments that promote critical thinking and collaboration (Learn, 2000).

However, merely having theoretical models is not enough to meet the broad array of complex needs exhibited by students with disabilities. This is where having a conceptual framework becomes important. The Universal Design for Learning (UDL) framework gives us a practical and useful way to ensure that all students, no matter their ability range, have equitable access to the same STEM educational opportunities (Meyer, Rose, & Gordon, 2016). UDL emphasizes the need for flexibility in how content is presented, how students engage with it, and how they demonstrate their learning. The theoretical foundations of constructivism are applied in ways that ensure the STEM content is accessible and meaningful for students with disabilities – an integration of UDL principles that makes this study unique. (Dalton, 2017).

The theoretical and conceptual frameworks provide a comprehensive approach to addressing not only how students learn but also how that learning can be made accessible to all students. The process of learning is explained by theoretical models like constructivism, while the kinds of practical strategies needed to implement those models in diverse classrooms are provided by conceptual frameworks like UDL. Using both frameworks makes it possible to investigate the interaction between the theory and the practice. This research not only advances our understanding of interdisciplinary STEM education but also offers actionable strategies for educators working with students with disabilities (McLeskey et al., 2013). Integrative Learning Theory (Constructivist) and UDL both apply very well to this study; the selection to work with these frameworks is well-justified. Specifically, UDL can be seen as operationalizing constructivism by providing practical strategies for ensuring that hands-on, inquiry-based learning is accessible to all students, including those with disabilities, through multiple means of engagement, representation, and expression (Meyer, Rose, & Gordon, 2016).

Constructivist Learning Theory in STEM Education

Constructivist Learning Theory, which was mainly developed by Jean Piaget (1970) and later expanded upon by Lev Vygotsky (1978), states that learners actively build their own comprehension and construction of knowledge. These theories say that teaching is not enough; students must engage with the material and construct their own meanings. Instead of being on the passive end of information reception, students are on the active end of knowledge construction when they receive information and intelligibly interact with it. This theory is particularly influential in the context of STEM education, where hands-on, inquiry-based learning experiences are fundamental to student success.

At the core of Piaget's theory is the idea of cognitive development. This is where students traverse different stages of thought as they mature. He underscored the significance of active learning, proposing that the ideal conditions for student learning exist when the learners can explore and experiment in environments that challenge their present grasp of the world's workings. This is right in line with STEM education, which more often than not involves the kind of inquiry-based learning that has students doing hands-on activities that necessitate hypothesizing, testing, and refining their scientific understanding (Piaget, 1970). For example, in an interdisciplinary STEM project, students might learn about engineering principles through the design and testing of bridges, while also applying mathematics and using scientific knowledge about materials to get the job done. Such an approach encourages deeper understanding because students directly see how the various STEM disciplines intersect.

Vygotsky's theory enhances Piaget's ideas by adding the social dimension of learning. For Vygotsky, knowledge is constructed in a social context, with the help of others who know more (like teachers or so-called "knowledgeable peers"). These interactions occur in the Zone of Proximal Development (ZPD), which is the space between what a student can do alone and what they can do with help from someone who understands how to do it (Vygotsky, 1978). Within the STEM educational framework, this could consist of students collectively laboring on a project, with educators or fellow students lending a hand to assist the problem solvers of the future in moving toward solutions to the kinds of knotty issues that the not-too-distant future is certain to present. Students can develop vital critical thinking and problem-solving skills only when working within their ZPD and when left to their own devices are not nearly able to achieve this same level of development.

Principles of constructivism are especially pertinent to STEM education, which is based on inquiry and project-driven learning. These environments demand active student engagement and are built on a foundation such that the current theory of design and program is well understood at a deep level, which is the essence of constructivism. For instance, a constructivist STEM class might have students working in groups to design a solution to a real-world problem, such as developing a sustainable energy source or creating a prototype for an accessible technology. In these settings, students are not only learning STEM concepts but also applying them in ways that make the learning process meaningful and relevant to their lives outside the classroom (Learn, 2000).

In the context of special education, constructivist principles are especially beneficial because they promote individualized learning experiences that can be tailored to meet the unique needs of students with disabilities. Students can pace themselves in the inquiry-based learning approach. It allows learners to engage with the content of STEM subjects on their own terms. This is especially the case when hands-on activities are part of the equation, as these enable students to construct an understanding of the material that is personalized and meaningful. Myers and Beach (2004) noted the constructivist principles that inquiry learning is based upon, and they pointed to several ways these principles might relate to students with disabilities. So, by incorporating constructivist principles, educators can create more inclusive learning environments that empower students with disabilities to actively participate in STEM education, thus promoting both academic and social development (Scruggs et al., 2008).

Constructivism in Special Education

Principles of constructivism have been very effective for students with disabilities. These principles underscore the importance of active engagement, hands-on learning, and the application of knowledge in settings that are meaningful to the learner (Sabayleh & Sakarneh, 2023). Compared to traditional, mostly passive forms of instruction in which students receive information from teachers, constructivist approaches encourage learners to take an active role in their education by constructing their own understanding of content through experience and reflection (Piaget, 1970; Vygotsky, 1978). This is particularly significant in special education, where pupils with disabilities frequently profit from personalized, hands-on learning experiences that correspond to their specific necessities and aptitudes.

The engagement that constructivism allows for students with disabilities means they can work at their own pace and use their own personal learning styles. For example, inquiry-based learning, a key element of constructivist pedagogy, involves students exploring, questioning, and problem-solving in a hands-on manner, which is highly beneficial for students who may struggle with abstract concepts in more traditional learning environments (Learn, 2000). One of the primary benefits of constructivist learning in special education is the chance it gives students to apply their knowledge in ways that resonate with them and hold significance. This closely aligns with the notion that learning transpires optimally when students discern the tangible, real-world pertinence of what they are laboring to learn (Learn, 2000). For example, in a STEM project, a student with a disability might design an accessible technology solution. This would give the student a chance to apply engineering principles in a context that is directly related to his or her own experience. This not only enhances their understanding of STEM concepts but also empowers them to solve problems that have a tangible impact on their lives and the lives of others.

Vygotsky's concept of the Zone of Proximal Development (ZPD) emphasizes how the constructivist principles used in special education can be very effective. The ZPD refers to the range of tasks that a learner can complete with the help of a more knowledgeable other (e.g., a teacher, peer, or mentor) but cannot yet accomplish independently (Vygotsky, 1978). When it comes to special education, this principle is often employed in scaffolding. That is where teachers give much more support and guidance as students work through tasks and remove that support more gradually than students develop greater independence (Wood, Bruner, & Ross, 1976). This technique is especially advantageous for students with disabilities since it lets them tackle difficult STEM subjects at their own speed, with all the needed assistance around to guarantee their triumph. Also, social constructivism—that collective of ideas and activities through which a group of people comes to understand and know something—benefits students with disabilities in another way. In a constructivist STEM classroom, students work together on projects and experiments, learning from one another and from their teachers. This collaboration not only bolsters thinking and reasoning but also promotes the social and emotional growth of all involved, as students with disabilities work with their peers; hone their communication skills; and develop an identity, a sense of belonging, and a pathway to greater independence (Friend & Cook, 1992).

In general, the constructivist method fits nicely with Universal Design for Learning (UDL) principles. UDL emphasizes that there must be flexibility in teaching methods and that there must be "multiple means of" (1) engagement, (2) representation, and (3) expression (Meyer, Rose, & Gordon, 2016). In an environment of special education that is based on a constructivist theory, students are afforded the chance to actively immerse themselves in STEM content. This is done in such a way that it accommodates their various individualities, thus allowing all students to succeed in an academic environment, while also developing critical thinking, problem-solving, and collaboration skills. By focusing on inquiry-based, hands-on learning, constructivism provides a framework for creating inclusive, meaningful educational experiences for students with disabilities.

Universal Design for Learning (UDL) in Special Education

Universal Design for Learning (UDL) is an all-encompassing educational framework. It was UDL that provided the impetus to construct a frontier within which all individuals might learn and teach in a transformed, optimized manner. This is particularly true when one considers the totally and universally flexible options for many pathways of learning that UDL affords. These allow for a maximum diversity of individuals to use many different kinds of approaches in ways that are perfectly suited to the nature of their variabilities, which is the nature of all learners. The UDL highlights how vital it is to create a curriculum from the outset that is accessible to all students, rather than attempting to retrofit a curriculum designed for the average student to meet the needs of those who have significant disabilities (Meyer, Rose, & Gordon, 2016; CAST, 2018). This proactive method assists in eliminating obstacles to learning by providing various routes for students to interact with, comprehend, and show their understanding and knowledge, making it especially useful in the context of special education, where students often need individualized support to access the curriculum (Rose et al., 2006).

Three core principles form the foundation of the UDL framework, and each one addresses a different facet of the learning process. They are:

A. Multiple Means of Engagement

B. Multiple Means of Representation

C. Multiple Means of Action and Expression

The principles were deliberately articulated to be as clear and simple as possible. They encompass the entire learning experience.

Multiple Means of Engagement

This principle emphasizes the way students find motivation and achieve engagement in their learning. UDL understands that students have different interests, backgrounds, and motivations, and that a single approach to engagement will not work for all learners. By providing multiple ways to engage students – such as offering choices in how they approach tasks, incorporating culturally relevant materials, or varying levels of challenge, teachers can ensure that all students find ways to stay motivated and engaged (Meyer et al., 2014). For students with disabilities, offering several ways to engage is essential. That makes it possible for them to join in the way that suits their distinct strengths and needs (Rose & Meyer, 2002).

Multiple Means of Representation:

This principle deals with the presentation of information to students. It is critical to realize that not all students are alike, either in their basic characteristics or in the ways they learn. What works well for one student may not work well at all for another. This principle posits that the variants of UDL allow users to accommodate for the differences in how students process and perceive information. To accommodate this variability, it is important for teachers to present content in several different kinds of formats – text, audio, video, diagrams, and physical models , so that the range of ways in which students comprehend and process information can be accessed (Meyer et al., 2014). For instance, a visually impaired student might depend on auditory accounts of visual material, whereas a student with a learning disability might find texts in a simplified form or graphic organizers beneficial (Dalton, 2017). This adaptability makes certain that learners with disabilities can interact with the coursework in manners that are suited to them and make the material comprehensible, no matter the nature of their impairments (CAST, 2018).

Multiple Means of Action and Expression

This principle is about how students show what they have learned. UDL acknowledges that students vary widely in how they plan, organize, and carry out tasks. And it insists that offering multiple ways for students to express their knowledge is a necessary part of making an inclusive learning environment (Meyer et al., 2014). Some students, for instance, might choose to show they understand the material by putting together a “model” or some other kind of visual display. Yet, others might prefer to put the same amount of understanding into a “hands-on” demonstration of the material. In a UDL classroom, students are provided with different options for completing assignments, allowing them to choose the methods that best align with their skills and preferences (Rapp & Arndt, 2012). His principle has particular importance in special education because students with disabilities may need unconventional means to show they understand due to physical, cognitive, or communication barriers (Hitchcock, Meyer, Rose, & Jackson, 2002).

Importantly, UDL is not a uniform approach that can be used in all settings; instead, it is a flexible framework that provides equitable access to learning by offering multiple pathways for engagement, representation, and expression (Rose et al., 2006). This is extremely significant when it comes to special education. Students with disabilities often encounter formidable challenges in trying to obtain a traditional education. By designing lessons and assessments that accommodate a range of learning styles and abilities, UDL ensures that all students can participate meaningfully in the learning process (Hitchcock et al., 2002). Furthermore, UDL agrees with the principles of inclusion and supports the notion that students with disabilities should be fully integrated into general education classrooms and provided with the tools and strategies they need to succeed alongside their peers (McGuire, Scott, & Shaw, 2006).

UDL in STEM Education

The integration of UDL principles into STEM education is essential to ensuring that all students, including those with disabilities, have access to meaningful, engaging, and equitable learning opportunities. STEM instruction, concentrating on the fields of science, technology, engineering, and mathematics, frequently requires students to grapple with difficult and sometimes esoteric material. For students with disabilities, this can present a real barrier to understanding and success. Utilizing UDL in STEM teaching and learning gives teachers the opportunity to design lessons and learning experiences that meet the array of learning needs making STEM content more accessible and engaging for all learners (Dalton, 2017).

One of the key challenges in STEM education is addressing the diverse ways students process and interact with information. The challenge is met by the UDL principle of multiple means of representation, which encourages educators to present the STEM content in a variety of formats. These include not just text but also diagrams, videos, hands-on experiments, and digital simulations (Meyer, Rose, & Gordon, 2016). For students with disabilities, this flexibility is crucial. For example, an individual who is visually impaired might gain from having complex diagrams described to him or her audibly, whereas an individual with a learning disability might need simplified text or visual aids to comprehend abstract, top-tier scientific concepts (CAST, 2018). Providing content in multiple formats ensures that all students can access STEM material in ways that align with their strengths and needs, ultimately leading to greater comprehension and engagement.

Multiple means of engagement, another core UDL principle, is equally important in STEM education. This principle emphasizes providing students with various ways to become motivated and engaged in learning. In STEM classrooms, this might involve giving students choices in how they approach projects or assignments, such as allowing them to choose between conducting a hands-on experiment or using a computer simulation to explore scientific phenomena (Meyer et al., 2014). By offering options for engagement, teachers can cater to the different interests, backgrounds, and motivations of their students, helping to keep them invested in STEM content. This is particularly important for students with disabilities, who may require individualized approaches to stay engaged, such as integrating STEM topics with real-world, meaningful contexts that resonate with their personal experiences (Dalton, 2017).

Multiple means of action and expression is another vital UDL principle that can be applied to STEM education. This principle focuses on providing students with various ways to demonstrate their understanding and mastery of STEM concepts. In traditional STEM classrooms, assessments may rely heavily on written reports or standardized tests, which can disadvantage students with disabilities, particularly those with difficulties in writing or test-taking. UDL encourages teachers to offer alternative forms of assessment, such as allowing students to build models, create digital presentations to demonstrate their understanding (Rapp & Arndt, 2012). For example, a student with a physical disability might use computer-aided design (CAD) software to create a digital prototype instead of physically building a model, while another student might create a video presentation to explain a scientific experiment they conducted. These options not only accommodate students' diverse needs but also provide opportunities for all students to demonstrate their knowledge in ways that best suit their abilities (Dalton, 2017).

In addition to promoting inclusivity, applying UDL principles in STEM education fosters collaborative learning environments. Many STEM activities, such as group experiments, engineering design challenges, and coding projects, naturally lend themselves to collaboration. By providing multiple ways for students to contribute to group work, UDL ensures that students with disabilities can fully participate in these activities. For example, in a group project where students are tasked with designing an eco-friendly building, one student might take on the role of researcher to find relevant information, while another student might create the design using a computer program (Rapp & Arndt, 2012). UDL makes it possible for all students, regardless of their abilities, to contribute meaningfully to the collaborative process, fostering both academic and social growth.

In conclusion, applying Universal Design for Learning (UDL) principles in STEM education helps to break down the barriers that often prevent students with disabilities from fully accessing and engaging with STEM content. By providing multiple means of engagement, representation, and action and expression, UDL ensures that all students, regardless of their abilities, can participate meaningfully in STEM education, develop critical thinking and problem-solving skills, and succeed in both academic and future professional contexts (Dalton, 2017; Meyer et al., 2014).

UDL's Role in Special Education

Universal Design for Learning (UDL) plays a critical role in promoting inclusivity in special education by providing a flexible framework that adapts curricula to meet the diverse needs of all students, including those with disabilities. The implementation of UDL in STEM education is particularly important in special education settings, where students often face barriers to learning due to a wide range of physical, cognitive, and emotional disabilities (Rapp & Arndt, 2012). By incorporating the core UDL principles of multiple means of engagement, representation, and action and expression, teachers can ensure that all students have equitable access to STEM content, fostering both academic success and social inclusion.

Studies have demonstrated that UDL not only makes learning more accessible for students with disabilities but also promotes inclusivity by ensuring that students can participate meaningfully alongside their peers (Katz, 2013; Wilson, 2017). In STEM education, students with disabilities may struggle with accessing complex content or engaging with hands-on activities. However, UDL offers strategies that enable teachers to adapt STEM curricula to meet the unique needs of their individual students. This might involve the use of some students, which is most commonly referred to as ”differentiated instruction”; other students might require “alternative assessments” (Rapp & Arndt, 2012) for UDL to really work. Removing learning obstacles allows UDL to bring the space of full engagement to the STEM content of not just students with disabilities but also to their many typically developing counterparts (Janshego, 2024). The same rich, rigorous, and relevant content is available to those who are in all states of ability.

A central responsibility of UDL in special education is ensuring flexibility. In a typical classroom, one would meet students with disabilities who need individualized modifications to access the curriculum, such as more time for a task or alternative formats for materials (Dalton, 2017). UDL anticipates this variability by designing curricula that are inherently flexible and can accommodate a range of learning needs from the outset. For instance, a STEM curriculum based on UDL may incorporate visual, auditory, and tactile learning experiences, enabling students of all abilities to engage with the same content in the manner most effective for them (CAST, 2018). This proactive approach not only promotes inclusion but also reduces the need for reactive accommodations, ensuring that all students have equal opportunities to succeed in the classroom.

Another area where UDL promotes inclusivity in special education is engagement. The engagement of students with disabilities in traditional STEM curricula can be very challenging. They may find it impossible to engage in traditional curricula, particularly if the content is presented in ways that are not meaningful or relevant to them. Or, if the presentation of the content is not right for them. This challenge is met by UDL in providing many means to engage students, for instance, letting them choose how to tackle assignments, weaving in example tasks that are relevant across cultures, or ensuring the main problem of a task is ambitious enough to challenge even the top students while providing hints and scaffolding to help others succeed (Meyer, Rose, & Gordon, 2016). For example, in a STEM lesson on environmental science, the learners could be given the choice of conducting a hands-on experiment, participating in a virtual simulation, or working with a partner to complete a research project. These options allow students with disabilities to engage with the material in ways that align with their strengths and interests and vary across projects. This not only fosters a sense of ownership but also makes students far more likely to complete the work.

The UDL framework promotes inclusive STEM education in part by ensuring adequate representation for all students, especially those with disabilities. These students often find it particularly challenging to access information and demonstrate their knowledge when impaired sensory, linguistic, or cognitive abilities get in the way. UDL's principle of multiple means of representation ensures that students can access STEM content in various formats, such as videos, diagrams, interactive models, or simplified texts, to suit their individual needs (CAST, 2018). For instance, a learner who has a hearing impairment may utilize closed captions or visual aids to apprehend content in a science video. In contrast, a learner with a disability in the area of learning might derive great benefit from graphic organizers that deconstruct elaborate scientific concepts into far more digestible and understandable components. Access to these flexible pathways to learning guarantees that all students, regardless of their individual abilities, will successfully apprehend and engage in meaningful ways with the STEM curriculum (Hitchcock et al., 2002).

In addition, UDL fosters inclusion in assessment by enabling various methods for students to showcase their understanding. Assessments in a typical STEM course might require students to take a written exam or assemble a written lab report. Yet these exacting kinds of tasks do not necessarily portray the kinds of understanding that students who struggle with the "written expression" part of the disability spectrum might otherwise demonstrate if they were allowed to express their understanding through some other medium. Teachers are encouraged by UDL to offer alternative forms of assessment that might include creating multimedia presentations and building models to complete tasks (Rapp & Arndt, 2012). For example, a student with a physical disability could use speech-to-text software to compose in written form a report on a STEM project, while another student might opt to use video to convey to the viewer the mathematics of the problem they solved and the process they used to arrive at the solution. These flexible assessment options allow students with disabilities to demonstrate their knowledge in ways that align with their skills and abilities, promoting both academic success and a sense of inclusion (Dalton, 2017).

The effectiveness of UDL in promoting more inclusivity in special education areas is well supported by research. Indeed, several studies indicate that UDL-based STEM programs result in improved student performance and outcomes (Rapp & Arndt, 2012; Schreffler et al., 2019; Seok et al., 2018). Moreover, these same studies indicate that UDL-based STEM programs provide more equitable access to content and opportunity, and they significantly reduce barriers to participation. It has been demonstrated that these programs boost engagement and comprehension among learners with disabilities. Furthermore, they help increase a sense of belonging in school and among peers, traditionally a somewhat forlorn goal for a segment of the school population that is often marginalized (Marino, 2009). Utilizing UDL to adapt STEM curricula allows teachers to create inclusive learning environments that give all students the opportunity to meaningfully and rigorously participate in STEM activities.

Challenges in Implementing STEM Education in Special Education

The implementation of STEM education in special education settings presents a variety of challenges, many of which stem from systemic, pedagogical, and resource-related barriers. These obstacles can hinder the ability of special education teachers to effectively integrate STEM into their curricula and provide equitable learning opportunities for students with disabilities. Addressing these challenges is critical for ensuring that students with disabilities are not left behind in the rapidly growing STEM fields.

Systemic Barriers

One of the most monumental obstacles to carrying out STEM instruction in special ed settings is the existence of systemic barriers. These barriers take several forms and affect many aspects of the special STEM classroom. They include limited access to materials and resources, inadequate professional development, and scant administrative support. Numerous educational institutions, especially those for students with disabilities, do not possess sufficient funding and supplies needed to properly implement and sustain STEM programs (McDonald, 2016). This can manifest as a lack of funds for STEM-related equipment, technology, and learning materials. Without the proper tools, special education teachers cannot effectively teach complex STEM concepts.

Another systemic issue is that special education teachers are not being provided with professional development in the area of STEM education (Layden et al., 2023). The fields that make up STEM are always changing, and educators need to keep current with the new developments in both content knowledge and instructional strategies. However, many special education teachers who serve in the STEM area feel they have been insufficiently trained to integrate STEM into their classrooms, particularly in accessible ways for students with disabilities (McDonald, 2016). Without targeted professional development that addresses both STEM content and the unique needs of students with disabilities, teachers may struggle to provide meaningful and inclusive STEM education (Clements et al., 2023).

Finally, a deficiency in administrative support can also be a sizeable hurdle. Administrators may not fully grasp the vital role that STEM education plays for students with disabilities, or they may place a higher priority on other parts of the curriculum, leaving STEM on the back burner (Klimaitis & Mullen, 2021). This can result in limited support for teachers who wish to implement STEM programs, as well as a lack of funding and resources dedicated to STEM initiatives (McDonald, 2016). Lack of solid support from the administration makes it hard for special education teachers to conduct and uphold effective STEM programs in their classrooms.

Pedagogical Barriers

Besides systemic challenges, special education teachers face pedagogical obstacles trying to integrate STEM disciplines. One of the primary roadblocks is the need for differentiated instruction, which requires teachers to tailor their instructional approaches to meet the diverse learning needs of students with disabilities. STEM education tends to involve concepts that are both abstract and complex, and while this may be fine for students who are not disabled, it can make things very challenging for students who have cognitive, emotional, or physical disabilities (Mohamad Hasim et al., 2022). To address this, teachers must create differentiated lessons that give students several ways to access and engage with the material. These ways might involve using visual aids, performing hands-on tasks or activities, and using progressively more sophisticated technological tools for learning (Marino, 2009).

Moreover, bringing together the many disciplines of STEM into one curriculum can be especially difficult for special education teachers. They have to strike a balance between doing what is necessary to meet the particular educational goals of their students and following the mandates of the STEM curriculum. For instance, a lesson that combines math and engineering might necessitate students to use algebraic principles to come up with a design for a structure. This could prove quite hard for some students with disabilities who struggle with abstract reasoning (Mohamad Hasim et al., 2022). In order for students to work successfully in interdisciplinary STEM activities, teachers must creatively find ways to scaffold learning and provide the necessary support.

Resource-related Barriers

Finally, there are significant resource-related barriers that hinder the implementation of STEM education in special education classrooms. One of the most pressing issues is the shortage of STEM-related materials, equipment, and technology that are accessible to students with disabilities. Many schools, particularly those serving low-income or rural populations, lack the financial resources to provide adequate STEM materials, such as laboratory equipment, engineering kits, or computer software (Szwed & Bouck, 2013). This lack of resources is compounded by the fact that specialized equipment designed for use by students with disabilities—such as modified tools for science experiments or accessible coding programs—can be expensive and difficult to obtain.

The absence of appropriate resources makes it challenging for teachers to create engaging and hands-on STEM experiences for their students. For example, a science lesson on electricity might be difficult to teach without access to electrical circuits or materials that allow students to safely experiment with different forms of energy (Szwed & Bouck, 2013). Similarly, engineering projects that require the use of 3D printers or design software may be out of reach for many special education classrooms due to the high cost of equipment.

In addition to physical materials, there is often a lack of curricular resources that are specifically designed for students with disabilities. While there are many STEM curricula available for general education students, few are tailored to meet the needs of students in special education. This means that teachers often have to adapt general education STEM materials on their own, which can be time-consuming and challenging, particularly for those who do not have specialized training in STEM education (Szwed & Bouck, 2013).

Teacher Perspectives and Experiences in Special Education STEM Implementation

The successful implementation of interdisciplinary STEM education in special education settings depends heavily on the beliefs, self-efficacy, and experiences of teachers. Special education teachers play a pivotal role in adapting STEM content to meet the needs of their students, and their confidence in their ability to teach STEM subjects significantly influences how they approach STEM integration in the classroom. In addition to personal beliefs and self-efficacy, professional development (PD) tailored specifically to the needs of special education teachers is essential for building the knowledge and skills necessary to effectively teach STEM content.

Teacher Beliefs and Self-Efficacy

Teacher beliefs about STEM education, particularly in relation to their students' abilities, are a major factor in determining whether and how STEM content is integrated into special education curricula. Teachers who believe that STEM subjects are beyond the reach of their students with disabilities may be less likely to incorporate STEM activities into their classrooms (Pajares, 1992). Conversely, teachers who believe that all students, including those with disabilities, can succeed in STEM education are more likely to engage their students in meaningful STEM learning experiences. Research shows that teachers' beliefs about their students' abilities are closely linked to the expectations they set and the opportunities they provide for students to engage with challenging material (Tschannen-Moran & Hoy, 2001).

Another critical factor influencing STEM implementation is teacher self-efficacy—the belief in one's own ability to teach effectively. Teachers with high self-efficacy are more likely to take on the challenges of teaching interdisciplinary STEM subjects, even in the face of limited resources or systemic barriers (Tschannen-Moran & Hoy, 2001). This is especially important in special education settings, where teachers often need to adapt STEM content to meet the diverse needs of their students. Teachers with strong self-efficacy are more likely to experiment with new teaching strategies, integrate assistive technologies, and provide differentiated instruction to ensure that all students can access STEM content (Pajares, 1992). In contrast, teachers with low self-efficacy may feel overwhelmed by the challenges of teaching STEM and may avoid incorporating interdisciplinary activities, opting instead for more traditional teaching methods that feel safer and less demanding.

Studies have shown that teacher self-efficacy is not static but can be influenced by professional experiences and the availability of support. For instance, teachers who receive positive feedback from colleagues or experience success in implementing new teaching strategies are likely to see an increase in their self-efficacy (Tschannen-Moran & Hoy, 2001). In special education STEM contexts, this might involve successfully adapting a science experiment for students with disabilities, which could boost a teacher's confidence in their ability to continue integrating STEM subjects into their teaching.

Teacher Professional Development

Professional development (PD) is a critical component in helping teachers build the skills and knowledge needed to effectively implement interdisciplinary STEM education in special education settings. However, traditional PD programs often fail to meet the specific needs of special education teachers, particularly in relation to STEM education. Special education teachers face unique challenges, such as differentiating instruction, integrating assistive technologies, and adapting complex STEM content for students with a wide range of abilities (Desimone, 2009). Therefore, PD programs that are tailored to the needs of special education teachers are essential for ensuring that these educators are equipped to teach STEM subjects effectively.

One of the key elements of successful professional development is content-focused learning, where teachers are given opportunities to deepen their understanding of STEM subjects and learn how to teach these subjects in ways that are accessible to students with disabilities (Penuel et al., 2007). This could involve workshops that focus on integrating technology into STEM lessons, strategies for differentiating instruction, or methods for using inquiry-based learning to engage students with disabilities in hands-on STEM activities. PD programs that emphasize collaborative learning are also particularly effective, as they allow teachers to work together to share strategies, troubleshoot challenges, and support one another in implementing STEM education in their classrooms (Desimone, 2009).

In addition to content-specific learning, ongoing, sustained professional development is crucial. Studies have shown that one-time workshops or short-term PD programs are often insufficient for creating lasting changes in teaching practice (Penuel et al., 2007). Instead, professional development should be an ongoing process that provides teachers with continuous support as they implement new strategies in their classrooms. This might include regular coaching sessions, peer observations, or opportunities to participate in professional learning communities (PLCs) where teachers can collaborate with colleagues to reflect on their practice and share insights about STEM education in special education settings (Penuel et al., 2007). These ongoing supports help teachers to refine their skills over time and increase their confidence in teaching interdisciplinary STEM content.

Furthermore, research highlights the importance of job-embedded professional development, where teachers have the opportunity to apply what they are learning in real-world classroom settings (Desimone, 2009). In the context of special education STEM, this could involve teachers experimenting with new strategies in their own classrooms, such as using assistive technologies to support students in a STEM project or adapting a science experiment to meet the needs of students with diverse abilities. By embedding professional development directly into teachers' daily practice, PD programs can help ensure that teachers feel more confident and capable of implementing STEM education in meaningful ways.

In conclusion, both teacher beliefs and self-efficacy play a critical role in the successful implementation of interdisciplinary STEM education in special education settings. Teachers who believe in their students' abilities and feel confident in their own teaching skills are more likely to take on the challenges of integrating STEM subjects into their classrooms. To support this, professional development tailored to the needs of special education teachers is essential. PD that focuses on content knowledge, provides collaborative and sustained learning opportunities, and is embedded in real-world practice helps teachers develop the skills and confidence necessary to make STEM education accessible and engaging for all students.

Assistive Technologies in STEM Education for Students with Disabilities

Assistive technologies play a crucial role in supporting students with disabilities in accessing and engaging with STEM education. In many cases, students with disabilities face significant barriers to participation in science, technology, engineering, and mathematics (STEM) subjects, particularly when it comes to complex concepts, hands-on activities, and the need for inquiry-based learning. Assistive technologies (AT) provide the tools necessary to break down these barriers, enabling students with diverse needs to engage meaningfully with STEM content and develop critical thinking and problem-solving skills.

Overview of Assistive Technologies

Assistive technologies refer to tools, devices, or systems designed to help individuals with disabilities perform tasks that they might otherwise find challenging. In educational settings, a wide range of assistive technologies are used to support students with disabilities, particularly in accessing STEM curricula. Some of the most commonly used AT tools in STEM education include text-to-speech software, screen readers, and digital manipulatives (Marino, 2009). Each of these tools serves a unique function in making STEM content more accessible to students with disabilities.

Text-to-speech software allows students with disabilities, particularly those with reading challenges, to access written STEM content through auditory means. This can be especially helpful when students are engaging with complex scientific texts or mathematical problems, as the software reads aloud the content, enabling students to process the information more effectively (Dell et al., 2012). For example, a student with dyslexia might use text-to-speech software to understand the steps of a science experiment by hearing the instructions rather than struggling to decode the text.

Screen readers are another essential tool for students with visual impairments, allowing them to access digital content by converting text and images on a screen into speech or braille. In STEM education, screen readers are particularly useful for students who need to access complex visual information, such as charts, graphs, or diagrams in mathematics and science (Dell et al., 2012). This ensures that students with visual disabilities can engage with the same materials as their peers, promoting inclusivity in STEM learning environments.

Digital manipulatives, such as virtual models or interactive simulations, provide students with disabilities an alternative way to explore and engage with STEM concepts. These tools offer visual, auditory, and tactile feedback, allowing students to experiment with scientific phenomena or mathematical equations in ways that are adapted to their specific needs (Marino, 2009). For example, students with physical disabilities who may be unable to participate in traditional hands-on experiments can use digital manipulatives to simulate scientific processes, such as the growth of plants or the movement of planets.

Assistive technologies like these not only help students access STEM content but also promote greater independence and self-confidence in the learning process. By providing students with the tools they need to overcome barriers to learning, assistive technologies empower them to engage fully with STEM subjects, thus promoting inclusion and equity in education.

Role of Assistive Technologies in Interdisciplinary STEM

The role of assistive technologies becomes even more pronounced in interdisciplinary STEM education, where students are expected to integrate knowledge from multiple disciplines—such as science, technology, engineering, and mathematics—and apply it to real-world problems. Assistive technologies allow students with disabilities to participate in interdisciplinary, hands-on, and inquiry-based learning activities that would otherwise be inaccessible to them (Chambers, 2020).

In interdisciplinary STEM, students are often tasked with solving complex, open-ended problems that require the application of various STEM skills. For example, a project might ask students to design a sustainable building, requiring them to use mathematical calculations, scientific knowledge about energy efficiency, and engineering design principles. For students with disabilities, assistive technologies are essential in enabling them to fully participate in such projects. A student with a physical disability might use computer-aided design (CAD) software to create blueprints for the building, while a student with a learning disability might use speech-to-text software to articulate their ideas during a group discussion. These technologies provide alternative pathways for students to demonstrate their understanding and contribute to collaborative projects (Chambers, 2020).

Moreover, assistive technologies play a vital role in supporting inquiry-based learning, a core component of interdisciplinary STEM education. Inquiry-based learning encourages students to ask questions, conduct experiments, and develop their own solutions to problems. However, for students with disabilities, the traditional hands-on nature of inquiry-based learning can present significant challenges. Assistive technologies help bridge this gap by providing alternative ways for students to engage in the inquiry process. For example, a student with a motor impairment might use a robotic arm to conduct a science experiment, or a student with a cognitive disability might use an interactive simulation to explore the properties of a chemical reaction (Marino, 2009). These technologies ensure that students with disabilities are not left out of critical STEM learning experiences and can actively participate in exploring and understanding complex STEM concepts.

In addition to facilitating hands-on learning, assistive technologies also enhance collaborative learning in interdisciplinary STEM projects. Many STEM activities require students to work in groups to solve problems or conduct experiments. Assistive technologies, such as communication devices or collaborative software platforms, allow students with disabilities to contribute to group discussions and projects in meaningful ways. For example, a student with a speech impairment might use a communication device to share their ideas with the group, while a student with a mobility impairment might use a tablet or other technology to contribute to a shared project (Chambers, 2020).

In conclusion, assistive technologies are integral to making interdisciplinary STEM education accessible and inclusive for students with disabilities. By providing multiple pathways for students to engage with and demonstrate their understanding of STEM content, assistive technologies ensure that all students have the opportunity to participate in hands-on, inquiry-based learning activities that promote critical thinking, problem-solving, and collaboration. As STEM education continues to evolve, the role of assistive technologies in supporting students with disabilities will remain crucial in creating equitable and inclusive learning environments.

Inclusion and Equity in STEM Education for Students with Disabilities

Inclusion and equity are critical components of providing students with disabilities access to meaningful and engaging STEM education. Historically, students with disabilities have faced numerous barriers to participating fully in STEM subjects, often due to the design of learning environments that do not account for their diverse needs. In response, inclusive education models and frameworks have been developed to ensure that all students, regardless of ability, have the opportunity to succeed in STEM education. This section reviews the principles of inclusive education as they relate to STEM learning environments and discusses how interdisciplinary STEM education can address disparities in access and ensure equitable opportunities for students with disabilities.

Inclusion in STEM

Inclusion refers to the practice of educating students with disabilities alongside their typically developing peers in general education classrooms, with appropriate supports and accommodations to ensure that all students can participate meaningfully in the learning process (Florian, 2014). In the context of STEM education, inclusion means designing learning environments and instructional practices that are accessible to students with disabilities, while ensuring that they have the same opportunities to engage with and contribute to STEM subjects as their peers.

One of the key principles of inclusive education is that students with disabilities should not be segregated or placed in separate classrooms based on their abilities, but rather, they should be integrated into general education settings where they can learn and collaborate with students of all abilities (McLeskey et al., 2013). This principle is especially important in STEM education, where collaboration, hands-on learning, and problem-solving are central components of the curriculum. Inclusive STEM classrooms allow students with disabilities to participate in these activities alongside their peers, promoting both academic and social development.
Inclusion in STEM also involves providing appropriate accommodations and supports to ensure that students with disabilities can access STEM content. These accommodations might include modifications to instructional materials, the use of assistive technologies, or changes to the physical environment to make hands-on experiments and activities more accessible (Florian, 2014). For example, a student with a physical disability might require modified equipment to

participate in a science experiment, or a student with a learning disability might need visual supports to help them understand complex mathematical concepts. By providing these supports, teachers can create an inclusive learning environment where all students can engage with STEM content at their own pace and in ways that align with their unique abilities.

Research shows that inclusive STEM classrooms benefit not only students with disabilities but also their typically developing peers. When students with and without disabilities work together on STEM projects, they have the opportunity to learn from one another, share diverse perspectives, and develop important skills such as communication, empathy, and collaboration (McLeskey et al., 2013). Inclusive STEM education promotes a sense of belonging for all students, ensuring that students with disabilities are valued and included as active participants in the learning process.

Equity in STEM Access

While inclusion focuses on integrating students with disabilities into general education settings, equity in STEM education addresses the need to provide all students, regardless of their background or ability, with equitable access to high-quality STEM learning opportunities. In many cases, students with disabilities have been denied access to rigorous STEM content due to systemic barriers such as limited resources, inadequate teacher training, and a lack of inclusive curricula (Honey et al., 2014). Interdisciplinary STEM education provides a unique opportunity to address these disparities by designing STEM programs that are flexible, accessible, and responsive to the needs of all learners.

One of the ways in which interdisciplinary STEM education promotes equity in access is by offering students multiple pathways to engage with STEM content. In traditional STEM classrooms, students with disabilities may be excluded from hands-on activities or complex problem-solving tasks because these activities are not designed with their needs in mind. However, interdisciplinary STEM education, with its focus on inquiry-based learning, collaborative projects, and real-world problem-solving, provides a more flexible approach that allows students to engage with STEM content in ways that are meaningful and accessible to them (Honey et al., 2014).

For example, in an interdisciplinary STEM project, students might be tasked with designing a solution to an environmental challenge. While some students may contribute to the project by conducting research or writing a report, others may participate by creating models, using technology to simulate experiments, or developing presentations to communicate their findings. This flexibility ensures that students with diverse abilities can all contribute to the project, each using their strengths and interests to engage with the STEM content (Florian, 2014).

Equity in STEM access also involves addressing the systemic barriers that have historically limited opportunities for students with disabilities to pursue STEM careers. Research has shown that students with disabilities are significantly underrepresented in STEM fields, both in higher education and in the workforce (Honey et al., 2014). This disparity is due, in part, to the lack of early exposure to STEM subjects and the failure of schools to provide students with disabilities the support they need to succeed in these fields. Interdisciplinary STEM education, by offering inclusive and accessible learning experiences, can help to bridge this gap by providing students with disabilities the opportunity to develop the critical thinking, problem-solving, and collaboration skills needed to pursue STEM careers.

Furthermore, ensuring equitable access to STEM education for students with disabilities requires that schools and educators commit to creating inclusive STEM curricula that are designed from the outset to meet the needs of all learners (McLeskey et al., 2013). This includes providing professional development for teachers to help them develop the skills and knowledge necessary to implement inclusive STEM practices, as well as ensuring that schools have the resources needed to support students with disabilities in STEM classrooms. By prioritizing equity in STEM education, schools can ensure that students with disabilities have the same opportunities as their peers to succeed in STEM subjects and pursue future careers in STEM fields.

In conclusion, promoting inclusion and equity in STEM education for students with disabilities is essential for ensuring that all students have access to high-quality learning opportunities and the chance to succeed in STEM fields. By integrating students with disabilities into general education STEM classrooms and providing them with the supports they need to engage with the content, schools can create inclusive environments where all students can thrive. At the same time, interdisciplinary STEM education provides a flexible and accessible approach to addressing disparities in access, ensuring that students with disabilities have equitable opportunities to develop the skills needed for success in the 21st century (Florian, 2014; Honey et al., 2014).

Gaps in the Literature

While significant progress has been made in understanding how to implement STEM education for students with disabilities, several gaps remain in the current literature. These gaps highlight areas where further research is needed to better understand how interdisciplinary STEM education can be adapted and made more inclusive for all learners.

Limited Research on Interdisciplinary STEM in Special Education

One of the most prominent gaps in the literature is the lack of research on how interdisciplinary STEM education is implemented specifically in special education settings. While there is an abundance of research on STEM education in general education contexts (Honey et al., 2014), far fewer studies have explored how the integration of science, technology, engineering, and mathematics can be adapted to meet the needs of students with disabilities. Research has predominantly focused on individual STEM disciplines, such as math or science, but there is limited understanding of how interdisciplinary approaches can benefit students with disabilities and how teachers can effectively integrate these disciplines in inclusive classrooms (Scruggs et al., 2008). This gap underscores the need for more studies that investigate how interdisciplinary STEM education can be tailored to support the diverse needs of students in special education settings.

Lack of Focus on Teacher Training and Professional Development in STEM for Special Education

Another critical gap in the literature is the lack of research on professional development (PD) specifically aimed at preparing special education teachers to implement STEM education. While the importance of PD in improving teacher efficacy and instructional practices is well-established (Desimone, 2009), there is limited research on PD programs that are designed specifically for teachers working with students with disabilities in STEM contexts. Studies on PD often focus on general education teachers, neglecting the unique challenges that special education teachers face in adapting STEM curricula for their students (Penuel et al., 2007). Further research is needed to explore how PD programs can be tailored to address these challenges, equipping teachers with the knowledge and skills necessary to effectively integrate interdisciplinary STEM content in special education classrooms.

Insufficient Research on the Long-term Impact of Assistive Technologies in STEM

While there is a growing body of research on the role of assistive technologies in supporting students with disabilities in STEM education (Marino, 2009), much of this research is focused on the short-term effects of these technologies in improving access to content. There is a notable gap in studies that explore the long-term impact of assistive technologies on student learning outcomes and engagement in STEM fields. Specifically, there is limited evidence on whether the use of assistive technologies in K-12 STEM education translates to increased participation in postsecondary STEM education or careers for students with disabilities (Chambers, 2020). Longitudinal studies are needed to examine how assistive technologies influence students' STEM learning trajectories over time and whether they contribute to sustained interest and success in STEM fields.

Limited Understanding of Equity in STEM for Students with Disabilities

Although the concept of equity in STEM education has been widely discussed in the literature (Honey et al., 2014), there is still a limited understanding of how to ensure equitable access to STEM learning opportunities for students with disabilities. Much of the existing research on equity in STEM focuses on issues related to gender or race, with relatively little attention paid to the specific barriers faced by students with disabilities in accessing high-quality STEM education (Florian, 2014). Further research is needed to explore how schools can systematically address these barriers and create more equitable learning environments that support the participation of students with disabilities in STEM education. This includes examining the role of school policies, resource allocation, and teacher attitudes in promoting equity in STEM access for students with disabilities.

Measuring STEM Learning Outcomes for Students with Disabilities

Another significant gap in the literature is the lack of validated assessment tools for measuring STEM learning outcomes for students with disabilities. Current assessments in STEM education often rely on standardized tests or performance tasks that may not be accessible or appropriate for students with diverse needs (Mohamad Hasim et al., 2022). There is a need for more research on developing inclusive assessment tools that accurately reflect the learning outcomes of students with disabilities in STEM subjects. These tools should account for the variability in how students with disabilities access and engage with STEM content and provide a more comprehensive understanding of their learning and progress in these fields.

Need for Research on Inclusive STEM Classroom Practices

Finally, there is a gap in research exploring inclusive classroom practices that effectively integrate students with disabilities into general education STEM classrooms. While there is growing interest in inclusive education models, few studies have investigated the specific strategies and supports that are most effective in ensuring that students with disabilities can fully participate in interdisciplinary STEM learning (McLeskey et al., 2013). This gap in the literature highlights the need for research that identifies best practices in inclusive STEM education, particularly in relation to collaborative learning, differentiated instruction, and the use of assistive technologies in inclusive classrooms.

Summary of the Literature Review

The literature reviewed in this study highlights the growing importance of interdisciplinary STEM education and its potential to provide students with disabilities meaningful access to critical 21st-century skills. The review explores how constructivist learning theory and the Universal Design for Learning (UDL) framework serve as foundational approaches for making STEM education more accessible, promoting hands-on, inquiry-based learning that caters to diverse learning needs. Constructivist principles encourage active engagement and problem-solving, while UDL emphasizes flexibility and multiple means of engagement, representation, and expression, ensuring that students with disabilities can participate fully in STEM learning environments (Meyer, Rose, & Gordon, 2016; Piaget, 1970; Vygotsky, 1978).

Research on STEM education in K-12 settings underscores the positive impact of interdisciplinary approaches in promoting student engagement, achievement, and preparedness for future careers. However, the integration of STEM subjects in special education remains underexplored, with existing studies often focusing on individual STEM disciplines rather than on the interdisciplinary nature of STEM in inclusive settings (Honey et al., 2014). The inclusion of students with disabilities in STEM education continues to face significant challenges, such as systemic barriers related to limited resources, insufficient professional development, and a lack of administrative support (McDonald, 2016).

In addition to systemic barriers, pedagogical challenges arise when special education teachers attempt to integrate STEM disciplines in ways that are accessible to their students. Differentiated instruction, the use of assistive technologies, and the need for ongoing support are essential components of effective STEM education in special education settings (Marino, 2009). Assistive technologies, such as text-to-speech software, screen readers, and digital manipulatives, play a crucial role in providing students with disabilities access to STEM content and hands-on learning activities, ensuring that they can engage with complex concepts despite physical or cognitive challenges (Dell et al., 2012).

The review also highlights the role of teacher perspectives and self-efficacy in influencing the successful implementation of interdisciplinary STEM education in special education. Teachers who believe in their students' abilities and feel confident in their own teaching skills are more likely to incorporate STEM activities into their classrooms (Tschannen-Moran & Hoy, 2001). Professional development tailored to the needs of special education teachers is critical in building this confidence and ensuring that teachers have the skills and knowledge necessary to adapt STEM curricula to meet the diverse needs of their students (Desimone, 2009; Penuel et al., 2007).

The literature further emphasizes the importance of inclusion and equity in STEM education. Ensuring that students with disabilities have equitable access to STEM learning opportunities requires both the integration of inclusive teaching practices and the removal of barriers that limit participation. Interdisciplinary STEM education, with its flexible and inquiry-based approach, provides a platform for addressing these disparities, allowing students with disabilities to engage in meaningful STEM learning experiences alongside their typically developing peers (Florian, 2014; Honey et al., 2014).

However, significant gaps in the literature remain, particularly in the areas of long-term impacts of assistive technologies, professional development for special education teachers in STEM, and inclusive classroom practices. Further research is needed to explore how interdisciplinary STEM education can be effectively adapted to special education settings and how schools can address the systemic and pedagogical barriers that continue to hinder access for students with disabilities.

In conclusion, the literature review demonstrates that while interdisciplinary STEM education holds great promise for supporting students with disabilities, there is still much work to be done in terms of creating inclusive, equitable, and accessible learning environments. By addressing the existing gaps in research and focusing on the implementation of inclusive teaching practices and professional development, future studies can help ensure that all students have the opportunity to succeed in STEM fields.

CHAPTER III: METHODOLOGY

The methods and procedures used to investigate the lived experiences and perspectives of special education teachers implementing interdisciplinary STEM education are detailed in this chapter. Primarily, this chapter established the foundation on which the research was built and presented an overview of the study and its associated research questions. This portion of the chapter offered insight into – and a kind of preface to the study's design. Next, the chapter served to set the stage for understanding the context in which the study took place and in which the participants live and work. Following this, the chapter presented a clear and detailed sketch of the appearance and processes of data collection and analysis in the study.

Study Overview

The focus of this investigation was the experienced realities and viewpoints of special education teachers in a rural district in the Southeastern United States as they implement interdisciplinary STEM education. Certainly, when the subject of STEM education comes up for discussion, it is usually in connection with general education settings. Rarely, if ever, is it discussed with respect to the implementation in a special education setting. This district, in fact, had an initiative underway, in which the special education department was included, to mete out, for the benefit of all teachers and students alike, the professional development necessary to serve as the bridge between what the special education teachers practiced prior to their STEM professional development and what they are expected to teach going forward. The objective of this study aimed to explore how these teachers perceived and piloted the integration of STEM into their specialized teaching environments. By capturing their insights, the study sought to contribute to the growing body of literature on interdisciplinary STEM education, particularly in special education settings, where the need for tailored approaches and resources is critical to fostering inclusive learning experiences for all students.

Research Questions

The main research question guiding this study were:

1. What are the lived experiences and perspectives of special education teachers regarding interdisciplinary STEM education?

This question aims to explore the comprehensive views and experiences of special education teachers as they implement and engage with interdisciplinary STEM education. By focusing on their lived experiences, the study seeks to uncover the nuanced and context-specific aspects of how these educators perceive and practice this approach in their classrooms.

Sub-Questions

To further explore particular elements of the primary inquiry, the study was directed by the following sub-questions:

1. What do special education teachers perceive as the benefits of interdisciplinary STEM education for students with disabilities?

- This sub-question aims to uncover the positive outcomes that special education teachers associate with interdisciplinary STEM education. It seeks to identify how these educators believe STEM education can enhance learning experiences for students with disabilities, such as improving engagement, fostering critical thinking, and developing problem-solving skills (Asghar et al., 2017). Additionally, it explores whether teachers observe improvements in students' social skills, motivation, and overall academic performance due to integrating STEM into their curriculum (Courtade et al., 2014).

2. What challenges do teachers face in implementing interdisciplinary STEM education?

- This sub-question focuses on the obstacles and difficulties special education teachers encounter when incorporating interdisciplinary STEM education into their classrooms. It aims to explore systemic issues, such as administrative support and time constraints, that may hinder the effective implementation of STEM education in special education settings (Cameron, 2011). Understanding these challenges is essential for developing strategies to support teachers and improve STEM education accessibility.

3. What strategies do teachers use to adapt STEM content for special education students?

- This sub-question investigates the methods and approaches that special education teachers employ to tailor STEM content to meet the diverse needs of their students.

By addressing these research questions, the study aimed to comprehensively understand special education teachers' perspectives on interdisciplinary STEM education. The findings offered valuable insights into the benefits, challenges, and strategies associated with implementing STEM in special education settings, ultimately contributing to developing more inclusive and effective educational practices.

Research Design

The research employed a phenomenological case study methodology to examine the lived experiences and perspectives of special education teachers' implementation of STEM education. The reason for selecting a phenomenological approach laid in its focus on understanding individual perceptions and interpretations of experiences. This aligned with the goal of the research, which was to capture, in rich detail, the lived experiences of special education teachers' implementation of STEM education (Creswell & Poth, 2018). A case study then served as an effective means of thoroughly exploring these teachers' experiences in "real world" contexts, thus providing some valuable contextual insights (Yin, 2018). This methodology effectively combined the strengths of phenomenology and case studies to comprehensively understand the phenomenon being investigated.

Justification for the Qualitative Approach

This study used a qualitative research design because it is the most suitable for gaining a deep understanding of the complex, context-specific phenomenon. Qualitative research methods are also particularly effective in capturing individuals' nuanced, subjective experiences, which is crucial for understanding the perspectives of special education teachers on interdisciplinary STEM education (Creswell & Poth, 2016). Qualitative research design allows for collecting detailed data through in-depth interviews, classroom observations, and document analysis. These methods are necessary for understanding the participants' experiences and the context in which they occur (Merriam & Tisdell, 2015), in other words, triangulating the data from these three sources yielded a clearer and more reliable picture of the phenomenon being studied (Merriam & Tisdell, 2015; Stake, 1995).

In addition, the way the qualitative approach provided flexibility in data collection and analysis, allowing for a more personalized and adaptive interaction with the emerging themes and insights during the study, made it an appropriate choice for this dissertation. As Patton (2015) expresses it, "Qualitative research is not about 'rigor.'" It is about accomplishing something with the research that is more important than the "one right way to do research." Patton (2015) implies that in qualitative work, even though there are accepted procedures for doing analysis, these procedures must be understood within the framework of achieving more important ends.

This study adopted a constructivist worldview, which posits that knowledge is actively constructed by individuals rather than passively absorbed. In the context of education, constructivism emphasizes the role of the learner in making sense of information through experiences, reflection, and social interaction (Piaget, 1970; Vygotsky, 1978). This perspective was particularly relevant in exploring the lived experiences of special education teachers, as it aligned with the notion that educators construct their understanding of teaching and learning through their interactions with students, colleagues, and the educational environment (Fosnot, 2013). Interdisciplinary STEM education, grounded in constructivist theory, promotes active, contextualized learning where teachers and students collaboratively build knowledge across distinct disciplines. This approach encouraged hands-on activities and real-world problem-solving, allowing students to integrate content from multiple STEM areas while maintaining the integrity of each discipline (Bybee, 2013; Learn, 2000). By using a constructivist framework, this study aimed to capture the complex, dynamic nature of how special education teachers integrate STEM principles into their teaching practices, reflecting the belief that their experiences and perspectives are shaped by their unique contexts and interactions (Schunk, 2012).

The researcher collected classroom observation data and conducted semi-structured interviews to understand the special education teachers' perspectives and lived experiences. To note how the teachers are integrating STEM education into their special education services, classroom observations were conducted. Semi-structured interviews were conducted to deepen the understanding of teachers' perspectives and lived experiences regarding STEM education integration into special education services.

Method

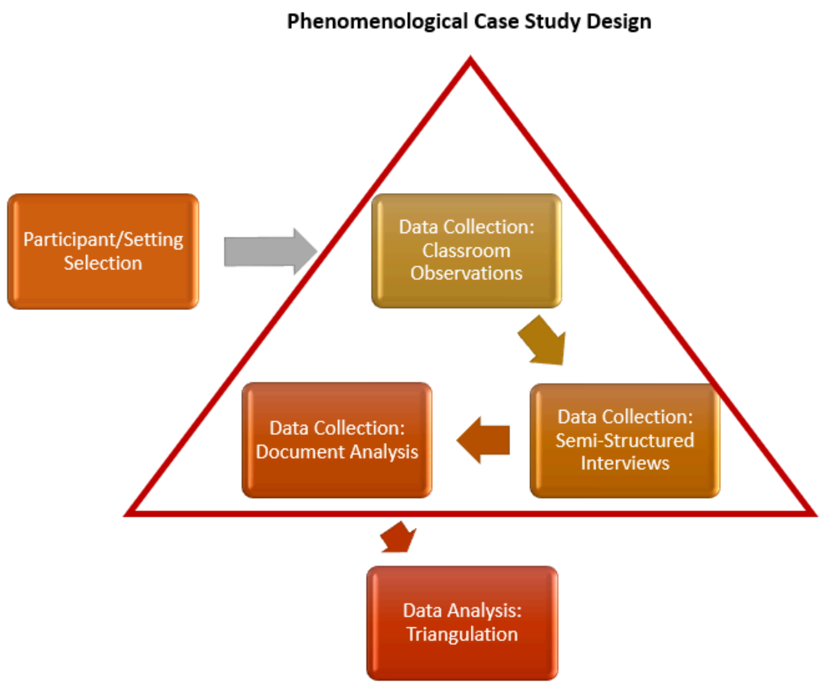
This study employed a phenomenological case study approach to explore the lived experiences and perspectives of special education teachers in implementing interdisciplinary

STEM curricula. This enabled a detailed examination of the educators' experiences with the unique challenges posed by interdisciplinary STEM education in special education environments (both self-contained and inclusive). Qualitative methods captured the complex, nuanced, and often difficult-to-express realities of the participants' lived experiences that are particularly relevant when exploring the types of enabling and constraining conditions that make interdisciplinary STEM curricula possible (or not) for the educators and their students. This approach allowed for in-depth exploration and interpretation of the participants' experiences in real-world educational contexts (Creswell & Poth, 2018).

Methodology Flowchart

A flowchart (Figure 3.1) provides a clear overview of the selected research design and the methodological steps that were taken. This flowchart outlines the progression of the study, beginning with the selection of a phenomenological case study approach and proceeding through the key stages of participant sampling, classroom identification, and the use of classroom observations as a screening tool. Moving in a left-to-right direction across the top of the flowchart, the reader can see how the research progressed, starting with participant/setting selection. From there, the research moved through data collection which consists of three primary data collection methods: classroom observations, semi-structured interviews, and document analysis. And then, it shows how the researcher analyzed the collected data using thematic analysis. Finally, the flowchart depicts the strategies used to ensure the study's trustworthiness, including data triangulation and member checking.This chapter provides a detailed explanation of each of the stages. The flowchart, however, serves as a visual summary of the overall methodology. It helps put into context the sequence and interconnectedness of the components of the study.

Figure 3.1 *Flowchart of Research Methodology*



Note: This flowchart illustrates the key stages of the research methodology, from design and participant selection to data collection and analysis.

In this section, the study described the method used to select and engage participants, collect data, and analyze findings to provide insights into the implementation of interdisciplinary STEM education in special education settings. Purposeful sampling was employed to select special education teachers who meet specific criteria. Criteria included 1. Certified special education teacher, 2. Experience teaching in special education for at least two years, 3. Actively involved in planning the implementation of STEM instruction in specially designed instruction, and 4. Willing to participant in an observation, interview, and submit documents. The desire was for 5-7 participants to participate in this study. . These teachers had interdisciplinary STEM education experience and expertise relevant to the study's focus. The special educators who participated in the study came from a range of instructional and administrative contexts. They managed a diverse student population, including students with various disabilities and at different grade levels. Data were collected in three ways: semi-structured interviews, classroom observations, and document analysis (Bowen, 2009). These methods allowed the study to “dig deep” into the contexts of the participants and to better understand how interdisciplinary STEM education was implemented and adapted for students with disabilities. The findings in this study were a result of timely and relevant data analysis collected during the study. Data triangulation and member checking increased the accuracy of the data. These same analyses ensured the varied participants in the study were accurately represented.

Ethical considerations, such as informed consent and participant confidentiality, were prioritized throughout the research process. This comprehensive approach ensured that the study captures varied perspectives on the challenges and benefits of integrating interdisciplinary STEM education into special education, offering a nuanced understanding of its implementation across different contexts.

Setting

This study was conducted in a rural district in the Southeast region of the United States. The district served approximately 2,000 students. The demographics of the students are approximately 81.5% African American, 4.6% Hispanic, 3.1% Caucasian, 7.1% American Indian or Alaska Native, 0.3% Asian or Asian/Pacific Islander, 0.4% Native Hawaiian or other Pacific Islander, and 3% two or more races. Approximately 70% of the students qualify for free and reduced lunch. The district could best be described as a low socioeconomic community. In 2019-2023, the per capita income of the county was $26,951, the median county income was $45,568, the median household income in the county was $45,071, and 35.9% of the people in the county lived below the poverty line. The district had approximately 91% of schools identified as low performing with approximately 55% of the schools having “met” expectations, 36% of schools having “not met” growth expectations, and 9% of the schools having “exceeded” growth expectations (Churchill, 2023). The schools within the district have school report card letter grades ranging from “B” to “F,” with over 60% of the schools having “F” (School Report Card, 2023). Approximately 13% of the student body has been identified as students with disabilities and meeting the criteria for special education (Ransdell, 2020).

Table 3.1 *Student Race and Gender*

Race or Gender	Percentage %
Hispanic	4.6
Caucasian	3.1
American Indian or Alaska Native	7.1
Asian or Asian/Pacific Islander	0.3
African-American	81.5
Two or More races	3

The special education department had a diverse staff. Approximately 29% are African American, 6% are Indian, 47% are Hawaiian/Pacific, and 18% are Caucasian. In terms of gender, 29% are male and 71% are female. As there is a national deficit in special education teachers, the district has contracted with international agencies and an attorney to recruit international teachers to serve the district. This gives perspective to the larger than expected percentage of Hawaiian Pacific special education teachers.

Sampling Method (Purposeful Sampling)

In this study, the researcher used a sampling method referred to as "purposeful sampling." This method involved intentionally choosing individuals with specific knowledge or experience related to the phenomenon under investigation (Merriam & Tisdell, 2015). In this case, purposeful sampling helped identify special education teachers with exceptional knowledge of interdisciplinary STEM education and can offer valuable insights into its implementation, benefits, and challenges (Creswell & Poth, 2016).

Participants

The participants in this study were special education teachers who had experience implementing interdisciplinary STEM education in their classrooms. To be eligible for participation, teachers must have met the following criteria:

- Hold a certification in special education.
- Have at least two years of experience teaching in special education settings.
- Be actively involved in implementing or planning to implement STEM curricula.
- Willing to participate in in-depth interviews, classroom observations, and provide relevant documents for analysis.

These criteria ensured that the participants had the necessary background and experience to provide meaningful insights into the research questions (Patton, 2015).

The researcher expected to invite all of the special education teachers in a rural district in the Southeast region of the United States of America. The district had approximately 20 positions, though a few are currently vacant. Therefore, the expected number of teachers invited to participate was approximately 5-7. Teachers were offered a $25 gift card to demonstrate appreciation for their time and effort in participating in the study.

Table 3.2 *Participant Characteristics*

Characteristics	Data
Teachers	6
African-American	0%
Hawaiian/Pacific	67%
Caucasian	33%
Male	50%
Female	50%
Certified	100%
Age Range	26-54
Educational Background Range	BA to MA
Years of Teaching Experience Range	4-24
Disabilities Served Range	Specific Learning Disability, Autism, Intellectual Disability, Other Health Impairment, Multiple Disabilities
School Setting Range	Regular-Separate; Rural

Criteria for Selecting Participants

The study involved 5-7 participants, a sample size supported by the literature on qualitative, phenomenological research (Creswell, 2013). According to Creswell (2013), phenomenological studies typically involve 5-10 participants, as this range allows for in-depth exploration of participants' experiences while still maintaining manageability in terms of data collection and analysis. The 5-7 participants in this study provided enough variation to capture different perspectives on the implementation of STEM education, while still allowing the researcher to conduct thorough interviews and analyses.

The inclusion criteria for selecting participants were as follows:

1. Participants must be special education teachers with at least one year of experience teaching students with disabilities in K-12 settings.
2. Participants must have experience teaching STEM subjects, either as part of an interdisciplinary STEM curriculum or through independently developed interdisciplinary STEM lessons.
3. Participants should work in classrooms where students with disabilities are the primary population served (e.g., special education classrooms or inclusive settings).

These criteria ensured that the selected participants had relevant and direct experience with interdisciplinary STEM education and can provide meaningful insights into the unique challenges and benefits of adapting STEM curricula for students with disabilities.

Special Education Settings

Participants in this study taught in self-contained, resource, and inclusive classrooms. These types of classrooms represent the primary instructional environments for students with disabilities. The experiences of teachers varied greatly, depending on the type of instructional environment in which they work. Thus, including teachers from all these environments gave a much broader base of experiences from which to draw when making decisions about the kinds of practices to study and promote.

Self-contained classrooms, also known as *separate* settings, are specialized places where students with disabilities learn separately from their typically developing peers. Teachers in *self-contained* classrooms have much more leeway in adapting STEM content to the precise needs of their students, but they face challenges that come from insufficient resources and the necessity of providing a highly individualized education (Friend & Cook, 1992). Insights from these teachers about the specific adaptations and stellar instructional strategies they use in *self-contained* classrooms will be beneficial to all teachers who work with students with disabilities.

Resource setting is where students with disabilities are served for part of their day outside of the general education classroom where specialized instruction can be provided, but most of the time they are educated with their non-disabled peers. The big difference in the way these students get instruction revolves around the use of their individualized education program (IEP). The teachers in the *resource* setting have a lot of room to make decisions concerning not only what materials to select but also what instructional strategies to use. These decisions are made with the individual student's unique profile in mind.

In the *general* education setting known as an inclusive classroom, children with disabilities are taught alongside their typically developing peers. While the typical *general* education classroom serves as the learning environment for about 40% of the nation's 7 million students with disabilities, many of these children were once educated in segregated environments (Florian, 2014). In an *inclusive* classroom, the *general* education teacher is charged with serving a student population that is not only academically diverse but also extremely different in terms of preferred learning styles and amounts.

When teachers from resource, self-contained, and inclusive classrooms were part of the study, it enabled the research to reflect a range of nearly all experiences. It allowed us to understand how interdisciplinary STEM education is adapted for students with disabilities in a very diverse set of educational settings. The study's findings shed light on what is needed in order to understand both the common ground and the unique aspects of the range of those different educational settings. The findings offered insights into the similarities and differences in teaching practices, challenges, and outcomes across these environments.

Demographics and Context

The selection of participants was from a broad array of special education environments. This includes inclusive settings, resource rooms, and self-contained special education settings. The geographic focus is a single school district, which encompasses both rural and urban schools. The study intends to include teachers from a range of demographic backgrounds to ensure a diversity of perspectives in the findings.

The researcher collected demographic details such as age, sex, and number of years in the teaching profession. This information was used to describe the respondents. This gives a vivid picture of who the respondents are and allows comparison with other groups. The study particularly targets schools that have put in place a school-wide STEM curriculum specifically for special education teachers. By examining a variety of contexts, the study aims for a comprehensive understanding of how interdisciplinary STEM education is perceived and implemented in special education settings.

Data Collection Methods

Before data collection could begin, the research secured IRB approval and approval from the district leadership. Once this was secured, the researcher recruited participants by emailing all potential participants a request for them to participate. A brief written description was provided within the consent to participate. Please see Appendix A for the consent to participate.

The data collection methods employed in this study are designed to capture a comprehensive understanding of how special education teachers implement interdisciplinary STEM education in their special education services. By utilizing a combination of in-depth interviews, classroom observations, and document analysis, the study aims to gather rich, detailed data from multiple sources to validate the data. These methods were carefully selected to provide a comprehensive view of the participants' experiences and the educational context in which they work. The triangulation of data from these different sources ensured a comprehensive analysis, enabling the researcher to explore the complexities of interdisciplinary STEM education in special education settings.

In-Depth Interviews

In-depth interviews were conducted using a semi-structured format, that allows for flexibility while ensuring that all key topics were covered. The interview guide included open-ended questions designed to elicit detailed responses about the participants' experiences and perspectives on interdisciplinary STEM education (Creswell & Poth, 2016). This approach facilitates a comprehensive exploration of the participants' thoughts and feelings, enabling the researcher to probe deeper into specific areas of interest as needed (Patton, 2015).

The interview process involved scheduling one-on-one sessions with each participant at a mutually convenient time and location. Each interview lasted approximately 60 to 90 minutes, providing ample time for in-depth discussion while being mindful of the participants' schedules (Merriam & Tisdell, 2015). Interviews were audio-recorded with the participants' consent to ensure accurate data capture and allow for thorough analysis later. Transcripts were generated from the recordings for coding and thematic analysis (Creswell & Poth, 2018). Once transcripts were verified against the recordings, the audio recordings were deleted. Interviews were coded with a participant ID, with no personally identifiable information collected. Each of these pieces of data was stored in an electronic folder with restricted access such that another person with the link could not access the files without it being explicitly shared with him or her. Please see Appendix B for the list of questions for the semi-structured interviews.

Classroom Observations

To gain a firsthand understanding of how special education teachers were implementing interdisciplinary STEM education, classroom observations were conducted. The focus of the observations was on the following three elements: 1. the kinds of instructional strategies the teachers use; 2. the nature of the interactions that occur between teachers and students; and 3. how the overall environment of the classroom supports or detracts from the student and teacher work. This work, of course, was almost always in context and somewhat subjective. Yin (2018) states that "an observation record is a rich source of contextual information."

The observation process involved a visit to each participating teacher's classroom, with each session lasting between 30 to 60 minutes, depending on the length of sessions being provided to the students. Teachers communicated with the research as to when they were available for interviews when the researcher provided options of dates. Observations were conducted on the same dates as the interviews for each participant. Field notes were taken during the observations to document key activities, interactions, and instructional methods. A STEM Observation Protocol was used to ensure consistency and comprehensiveness across all observations. The STEM Observation Protocol was by the National Institute for STEM Education based on research three meta-analysis and the National Research Council. The following Likert rating scale was added to the domains and actions that they created to establish a manner to report levels of implementation: 0-3 or NA. Please see Appendix C for the STEM Observation Protocol.

Additionally, digital tools such as audio recordings of the interviews were employed, with the participants' consent, to capture detailed classroom dynamics for further analysis (Merriam & Tisdell, 2015). Observations were coded with a participant ID, with no personally identifiable information collected. Each of these pieces of data were stored in an electronic folder with restricted access such that another person with the link could not access the files without it being explicitly shared with him or her to protect anonymity.

Document Analysis

Document analysis expected to include a review of various types of documents related to the implementation of interdisciplinary STEM education. Requested documents included lesson plans, instructional materials, student work samples, professional development materials, pictures or views, and assessment reports. Analyzing these documents could have provided insights into the curricular content, instructional strategies, and assessment practices used by the teachers (Bowen, 2009). The researcher requested that teachers share whatever they feel relevant in demonstrating how they implement interdisciplinary STEM education within their special education services. An electronic folder was provided to each teacher where they can contribute any document they wish to be reviewed. The electronic folders were kept secure by restricting the access such that anyone with a link could not access the documents unless the folder was explicitly shared with him or her. The folders were only shared with the researcher and each individual participant. However, no documents were submitted to the researcher. Though document analysis was expected to be a component of the data collection, participants did not submit any documents, so documents were not collected.

Data Analysis

The data analysis process in this study was designed to rigorously examine the relationship between special education teachers' experiences and the implementation of interdisciplinary STEM education. Using descriptive statistics, the study sought to connect the findings to the research questions, offering insights into patterns and relationships within the data. Descriptive statistics, such as the mean on action items on the STEM Observation Protocol, provided an overview of the data.

Next, the researcher used the constant comparative method (Glaser and Strauss, 2017) to analyze the thematic data used in this qualitative study. This method, which has its origins in grounded theory, used four steps. The first is open coding, in which the researcher identified codes based on themes emerging in the data. The second step was axial coding. Here, the researcher grouped together codes based on similarity. The STEM Observation Protocol did not provide some terms to the researcher as potential themes to look for. The third step was selective coding. In this step, the researcher compared categories and creates core categories. The last step is collating. Here, the researcher organized the codes and put everything together.

Coding Process (Step 1)

Data analysis started with coding, which means organizing and categorizing the amassed data. This study uses both inductive and deductive coding approaches. Inductive coding allowed themes to emerge naturally and without preconceived notions from the data. After a round of coding using an inductive approach, the researcher reviewed themes from the literature review and recorded some of the codes to reflect language from the literature. This enabled the researcher to identify patterns and insights that are grounded in the participants' experiences (Thomas, 2006). Deductive coding, in contrast, involved using a predefined framework based on the research questions and theoretical constructs that guide the analysis (Miles et al., 2014). Using both techniques allowed for a comprehensive and systematic examination of the data.

Thematic Analysis (Step 2 and 3)

Thematic analysis was carried out to extract and elucidate significant themes that represent the participants' experiences. To achieve this, one must engage closely with the data by reading and rereading the transcripts, field notes, and documents, as if they were the script for a play or movie in which the participants bring their experiences to life (Braun & Clarke, 2006). One must first identify the 'meaningful' segments of data across the entire dataset, for example, a transcript, and then assign preliminary codes to them. These preliminary codes should represent the 2nd and 3rd level of meanings that the preliminary textual segments might have (Flynn, 2007; in M. L. T. DeSantis & U. L. C. Furzer, 2012). After assigning preliminary codes, the next step was to group related codes into potential themes. These themes were organized into broader categories that reflect significant patterns across the entire dataset. The next significant task involves validating or checking the themes for coherence, as well as their consistency with the dataset. (Braun & Clarke, 2006).

Member checking was used to promote the validity and credibility of the findings. This was done by sharing the preliminary themes and interpretations with the participants. They were asked to verify the accuracy of the analyses and make suggestions if the themes do not resonate with their experiences. Participant feedback, when used appropriately, greatly enhanced the trustworthiness of the analyses conducted by researchers (Davis et al., 2019).

Triangulation (3 of 3)

Finally, triangulation augmented the study's reliability and validity by combining data from multiple sources, including interviews and classroom observations. By cross-checking and corroborating the findings from different data sources, the study ensured a comprehensive and nuanced understanding of the research questions (Denzin, 2012). Triangulation helped to identify and address inconsistencies and biases, providing a more robust and credible interpretation of the data (Patton, 2015). This activity was part of the case study design.

Ethical Considerations

This study was built on a foundation of ethics. Every stage of the research process was guided by ethical considerations, which were absolutely necessary to assure the protection and respect of participants. They are as follows:

1. Informed Consent: This protocol ensured that participants know what they were getting into, and allowed them to opt-out if they so chose.

2. Confidentiality: This measure, which safeguarded participants' private information, was essential to maintaining the "good life" that research participants should expect.

3. IRB Approval: This oversight stage, which occurred before any research participant was involved, made certain that not only is the "good life" expectation maintained, but that the study in question had integrity.

Informed Consent Process

Ethical research necessitated the informed consent of its participants. This meant that those who participated in research do so with a full understanding of the study's aims, means, and intent. To this end, Creswell and Poth (2018) insist that the "detailed informed consent document" required by this study be given to prospective participants prior to their agreeing to take part in the research. Participants were required to sign a consent form indicating their understanding and willingness to participate. This process was designed to ensure that participants made an informed decision based on a comprehensive understanding of the study (Patton, 2015).

Confidentiality Measures

Ensuring the confidentiality of participants was essential for safeguarding their privacy and establishing trust. Several steps were taken to ensure confidentiality, focusing on the issues of anonymity, data storage, and access to data. When reporting findings from the study, the researcher used participant IDs instead of names or any other identifying information (Merriam & Tisdell, 2015). The researcher used “codes [that] conceal any potentially identifying information,” making it impossible for anyone other than the researcher to know which data belong to which participant (Bryman, 2016). Audio recordings were made of all interviews, but only those who needed to know were permitted to listen to the recordings (Davis et al., 2019) – in this case, the researcher. By implementing these measures, the study ensured that participants’ identities and personal information were protected throughout the research process.

Institutional Review Board (IRB) Approval

Before data collection, a research study underwent a careful review and an approval process by an Institutional Review Board (IRB). The IRB scrutinized the study’s design, methods, and ethical considerations to make sure everything complied with stringent ethical and regulatory requirements. The board also assessed the potential risks and benefits to research participants, the adequacy of the informed consent process, and the confidentiality provisions as they relate to participant protection (Patton, 2015). An IRB approval guaranteed that the study complied with all necessary ethical guidelines and provided the required protections for participants, thus ensuring the research was conducted with integrity and a strong ethical framework (Yin, 2018).

Limitations

Potential for Researcher Bias

A principal limitation of qualitative research was the potential for bias on the part of the researcher. In qualitative studies, researchers often work closely with participants and the data, which can lend itself to a more subjective mode of interpretation and, in turn, influence the findings. To counter this, the researcher employed various strategies, among which reflexivity might be the most well-known. Reflexivity involves the researcher in a continual process of “owning” one’s biases, which helps the researcher to better understand how these might be impacting the research (Patton, 2015). Additionally, the use of multiple data sources (interviews, observations, and document analysis) and triangulation helped to provide a more balanced and objective perspective (Creswell & Poth, 2018).

Generalizability of Findings

A further limitation was the generalizability of the findings. Qualitative research, particularly case studies, often focuses on a small number of participants in a specific context, which can place limits on the extent to which the results can be extended to other settings or populations (Yin, 2018). This study’s findings are context-specific and may not be applicable to all special education settings. However, the detailed, in-depth nature of qualitative research often provides a richer understanding of a phenomenon that can be built upon and extended to other contexts by practitioners and researchers (Merriam & Tisdell, 2015).

Reliance on Self-Reported Data

The study relied heavily on self-reported data from participants, which can be subject to biases such as social desirability bias, recall bias, and selective memory. Participants may have provided responses that they believe are expected or favorable, rather than those that accurately reflect their experiences and perspectives (Schneider, 2001). To address this limitation, the researcher employed techniques such as triangulation, cross-checking data from multiple sources, and member checking to validate the accuracy and authenticity of the self-reported data (Creswell & Poth, 2016). Additionally, the use of observations helped to corroborate and enrich the data obtained from interviews.

Summary

In summary, this chapter provided an overview of the research methodology employed to explore the lived experiences and perspectives of special education teachers as they implement interdisciplinary STEM education in a rural district in the Southeast region of the United States. The chapter began by outlining the study's objectives and research questions, which aimed to uncover the benefits, challenges, and strategies associated with integrating STEM education into special education settings. The research adopted a phenomenological case study methodology, utilizing a qualitative approach to capture the nuanced, context-specific experiences of the participants. This approach was justified by its ability to provide in-depth insights into complex phenomena, which were critical for understanding the perspectives of special education teachers in this context.

Data collection methods include in-depth interviews and classroom observations, with a focus on triangulating data from multiple sources to ensure a comprehensive analysis. The chapter also addressed the ethical considerations of the study, including the informed consent process, confidentiality measures, and Institutional Review Board (IRB) approval. It concluded by acknowledging the lack of direct student experience of the research, such as potential researcher bias, generalizability of findings, and reliance on self-reported data, and discusses the strategies employed to mitigate these issues.

CHAPTER IV: RESULTS

This chapter centers on the study's findings, which focuses on special education teachers' perspectives and experiences of interdisciplinary STEM education. The organization of the findings closely parallels the research questions. Five main themes emerged from the data, each with subthemes. Together, these themes and subthemes represent a holistic view of the phenomenon being studied. They also allowed a narrowing (in a way that closely resembles "zooming in") into each teacher's unique experience that together form a group experience. While this is "the experience of the group," it also has constitutive elements that represent special education teachers' interdisciplinary STEM experiences in a way that challenges the group makeup to be a conventional one. Furthermore, special education teachers as a group have unique attributes that affect how this group interprets and experiences interdisciplinary STEM education.

The study is guided by one overarching research question and three sub-questions:

1. *Research Question 1*: What are the lived experiences and perspectives of special education teachers regarding interdisciplinary STEM education?
    a. *Sub-questions 1*: What do special education teachers perceive as the benefits of interdisciplinary STEM education for students with disabilities?
    b. *Sub-questions 2*: What challenges do special education teachers face in implementing interdisciplinary STEM education?
    c. Sub-questions 3: What strategies do special education teachers use to adapt interdisciplinary STEM content for students with disabilities?

By addressing these questions, the study aimed to shed light on the practical realities of implementing interdisciplinary STEM education in special education settings and identified actionable strategies for overcoming these challenges. The findings presented in this chapter are organized thematically to align with the research questions, providing a comprehensive understanding of the participants' experiences.

Context

The research was conducted in a rural part of an area in the Southeast region of the United States. The schools that took part in the research had differing amounts of access to resources for STEM education, which affected the teachers' methods for implementing and executing an interdisciplinary STEM curriculum. The special education programs in these schools serve a wide variety of students who have an equally vast number of different kinds of disabilities including learning disabilities, intellectual disabilities, physical disabilities, developmental disorders, and social emotional disorders. These different access levels and the types of disabilities did not inhibit but instead led to very rich conversations and interactions during both the observations and interviews that produced a lot of data. The contexts in which the research took place are very important, for access to resources and the nature of the disabilities students have served as a backdrop to the implementation of both interdisciplinary STEM curriculum and the special education programs that exist in these schools.

Participants

For this study, the participants comprised of six special education teachers from the Southeastern United States. They were selected for their experience and proficiency in interdisciplinary STEM education, as well as their enthusiasm for providing valuable insights into their perspectives and teaching practices. The researcher gave participants pseudonyms to maintain their confidentiality. The following table presents information about the participants.

Table 4.1 *Participant Information*

Participant	Years of Experience	Role	Educational Background	Demographics
P1	5 years	Co-teacher (Math, English)	Bachelor’s in special education	Male, Filipino
P2	11 years	Resource Teacher	Bachelor’s in special education	Female, Filipino
P3	7 years	Occupational Course of Study Teacher	Master’s in criminal justice	Female, Caucasian
P4	9 years	Inclusion Teacher	Bachelor’s in special education	Male, Filipino
P5	25 years	Separate Settings with Student on the Extended Content Standards	Bachelor’s degree in the theater arts and music minor	Male, Caucasian
P6	10 years	Math Inclusion Teacher	Bachelor's in Elementary Ed	Female, Filipino

Data Collection

This study took a thorough approach to the data collection process, ensuring that the lived experiences of special education teachers were captured in full. The methods used were not just a single method, which is often the case in qualitative research, but a combination of three methods: semi-structured interviews, classroom observations, and document analysis (Bowen, 2009). Added together, these three methods provided a rich and reliable data set. The study also used an approach in combination with these three methods to enhance the validity of the findings, which is called triangulation.

This investigation was rooted in the transcendental phenomenology of Moustakas (1994), which places a strong emphasis on epoche (bracketing). In this process, the researcher sets aside preconceptions to understand more clearly the lived experiences of the individuals being studied.

The researcher first obtained approval from the Institutional Review Board (IRB) of the university where the researcher is enrolled. Then, access to the participants was sought from key district administrators, including the Superintendent, Assistant Superintendent, and Director of Special Education, in a rural Southeastern region of the United States. These approvals were granted via email communications with both the Superintendent and Director of Special Education (see Appendix D). Once access was granted to the participants, IRB approved communications were emailed to all special education teachers in the selected district. A total of six special education teachers agreed to participate in the study (N = 6) and signed the informed consent forms that were returned to the researcher.

Observation and Interviews

Once the participants were selected, the researcher scheduled individual meetings with each of the six participants to conduct the classroom observations and semi-structured interviews (see Appendix F). The meetings served a dual purpose. First, they provided the opportunity for the researcher to verify, through the use of a STEM observation protocol, whether the participants were actually delivering interdisciplinary STEM education in their classrooms. The protocol itself was developed by the National Institute for STEM Education and is based on three meta-analyses, as well as the National Research Council's framework.

Second, the observations (and follow-up interviews) served as a means for the researcher to collect data that would address the research questions. Karp and Zia (2018) stated that the observational tool assesses "the degree to which the interdisciplinary context of the lesson under observation was apparent . . ." (p. 4). In order to obtain a well-rounded view of each participant, observations and interviews were conducted with all six of the selected participants.

The STEM observation protocol has 15 actions across 3 domains (Creating an Environment for Learning, Building Scientific Understanding, and Engaging Students in Scientific and Engineering Practices), with each action having three subcomponents that are rated to provide an overall score per action. Each subcomponent is rated on a scale of 0-3, with 3 being the highest rating. Thus, each action could receive a score between 0-9. The highest combined score across all three domains would be a 135. Observations from each participant ranged from 95 (Participant 4) to 109 (Participants 1 and 2). See Table 4.2 for more information.

Table 4.2 *STEM Observations Indicators Across Participants*

Indicators	Part 1	Part 2	Part 3	Part 4	Part 5	Part 6	Avg
Domain 1: Creating an Environment for Learning (E)							
Action 1: Creating a Positive Classroom Culture (E-1)	9	9	9	9	9	9	9
Action 2: Establishing Cooperative Learning (E-2)	6	6	5	8	9	8	7
Action 3: Integrating Technology (E-3)	9	9	6	6	9	9	8
Action 4: Connecting Learning Outside the Classroom (E-4)	7	7	7	5	6	6	6.33
Domain 2: Building Scientific Understanding (U)							
Action 1: Implementing Inquiry (U-1)	9	9	8	7	9	9	8.5
Action 2: Addressing Student Misconceptions (U-2)	9	9	5	0	9	0	5.33
Action 3: Facilitating Questioning and Discourse (U-3)	9	9	9	9	9	9	9
Action 4: Utilizing Assessment (U-4)	9	9	9	9	9	9	9
Action 5: Building Scientific Literacy (U-5)	9	9	9	9	6	6	8
Domain 3: Engaging Students in Scientific and Engineering Practices (P)							
Action 1: Cultivating Scientific Investigations (P-1)	6	6	6	6	6	4	5.67
Action 2: Developing Engineering Solutions (P-2)	6	6	6	6	6	6	6
Action 3: Fostering Data Utilization (P-3)	5	5	5	5	5	5	5
Action 4: Implementing Project-based Learning (P-4)	8	8	8	8	8	8	8
Action 5: Facilitating Claim-Evidence-Reasoning (P-5)	2	2	2	2	2	2	2
Action 6: Promoting Scientific Argumentation (P-6)	6	6	6	6	1	6	5.17
Total Score: earned/possible (possible calculated as 3 per item not considered N/A)	109	109	100	95	103	96	102

Recording, Transcription, and Data Management

Each semi-structured interview was recorded, adhering to the IRB guidelines and the informed consent of the participants. Recording is vitally important in this phenomenological case study for ensuring accuracy, depth of analysis, and, above all, credibility (Lim, 2024). It preserved the participants' exact words and their meaning, minimizing misinterpretation and researcher bias. It also allowed for the necessary transcription for the thematic coding that was vital to the research process. Coding demanded some creativity and a lot of thinking about what the participants had said and what their saying meant. According to Halcomb & Davidson (2006), verbatim transcription was vital to that process and to the credibility of the research. The researcher met first with the participant in the classroom for observations prior to the interview. The interview then commenced with a reminder that the session would be recorded and followed with the reaffirmation of the participant's informed consent. The researcher used semi-structured, scripted questions for the actual interview (see Appendix B for questions). Once the interview was completed, the recording was downloaded, named using the participant's code number, and uploaded to a secure transcription software. The software then produced a verbatim transcript of the recording. The researcher reviewed this transcript for accuracy before moving on to the next step.

Subsequent participant interviews with the following participants followed the same process with each participant confirming their consent before the researcher proceeded. The interview for the last participant was conducted in its entirety online, via Zoom, with a dedicated link used for this instance of the platform. Despite the virtual format, the same data collection protocol was followed as with the earlier instances of this interview process. Once the interview had concluded, the recording and transcript were processed, stored, and managed with the same secure procedures that have been in place since the very first session.

Data Analysis

The researcher designed the analysis to systematically interpret participants' lived experiences while ensuring methodological rigor, reflexivity, and transparency. Data analysis centered around observation data and interview data, as teachers did not submit any documents for document analysis. The researcher followed Moustakas' (1994) framework for transcendental phenomenology, which emphasizes bracketing (epoche), thematic analysis, and structuring/synthesizing the text/structure. The following are the phases through which the data was analysed:

Phase 1: Initial Data Immersion and Holistic Reading

This phase started with a holistic read of the first interview transcript for each participant. This initial read was all about getting a good sense of their experiences and understanding the big themes – what is common among all the participants and what is unique to individual ones. After that, it was time for a close read, a line-by-line read, really, to get at the specifics, the details, the meanings, and the nuances of what was said. No formal coding was conducted to ensure both general and detailed insights were first understood.

Phase 2: Coding and Reflexive Journaling

After doing close readings of the interview data, the researcher began open coding, breaking the data into meaningful parts that were related to the study's focus. The researcher assigned a code to these parts that captured the participants' perspectives on interdisciplinary STEM education. This was done in a segmented fashion, meaning that the researcher would read a small portion of the data, make a code, and then repeat until the researcher had gone through all the data and had made codes for all the parts that needed to be coded.

The coding procedure was uniformly applied to all first-round interviews, thus ensuring the consistent and reliable segmentation of the data. Once all initial interviews had been coded, the coherence and clarity of the coded segments were ensured as the researcher assigned a clear operational definition for each code. These definitions identified the explicit meaning that each code represented and ensured that the representation was accurate to the meaning of the segments the researcher was now “reading” for. This is, in essence, a “triple-checking” of the codes for quality. If a text segment did not fit neatly into a code, it was reassigned to a better-fitting code or used to make a new, emergent code. If these options did not work well, the coded segment was either discarded or characterized as a theme.

Codes from the interviews addressed beliefs of STEM education, benefits, and barriers. All teachers (100%) noted that they had received STEM professional development, felt that STEM education increased engagement, and felt that they needed follow-up from the professional development. Five of the teachers (83%) also commented that they needed additional time, professional development, and technical knowledge to implement as they integrated STEM education into their specially designed instruction. See Table 4.3 to see the codes identified in each interview by participants.

Table 4.3 *Codes Across Participants from Interview Data*

	Noted Occurrences of Codes Across Participants						
Codes	**Part 1**	**Part 2**	**Part 3**	**Part 4**	**Part 5**	**Part 6**	**Coded Across Participants**
Has received STEM PD	1	1	1	2	1	1	100%
Engagement	2	2	4	4	1	6	100%
Need for follow-up	4	3	1	1	1	4	100%
Need time	4	7	3	3		7	83%
Need for Training	1	3	6	3		6	83%
Need for technical knowledge	3		1	1	1	7	83%
Integration	4		5	2	1	9	83%
Need for resources			5	2	3	3	67%
Need for curriculum for integration		3	1	5		2	67%
Need for collaboration	2	2	1			3	67%
Need for support from Admin		1	1	1	3		67%
Promising, improve problem solving/critical thinking, future of education/good for future jobs		1	1	1	1		67%
Focus on Student Needs	3	1	3			2	67%
Strategy: Connected to real life			1		1	3	50%
Need for strategic plan/systematic integration			1	1		4	50%
Motivational	1		1		1		50%
Differentiation	1		3			3	50%
Supplemental	2	1					33%
Student need for hands on	1		5				33%
Strategy: Multi-sensory			3			1	33%
Strategy: modeling	1			1			33%
Start with small steps	2					2	33%
Should be stand alone class/extracurricular				3		1	33%

Phase 3: Thematic Analysis and Pattern Recognition

The second round of interviews was analyzed using the same systematic approach as the first: a holistic read of the whole transcript, a line-by-line read to zero in on key insights, and the application of the refined coding framework to ensure consistency and identify evolving themes and important motifs. All the while, the researcher maintained a steady and thoughtful gaze at all sets of data to ensure all findings were captured and emerging stories and themes were making sense. Once the researcher was satisfied with all coding and had recorded all frequencies, the researcher began the task of synthesis. The researcher used several layers of emerging insights to perform this act of literary toiling and ensure illumination of any veiled findings.

The researcher went beyond superficial themes to identify deeper meanings in participants' experiences with the problem of practice because they engaged in an iterative process. The researcher also followed Vagle's (2018) hermeneutic circle, returning to original interview excerpts to ensure that what was being called a theme remained grounded in the participants' authentic narratives.

Phase 4: Member Checking

In order to increase the credibility and trustworthiness of the findings, the researcher conducted member checking to validate the findings. Member checking was accomplished by sending individual thematic analysis summaries to each of the six participants. This is necessary because according to Anney (2014) by doing member checks it eliminates researcher bias and creates a more reliable document. The researcher requested that the participants review the themes identified by the researcher during interview analysis to confirm for accuracy and relevance in what each participant was conveying and respond within one week. In the week following the sending out of the individual thematic analysis summaries, all six participants responded, providing affirming feedback regarding the accuracy and relevance of the themes that had been identified.

Phase 5: Structural and Textural Description Development

After thematic validation was completed, the researcher constructed the final phenomenological descriptions. For this, the method described by Moustakas (1994) in his book

“Phenomenological Research Techniques” was used. Moustakas’ method consists of two primary components: structural and textural descriptions. The first part of the method yields a structural description synthesis of the individual themes identified during thematic validation. This structural description conveys how the participants contextualize their experiences and how systemic factors influence STEM education. The next part of the method, textural description, conveys how the participants automatically experience the phenomenon of interest. According to Mueller (2019). It involves a closer examination of all the raw story fragments to yield a set of direct excerpts that can be used to illustrate the themes in the structural description. Throughout this process, the researcher maintained a reflexive journal (see Appendix E).

Themes

The lived experiences, challenges, and strategies of six special education teachers in implementing interdisciplinary STEM education for students with disabilities are the basis for the analysis presented here. The analysis emanates from the semi-structured interviews and centers on the emerging themes. The findings are categorized into three major themes that reflect the teachers’ narratives and provide insight into their experiences of trying to implement a STEM curriculum with their students. The themes emit three major components: (1) the benefits of STEM integration, (2) the challenges of STEM integration, and (3) the necessary adaptations to instruction for the successful integration of STEM in special education classrooms.

Theme 1:Implementation of STEM Education in Special Education.

The incorporation of STEM education into special education classrooms offers both opportunities and challenges. The participants shared their views on how they weave STEM into their teaching practices. Participants shared their perspectives on how STEM is incorporated into their teaching practices, emphasizing its role in enhancing traditional instruction rather than replacing it. Yet the participants, who are STEM teachers and special education teachers, told us with useful specificity how STEM can work in special education classrooms by serving as a reasonably good proxy for what happens in nondisabled classrooms when STEM is part of the educational mix.

STEM as a Supplementary Tool.

Two of the six participants described STEM education as a supplementary tool rather than a standalone curriculum. Teachers emphasized that STEM serves to enhance existing instruction by providing hands-on learning experiences, fostering problem-solving skills, and reinforcing academic content across various subjects. In the context of special education, teachers are focused on providing the legally agreed upon specially designed instruction, which is typically centered around reading, math, writing, social emotional skills, communication, behavior, etc. Therefore, teachers shared that STEM is a great tool to use when teaching these content areas, effectively increasing motivation and engagement. This enables the specially designed instruction to be more relevant and meaningful for students.

- ***P1:*** *"I wouldn't say it's used by itself, but rather as an accent or supplementary thing to enhance what we are already doing."*
- ***P2:*** *"It is a tool that we could use as a supplementary resource to basically make the whole experience of the student meaningful."*

STEM and Sensory Integration.

Teachers viewed STEM education as highly beneficial for sensory integration, particularly for students with learning disabilities and sensory processing disorders. Participants highlighted how technology-based STEM tools (e.g., VR goggles, coding robots, and manipulatives) engage multiple senses, reinforcing students' cognitive processing and retention.

- **P2:** *"STEM education really addresses sensory integration, because there are some technologies that could enhance the learning styles [CB1] of the students, like if they are visual, if they are auditory or kinesthetic."*
- **P3:** *"You need to have hands on activities, and you need to have different materials in order to for the students to manipulate and talking about benefits – involving your hands, there is different senses, the more they retain information."*

Theme 2: Perceived Benefits of STEM for Students with Disabilities.

Teachers highlighted numerous benefits of integrating STEM education into special education classrooms, emphasizing its positive impact on student engagement, motivation, and cognitive development. STEM-based learning was described as a dynamic and interactive approach that fosters a deeper understanding of academic concepts while also building essential life skills. Participants particularly noted how STEM enhances student enthusiasm for learning and cultivates critical thinking and problem-solving abilities. The following sections explore these benefits in greater detail.

Increased Engagement and Motivation.

Participants overwhelmingly reported that STEM increases student engagement and motivation, particularly for students who struggle with traditional learning approaches. Many teachers noted that their students showed excitement when using STEM resources.

- **P1:** *"Students enjoyed building with Legos and using Beebots – they asked if they could do it again at the end of the day."*
- **P3:** *"STEM tools create that 'aha' moment—students become actively involved in learning, making it more meaningful."*

Development of Problem-Solving and Critical Thinking Skills.

Many teachers reported that STEM activities encourage students to develop problem-solving skills through trial and error and self-directed exploration.

- **P1:** *"STEM allows students to think through problems and adjust their approach—it fosters metacognition."*
- **P4:** *"When they build structures or work on STEM challenges, they learn persistence and collaboration - essential life skills."*

Theme 3: Challenges in Implementing STEM Education in Special Education.

STEM education provides a pathway to significant benefits for students with disabilities. Yet, there are unavoidable challenges in fulfilling its promise in special education settings. Participating teachers named several barriers that get in the way of integrating STEM effectively into their instruction. Five of the six participants (83%) expressed uncertainty about how to incorporate STEM effectively due to inadequate professional development opportunities. Additionally, time constraints and competing instructional priorities made it difficult to fully implement STEM initiatives. For some teachers, this barrier translates into having to make a choice between the integrated STEM instruction and the special education curriculum they have been provided. The availability of resources and support from administration varied thereby complicating and making the execution of STEM almost impossible. The following sections discuss these challenges in greater detail.

Lack of Training and Professional Development.

A frequently mentioned challenge by participants was the absence of formal training in STEM integration for special education. Teachers expressed they were not confident to effectively put STEM strategies into action and thought that the professional development they had received was not up to par.

- **P2:** *"We had training, but we still need more. Without a structured curriculum, teachers end up just 'winging it'."*
- **P4:** *"I wasn't properly trained to use some of the STEM resources, so I wasn't sure if I was using them correctly."*

Time Constraints and Competing Responsibilities.

Participants noted that inadequate time is a significant barrier to implementing STEM. They said it is hard to find time for STEM instruction when there are so many other demands on instructional time such as IEP goals, behavioral interventions, and academic remediation.

· **P5:** *"As a special education teacher, I have so many responsibilities—IEPs [Individualized Education Programs], paperwork, behavior management—there's little time left for STEM."*

- **P6:** *" And I would say the students were really engaged, since it's a different type of activity. But the concern there was the time of implementation, since it quite took more time."*

Limited Resources and Administrative Support.

Some participants conveyed to the researcher that the resources for STEM integration were adequate and that the kind of structured administrative support one would expect was lacking. Briefly put, they assert that their district provided some STEM equipment but that there was little to no guidance on how to use these tools effectively.

- **P2:** *"Yes, the administration purchased resources, but we didn't get the planning time to figure out how to use them properly."*

- **P3:** *"STEM implementation depends on having enough resources, but in our district, we have to share, and sometimes there's not enough for everyone."*

Addressing the Research Questions

After settling on the final themes and descriptions, the researcher began to address the study's main research question and its three sub-questions. The work involved not just answering the questions but also doing the all-important synthesis to better understand the not-always-obvious thematic findings that had emerged during analysis. In simpler terms, the researcher had to make sense of the potentially contradictory findings at the different experience levels that had emerged across the various participant groups.

Overarching Research Question:

1. What are the lived experiences and perspectives of special education teachers regarding interdisciplinary STEM education?

To address this question, the thematic patterns that the researcher found from the interviews, classroom observations, and reflective journals merged into one comprehensive thematic pattern. This comprehensive thematic pattern reflects not only the perceptions of the participants but also the essence of their lived experiences, which includes their perceptions, instructional practices, and emotional responses to implementing interdisciplinary STEM education. The researcher preserved the distinct voices of each participant by integrating both structural and textual descriptions and identifying common themes across cases.

Sub-question 1: Perceived Benefits of Interdisciplinary STEM for Students with Disabilities

The researcher studied interview responses concerning favorable student outcomes, honing in on academic, social, and cognitive benefits noted by the special education teachers.

Afterwards, the researcher carried out a frequency analysis. The benefits that appeared most often in the teachers' remarks were as follows:

- Enhanced student involvement, engagement, and drive in STEM-related assignments.
- Enhanced skills in problem-solving and critical thinking.
- Improved collaboration and communication skills among students with disabilities.
- More significant, practical learning instances that helped instill a stronger grasp of the core concepts.

These conclusions were backed by classroom observation data, which offered context to the evidence of students actively participating in interdisciplinary STEM lessons. Participants stated that intertwining STEM disciplines with special education strategies enabled students to apply learning in authentic, real-world scenarios and bolstered their confidence in performing academic tasks.

Sub-question 2: Challenges in Implementing Interdisciplinary STEM Education

To investigate the obstructions and hurdles confronting special education teachers, the researcher analyzed coded interview responses and reflexive journal entries. The challenges most frequently reported were:

- Access to STEM resources and instructional materials designed for students with disabilities is limited.
- Insufficient professional development pertaining to interdisciplinary STEM instruction in special education environments.
- Time pressure from competing teaching commitments and individualized education plan (IEP) responsibilities.

- Challenges identifying effective ways to differentiate STEM instruction for a variety of unique learners.

The researcher performed a comparative analysis to determine if these difficulties were present in both groups or if they were just in one group. Prior to the analysis, it was confirmed that group one (P2, P4) and group two (P1, P3, P5, P6) contained a sufficient number of participants to compare their experiences. The findings indicated that both groups did encounter these challenges, but the prior STEM experience (or lack thereof) seemed to play a role in how confident individuals felt about making changes. Individuals who had prior STEM experience felt confident; those who had limited exposure to STEM before this study did not feel as confident.

Sub-question 3: Strategies for Adapting STEM Content for Students with Disabilities

To pinpoint successful teaching strategies, the researcher examined accounts from participants about their use of teaching methods, curriculum alterations, and direct classroom practices. The critical strategies for adapting included:

- Principles of Universal Design for Learning to make STEM lessons accessible to all students.
- Problem-solving in the real world engages students perfectly with hands-on, inquiry-based learning.
- Models of collaborative learning, such as peer mentoring and small-group activities in STEM, provide a way of delivering structured support.
- Disassembling STEM concepts into scaffolded, sequential steps to suit students' individualized education plans (IEPs).

In order to validate these strategies, the researcher used triangulation to analyze the findings. One way the researcher found to do this was by using observation data to see, in real-time classroom settings, how teachers were implementing the adaptive techniques. Another was through the use of reflexive journal notes which recorded, in a way that added some interpretive depth to the analysis, participants' reflections on the effectiveness of these strategies.

Conclusion

In conclusion, this study focused on understanding teachers's perspectives of interdisciplinary STEM education within the context of special education. The researcher ensured that the analysis was aligned with the study's research questions and was both comprehensive and rigorous, using several data sources. The central research question that this study sought to answer was aimed at understanding the experiences of special education teachers who are implementing STEM education. To answer this question, the researcher was capturing the perspectives of the participants in a way that would allow for a total view of the phenomena in question.

To provide a systematic answer to the sub-questions, a detailed thematic framework was utilized, ensuring that all aspects of the research inquiry were examined in depth. This framework allowed for the emergence of key themes that reflect teachers' insights into the benefits, challenges, and instructional adaptations that are associated with STEM integration in special education classrooms. The findings were made more valid by the consistency and recurrence of these themes across several interviews.

In addition, the participants' varying responses were carefully contextualized according to the backgrounds in STEM education. Prior experience as a STEM educator often influenced how these teacher-participants interacted with and interpreted the implementation, as well as the perceived amount of structure and amount of support necessary for successful integration. In essence, their demographic stories helped tell the story of the implementation. More specifically, the analysis advantaged both the individual and group variations of the perspectives, problems, and solutions offered by the participants. In this way, the report ensures that not only is the pathway followed by the participants well-documented, but it is also reflective of a type of work that might become more common in special education, as well as a type of work that might lead to more successful STEM integration stories across the board.

CHAPTER V: DISCUSSION

The purpose of this study was to explore the lived experiences and perspectives of special education teachers regarding the implementation of interdisciplinary STEM education for students with disabilities. Through semi-structured interviews and classroom observations, the study examined teachers' perceived benefits, challenges, and instructional strategies in integrating STEM into special education settings. This research was guided by one overarching question and three sub-questions:

1. What are the lived experiences and perspectives of special education teachers regarding interdisciplinary STEM education?
    a. What do special education teachers perceive as the benefits of interdisciplinary STEM education for students with disabilities?
    b. What challenges do special education teachers face in implementing interdisciplinary STEM education?
    c. What strategies do special education teachers use to adapt interdisciplinary STEM content for students with disabilities?

This study's findings are that STEM education can greatly enhance the learning of students with disabilities. In particular, it fosters engagement, critical thinking, and problem-solving skills. However, the participants also identified several significant pushbacks to effectively implementing STEM education for students with disabilities. Teachers used adaptive strategies to get around these barriers. These strategies included:

- Differentiation (the practices that allow a single teacher to effectively reach a diverse group of learners (Tomlinson, 2017));

- Hands-on learning (students doing rather than just listening to the teacher (Haury & Rillero, 1994)); and
- Collaboration with general education teachers (working together to reach students with diverse learning needs (Pugach et al., 2014)).

This chapter gives a complete account of the study's findings, discussing them in relation to the existing literature. The chapter will also explore the practical implications of these findings, acknowledge the limitations of the study, and offer recommendations for future research and for educational policy. The interpretations of the findings come first in the discussion; the implications for practice follow; then, the limitations of this study are acknowledged; and finally, recommendations for future research are made before the discussion concludes. In this way, the discussion attempts to bridge the gap between theory and practice, between theory and policy, in the broader discourse on inclusive STEM education.

Interpretation of Findings

This section presents a detailed examination of the study's outcomes and how they relate to the research questions and prior studies in the area. The findings showed that implementing interdisciplinary STEM education for students with disabilities offers both opportunities and challenges. Special education teachers supported the potential of STEM education to increase engagement and to sharpen the problem-solving and critical thinking skills of students. But those same teachers also saw some very real barriers to making STEM education a part of the curriculum for their students – insufficient resources, an absence of professional development, and just not enough time (Clements et al., 2023; Omosule, 2024). So, what do all of these findings together mean? This section tries to answer that question.

Special Education Teachers' Perceptions of STEM Education

One of the most significant themes that emerged from the findings was that STEM education is perceived as an adjunct tool rather than a standalone curriculum. Teachers emphasized that STEM enriches the traditional curriculum by incorporating "hands-on, experiential activities" that engage students in problem-solving. Several interviewees noted that STEM activities engage the senses, particularly during the construction portion of design challenges. This is particularly beneficial for students with disabilities, Moomaw (2024) noted. "STEM activities involve what even I would consider could be multi-sensory experiences. They (students) are not only seeing what's going on. They're also feeling, touching, and sometimes they might be tasting or smelling if it's a project that's edible, like growing bacteria!" (2017, p. 2). Moreover, teachers recognized that STEM promotes cross-disciplinary learning by combining science, technology, engineering, and mathematics into authentic, real-world contexts. This notion is upheld by Honey, Pearson, and Schweingruber (2014), who posit that interdisciplinary STEM education sharpens cognitive flexibility and adaptability, which are vital skills for students with diverse learning needs.

Nevertheless, even though teachers valued STEM, they indicated that they did not have a structured framework for its implementation in special education settings. This aligns with what Roberts and Cantu (2019) found. They noted that there is no standardized STEM curriculum nor a system-wide plan for implementation within special education. And when teachers do attempt to implement something resembling STEM, they are left to their own devices to determine how best to implement.

Perceived Benefits of STEM for Students with Disabilities

Participants overwhelmingly reported that STEM enhances student engagement and motivation, particularly for students who struggle with traditional, lecture-based instruction. Participants also provided accounts of how project-based learning STEM initiatives helped students evolve into proactive participants in their educational experience. This observation aligns with the constructionist theory of learning (Papert, 1980), which posits that students learn best when they engage in activities that involve manipulating materials and that stimulate them to explore and discover. In addition, instructors noted that STEM fosters in students the development of problem-solving and critical-thinking skills – abilities that are often difficult to cultivate in a traditional classroom setting. This connects nicely with the research of Hwang and Taylor (2016), who found that students with disabilities benefited greatly from structured, inquiry-based learning. Their minds worked more freely and productively when they could do the kinds of things that these two authors called "beneficial behaviors." Students were learning when they were doing. Furthermore, participants noted that STEM assignments facilitated the enhancement of students' social capabilities, especially in tasks where students work together to solve problems. This aligns with Moore et al.'s (2014) research, which found that STEM pushes for teamwork and communication, which are necessary skills for students with disabilities in both academic and social settings.

Challenges in Implementing STEM Education

Despite the numerous benefits of STEM education for students with disabilities, its implementation in special education settings presents several challenges. For example, teachers noted that they are often confronted with obstacles that limit their ability to effectively integrate STEM into their classrooms, ranging from insufficient training to resource constraints and competing instructional priorities. These challenges often constrict the full potential of STEM-based learning, making it difficult for teachers to provide meaningful and accessible STEM experiences for their students. It is imperative that these barriers are understood to identify solutions that support teachers and enhance STEM opportunities for students with disabilities.

Lack of Professional Development

A primary roadblock that special education teachers face throughout the interviews was the lack of on-going training for special education teachers on how to effectively integrate STEM into their classrooms. While they shared that in the previous school year, there had been some weekend trainings, consisting of five hours training sessions across four Saturdays, the current year has not offered any training nor support for implementation. Teachers expressed uncertainty about which instructional strategies to use and how to modify STEM activities to meet individualized education plan (IEP) goals. This is consistent with Roberts and Schmidt (2020), who found that STEM training for special education teachers is often insufficient, leaving educators unprepared to adapt STEM for diverse learners.

Limited Resources and Support

Teachers also commented on a lack of adequate STEM resources, including technology, manipulatives, and specialized instructional materials. Some reported that they had access to STEM tools but were not given training on how to use them effectively. Others noted that they had equipment, but not the necessary software to use the equipment. This aligns with findings from Kelley and Knowles (2016), who argue that access to STEM resources is not enough; structured guidance and administrative support are necessary for successful implementation.

Time Constraints and Competing Responsibilities

Another crucial obstacle was the short amount of time available because of the large number of duties piled on special education teachers. The teachers have IEPs to plan, special education students to manage, and a lot of compliance paperwork to complete. On top of this, the teachers in the study felt that STEM teaching required even more prep time, which was difficult to accommodate within their existing workload. Intensifying with the time-restraint and lack of professional development, teachers felt that they had to spend significant amounts of time to determine how to implement STEM education within Special education, both in planning how to integrate and reviewing the equipment as the training for the equipment was over a year ago. Williams and Mangan (2019) seem to recognize this same struggle when they say that many special education teachers who work to integrate STEM into their curriculum also struggle to balance this with their other instructional priorities.

Strategies for Adapting STEM for Special Education

To address the problems with STEM education for special education students, teachers have taken different avenues or strategies to transform their directions into things that students with disabilities can access more easily and with more effectiveness. The strategies most frequently indicated during interviews include hands-on learning, differentiation, and individualized instruction to make sure STEM activities align with students' unique learning needs. Also, providing sensory-friendly materials and working spaces, and modifying the working assignments so they are within the achieved range of the students' working capacities and align with the students' unique styles of learning. Below are the main strategies employed by the participants to blend STEM into special education. The participants identified these approaches as key to their efforts.

Hands-On and Project-Based Learning

The effectiveness of hands-on, inquiry-based STEM activities was emphasized by the teachers in making STEM more accessible to students with disabilities. They in turn noted that physical engagement in activities such as building, coding, and experimenting made it much more likely for these students to internalize the core concepts of STEM beyond what was happening in the traditional classroom. This is consistent with what Bransford et al. (2000) found regarding active learning - which is, it enhances cognitive retention. Teachers also shared that though they felt less confident in using the equipment, students had an innate knowledge on how to use the technology and could model proper use better than the teachers.

Differentiation and Individualized Instruction

Many teachers modified STEM activities to align with students' IEP goals, using strategies such as scaffolding, task analysis (breaking down tasks into manageable steps), and personalized to student skills (i.e. a teacher had students complete an academic skill prior to using STEM as a motivator). Support for this finding comes from Tomlinson (2014), who contended that making STEM education accessible to a diverse learner demands a much more varied approach.

Collaboration with General Education Teachers

Several participants highlighted the importance of collaborating with general education teachers to ensure alignment between STEM instruction and core academic content. This supports findings by McLeskey and Waldron (2011), who found that co-teaching and interdisciplinary collaboration improve special education students' learning outcomes. The findings from this study suggest that while STEM education holds great promise for students with disabilities, successful implementation demands overcoming obstacles and barriers related to training, resources, and time-constraints. A few participants underscored the significance of working with teachers of general education to guarantee that there is alignment between the instruction of STEM and the essential academic content. Other participants recognize the value of STEM in increasing engagement and problem-solving; however, they require more professional development and institutional support to integrate STEM effectively into special education services. Which leads to the next section that will explore the practical implications of these findings for educators, administrators, and policymakers.

Implications for Practice

This study has some very significant outcomes for educators, administrators, and anyone in a policymaking position who is trying to improve STEM education for students with disabilities. The findings are especially relevant since they point out the clear value that not just teachers of special education but also students find in interdisciplinary STEM education. Despite these positive attitudes, though, interdisciplinary STEM education is often difficult to implement in what the authors term “challenging special education settings” (Basham & Marino, 2013; Israel et al., 2015). So, while the value of the kind of challenging but rewarding interdisciplinary STEM education is clear, its implementation is not. This section examines the practical implications of the findings and presents clear recommendations for tackling the classroom, school, and policy level challenges these findings reveal. The recommendations are evidence-based, drawn from current research and practices in inclusive education.

Implications for Special Education Teachers

This study’s findings bring to light some important aspects for special education teachers who wish to integrate STEM into their classrooms. To deliver STEM instruction effectively to students with a range of disabilities, teachers need adequate training; they need sufficient, accessible resources; and they need sound, systemic support (Basham et al., 2018; Israel et al., 2015). Maximizing student engagement and improving learning outcomes occurs when hands-on learning, differentiated instruction, and collaborative teaching methods are used (Mastropieri & Scruggs, 2017). All the ongoing professional development and the integration of structured, adaptable STEM curricula can do is empower teachers and give them the confidence to implement STEM strategies in special education settings (Pugach et al., 2014). By addressing these implications, educators can create more inclusive and meaningful STEM learning experiences for students with disabilities.

The Need for Differentiated STEM Instruction

The findings indicate that STEM education benefits students with disabilities by increasing engagement, problem-solving, and critical thinking. Nevertheless, it is vital for teachers to modify and differentiate the content of STEM subjects to meet a multitude of learning styles and disabilities. Enhancement of STEM instruction for students with special needs requires:

- Use hands-on, project-based learning strategies that offer multi-sensory experiences. These sensory-rich environments are shown to increase engagement and enhance understanding (Mastropieri & Scruggs, 2017; Basham et al., 2018).
- Scaffold instruction or breaking down STEM tasks into smaller, manageable steps that align with Individualized Education Program (IEP) goals. This, according to Bouck & Park (2018), ensures that progress is monitored and that the tasks are accessible to the students.
- Moreover, working together with STEM experts and teachers of general education is key to creating lesson plans that function on several tiers and that let students of disparate

ability levels interact in a significant way with STEM subject matter (Israel et al., 2015). Progressing toward this kind of deeply collaborative function can help achieve the kind of inclusive practices that promise all students a fair shot at succeeding in STEM learning.

Increasing Self-Efficacy in STEM Teaching

Many of the participants said they felt ill-equipped to carry out STEM teaching because of a lack of offerings in professional development. To begin to rectify this situation and to help improve the confidence of educators, the following recommendations are made:

- Take part in professional development programs with STEM emphasis that are specifically tailored for contexts like special education. These programs have been demonstrated to improve not just the teachers' professional skills but also their confidence in delivering the kind of content one might sometimes think is out of reach for non-mainstream students (Pugach et al., 2014; Basham & Marino, 2013).
- Aspiring educators in STEM should consider getting mentorship from experienced STEM teachers to learn effective strategies for classroom integration of the STEM disciplines (Israel et al., 2015).
- Participate in online communities and networks related to STEM education to share resources, learn from others, and stay up to date on the cutting edge of inclusive STEM instruction (Basham et al., 2018).

Through the formation of a deeper understanding of STEM methodologies and the creation of a robust professional network, teachers will be significantly more able to nimbly adapt and deliver instruction that is effective, meets professional standards, and responds to the diverse needs of students.

Implications for School Administrators

Successful integration of STEM into special education classrooms requires school administrators to play a key role. To enable this effective integration, they must ensure targeted professional development, sufficient planning time, and necessary STEM resources are accessible to the teachers of these classrooms (Basham et al., 2018; Smith et al., 2020). Moreover, the quality and inclusivity of instruction can be improved by doing two things: implementing structured STEM curricula in special education settings and fostering collaboration between special education teachers and general education teachers (Israel et al., 2015; Mastropieri & Scruggs, 2017). Schools can create an inclusive learning space, so that every student can benefit from the full STEM education they receive. It is not enough for schools merely to 'do' inclusivity. They must apply it thoughtfully and with intent, reaching deep into the schools' cultures to affect real change.

Expanding STEM Resources for Special Education

The research brought to light that numerous educators confronted problems stemming from not having enough suitable STEM materials or not having enough training to use these materials properly. To tackle these issues, school administrators ought to:

1. Put money into specific kits for STEM education, adaptive learning technologies, and physical learning tools, the kind that are made for students with disabilities. These kits and tools are meant to engage students and help them learn better (Bouck & Park, 2018; Basham et al., 2018).
2. Make sure that STEM resources are plentiful and accessible in classes for students with special needs. Ensure logistical ease so that teachers can implement STEM and remove from their way any obstacles (Pugach et al., 2014).

3. Offer systematic directions and professional growth so teachers can combine STEM materials with their present courses, letting them make the STEM activities work for the IEPs and instructional standards (Israel et al., 2015).

Also, school administrators should think about developing STEM spaces solely dedicated to special education for the hands-on, experiential learning of their students. These areas can be all about “STEM-ing” and can be where creativity, collaboration, and problem-solving take place (Mastropieri & Scruggs, 2017). At a minimum, the efforts just described need to be priorities in the development of schools to create and maintain inclusive environments for students with disabilities that empower them to succeed in the STEM disciplines.

Providing Dedicated Planning Time

Participants identified a major challenge: a lack of time to incorporate direct STEM instruction because responsibilities like IEP documentation, behavioral management, and administrative tasks took priority. To address the issue, administrators should:

1. Set aside specific times for teachers to devote to the planning and delivery of STEM lessons for students with disabilities. These lessons should be devised in a manner to ensure that the instruction is aligned with the goals of the students’ IEPs and with general educational standards (Edyburn, 2013; Thurlow et al., 2020).
2. Lower the non-instructional loads by simplifying the documentation for IEPs or providing more support staff in the classroom to help with tasks that are not strictly teaching, like keeping order in the classroom and doing paperwork (Friend & Cook, 2016).
3. Form STEM leadership teams with the personnel mixture of special education teachers, general education teachers, and STEM specialists. These teams then collaborate to

develop integrated lesson plans. They also use the time together to do what seems to be a rarely performed practice in education: share best practices (Hanline et al., 2018).

Structured support and dedicated planning time are two ways that administrators can help make STEM instruction an effective and sustainable practice in special education classrooms. These measures serve to lighten teachers' workloads and create not only the appearance of meaningful engagement in STEM but also – for the first time, in some instances – the reality of such engagement for students with disabilities.

Supporting Professional Development in STEM for Special Education

This study found that many teachers emphasized the importance of professional development that is targeted and focused on the kind of STEM education that they want to deliver to students with disabilities. In light of this finding, the researchers recommend that administrators should provide ongoing, targeted STEM training in the teaching of students with disabilities. This means not just special techniques for special education but also encoding in the training the special opportunities that exist to teach STEM to this population of kids (Desimone & Garet, 2015; National Research Council, 2011). Administrators should also conduct practical workshops in which educators can use the adaptive STEM resources and technologies to serve the diverse learning needs of their students (Brock & Carter, 2016). It is also important administrators create peer coaching and mentorship arrangements that team special education teachers with veteran STEM educators. This partnership can serve to enhance collaboration, furnish practical guidance, and encourage the sharing of best practices (Darling-Hammond et al., 2017). Schools can enable special education teachers to integrate STEM instruction effectively by empowering those teachers with ongoing professional development. The outcome is enhanced learning for students with disabilities.

Implications for Policymakers

All levels of education have a critical role to play to create the right conditions for equitable STEM education for all students with disabilities. At the top of the list of priorities for responsibility lies funding. Policymakers must ensure that money flows adequately to federal, state, and local levels, so that STEM resources, professional development, and inclusive curricula can be made available (Edyburn, 2013; Thurlow et al., 2020). The emphasis should also be placed on the significant policies that warrant the existence of specialized STEM training for special education teachers. It is essential to transform special education instructors into highly trained and specialized service providers who possess the empirically validated skills to accommodate an array of learning differences. Special educators must be well versed in the evidence-based strategies that allow diverse learners to access the same content as their typically developing peers (Brock & Carter, 2016; National Research Council, 2011). Additionally, fostering collaboration among educators from diverse fields and giving them clear, actionable directives for STEM implementation in special education will help narrow the gaps that rob too many students of access to and success in STEM (Friend & Cook, 2016; Hanline et al., 2018). Policymakers can create a more inclusive and effective system of STEM education by putting in place policies that prioritize accessibility, satisfying the needs of those who require instructions to be effective, and ensuring that all students engage in and benefit from equitable opportunities. In short, they can create a system in which all students can succeed.

Developing a Standardized STEM Curriculum for Special Education

From this study, a key finding was the lack of a formal STEM curriculum specifically crafted for students with disabilities. To remedy this, policymakers ought to create national and state-level directives for the inclusion of STEM teachings in special education. These directives should describe research-supported practices and give a basis for adapting STEM stuff to varied kinds of intelligences (Edyburn, 2013; Thurlow et al., 2020). Policymakers should also ensure that the Individualized Education Program (IEP) includes learning objectives for STEM. This is essentially a directive that requires IEP teams to include objectives that are aligned with STEM content in the IEP. This approach aligns with the principles of universal design for learning (UDL) and promotes inclusive education (Basham et al., 2018; Rose & Meyer, 2002). Policymakers ought to support investigations into the STEM education's long-term impacts on students who have diverse learning needs. Such research initiatives can yield significant amounts of potentially transformative knowledge (National Research Council, 2011). This can then be used in two ways: to develop types of curricula that are effective, and types of strategies (instructional, managerial, etc.) that lead to significantly better outcomes for the types of students we are concerned about.

Policymakers can provide teachers with clear instructional frameworks by creating a structured, research-based STEM curriculum for students with disabilities. They can ensure consistency in STEM implementation across special education settings. This approach supports educators and empowers students to engage meaningfully with STEM content. It enables them to develop and utilize critical skills that make them successful in the future.

Funding STEM Initiatives for Special Education

The study showed that a lot of teachers see a limited number of resources as a real barrier to effective STEM instruction. It placed the spotlight on the role of funding in resolving some of the issues schools face. Here are a few solutions the study offered:

1. Boost financing for STEM grants specifically meant for programs that educate the disabled. These grants can be used to buy materials, tools, and technologies designed for students with disabilities (Basham et al., 2018; Thurlow et al., 2020).
2. Subsidize adaptive STEM technologies, which have been shown to enhance engagement and accessibility for students with diverse learning needs. Such technologies include robotics, assistive devices, and virtual reality tools (Bouck & Park, 2018; Israel et al., 2015).
3. Encourage professionals in STEM education to pursue further development by granting them scholarships, stipends, or other forms of monetary support that will allow them to complete training programs of a specialized nature. This will enable them to pursue the kind of instructive work in STEM that we so desperately need (Desimone & Garet, 2015; National Research Council, 2011).

Policymakers can help close the equity gap and ensure that students with disabilities have access to compelling STEM learning opportunities by not only investing in STEM resources but also in the infrastructure and training essential for their effective implementation.

Strengthening Interdisciplinary Collaboration

Creating robust alliances between special education and STEM education initiatives is crucial to ensuring that all students – including those with disabilities, have equal access to engaging and relevant learning experiences and opportunities. Policymakers have a variety of ways they can go about this important task. Here are some key strategies:

1. Fostering teamwork among universities, STEM organizations, and school districts to build inclusive STEM programs. These collaborations can use their combined know-how

and resources to develop truly innovative and accessible learning experiences (Basham et al., 2018; National Research Council, 2011).

2. Creating policy frameworks that support collaborative teaching arrangements between special education teachers and general education teachers in the STEM disciplines. Co-teaching models have been shown to improve the quality and inclusivity of their instructional deliveries (Friend & Cook, 2016; Mastropieri & Scruggs, 2017).
3. Making sure that programs are explicitly accessible to students with disabilities in extending the STEM initiatives from statewide programs. These programs need to be designed with accessibility and accommodation as their foundation (Thurlow et al., 2020).

Policymakers can integrate STEM into wider educational policies and can foster partnership between sectors to achieve a more inclusive system in which all students enrolled have equitable access to STEM learning opportunities.

Limitations of the Study

Although this research offers valuable insights into the experiences of special education teachers who implement interdisciplinary STEM education, it has limitations – related to its scope, methodology, and the biases that might be inherent in any qualitative case study of this kind. It is very much a work in progress across those dimensions. Addressing those weaknesses serves two important purposes. First, it helps readers understand the findings in the appropriate context. Second, it identifies some problem areas where future research can build an even better understanding of STEM integration in special education.

Scope Limitations

This research occurs in a single rural school district in the southeastern United States; thus, the researcher must be cautious in generalizing its findings to other educational environments. This study offers an in-depth examination of the realities and perspectives of special education teachers in one unique context. While this may provide a closer look at the particularities of one system, it also raises questions about the transferability of the findings to as diverse a range of contexts as suburban, urban, or international schools – systems that operate under different conditions, different amounts of resources, and with different kinds of institutional support (Creswell & Creswell, 2017).

In addition, the investigation centered solely on STEM teaching in specialized education contexts. It yielded rich information about the intricacies of the practices, the challenges, and the lived experience of special education teachers. But it did not gather the viewpoints or input from general education teachers, who, along with special education teachers, co-teach and co-plan for students with disabilities in inclusive STEM classrooms. Perspectives from general education teachers might give better insight into how and if STEM is effectively taught in these inclusive settings (Friend & Cook, 2016).

To address these limitations, future research needs to broaden its horizon and reach suburban and urban school districts, as well as cross-disciplinary input from general educators, STEM professionals, and school administrators, to get a more holistic take on the factors influencing STEM implementation (or not) in diverse educational contexts and a clearer sense of best practices for making those contexts more inclusive and equitable.

Methodological Limitations

This study involved a small sample, consisting of six teachers. This size is appropriate for the qualitative phenomenological approach used, which prioritizes depth over breadth. Still, the small sample limits the generalizability of the findings to all special education teachers in different contexts and settings. I would argue, however, that generalizability is not the aim. Instead, what you have is a richly detailed and nuanced set of findings that offer a close-up lens on the participants' experiences (Creswell & Poth, 2017).

Furthermore, the research was underpinned by the predominant use of semi-structured interviews to gather data. This method permits a focused yet flexible exploration of the participants' experiences and accommodates more in-depth inquiry into their narratives. Even so, the interview data are self-reports, which in this instance are subject to all the biases that self-reported data can be expected to harbor. For example, the research participants may have been influenced by the tendency of interviewees to report in a biased way that makes them look good (social desirability bias) and/or to have been influenced by the normal human tendency to forget and to misremember things (recall bias) (Podsakoff et al., 2003). Self-reported data has these biases that remain a limitation of it, and they are there despite efforts to ensure that what was reported was accurate through member checking.

Larger, multi-site studies should be conducted in the future to counter the methodological limitations we have already discussed. Such studies could address not just the representativeness of the current findings but also their generalizability across different educational contexts. Future studies should also consider a mixed-methods approach, which could strengthen the research in terms of its validity. Right now, comparisons made between the qualitative and quantitative data are not done with the same level of rigor. If we could somehow integrate these two types of data into our analysis, the results would be far more convincing (Johnson & Onwuegbuzie, 2004). This approach would not only confirm reported experiences but also yield quantifiable results to guide policy and practice.

Data Collection Constraints

Although classroom observations were included as part of the data collection process, their scope was limited due to logistical challenges. These observations were conducted in pre-arranged settings, which may not fully capture the complexities and variability of daily classroom practices. For instance, teachers often balance multiple responsibilities – and when they do, they are not teaching STEM. This seems to be a time problem. In-depth data collection was limited by teachers' availability, which meant that some direct interview responses may have been constrained in depth and some follow-up interviews may not have occurred at all (Creswell & Poth, 2017).

Also, this study captures a moment in time for teachers, providing rare but valuable insights. It does not, and cannot, show how the strategies that these teachers used to implement STEM changed over time or impacted their students. To solve these limitations, further studies must carry out long-term classroom observations in order to understand better the implementation of STEM in practice. Observing teachers across different lessons, subjects, and contexts could yield a more refined picture of their approaches and the challenges they face (Yin, 2017).

In addition, longitudinal research over several semesters or academic years would yield rich insights into how STEM gets implemented over time. These studies could examine the ways in which teachers alters their strategy over time, the way in which sustained student engagement and achievement might be affected in the long run, and the kinds of systemic factors that either help or hinder STEM Education from enjoying solstitial results (Plano, et. al., 2015). Future research can furnish a far more resilient and dynamic comprehension of how STEM integrates within the context of special education, if it tackles the constraints laid out above.

Potential Researcher Bias

With any kind of qualitative research, the data collected is at least somewhat influenced by the researcher who is doing the collecting. Mitigating bias is therefore a crucial goal of this and any other qualitative study. How might I be biased? What are my personal, professional, and disciplinary orientations? What are my assumptions and expectations of participants and their experiences? These are questions I have attempted to answer in the sections that follow. These measures help ensure transparency and rigor, but they do not entirely eliminate the potential for bias (Creswell & Poth, 2017).

Future studies could achieve further objectivity by incorporating several researchers or inter-coder reliability checks during data analysis. This would allow for collaborative confirmation of themes and interpretations, with no risk of one person's bias affecting the results. (Lincoln & Guba, 1985). Also, using automated tools for qualitative coding, together with manual coding, could significantly improve the reliability and consistency of theme identification in our study. Some researchers are using NVivo and/or MAXQDA as coding tools. They are helping to code and, more importantly, to analyze qualitative data. (Saldana, 2021).

Future research can increase its credibility and trustworthiness by taking up these strategies. It can ensure that the findings it generates are rigorous and that the insights it gains are reflective of participants' lived experiences.

Ethical Considerations and Participant Privacy

This study followed the IRB (Institutional Review Board) guidelines to ensure that ethical standards were met and that participant confidentiality was maintained. Pseudonyms were used to protect participant identities. Nevertheless, the study was conducted within a specific school district, which raises the potential risk of indirect participant identification. That is, the "details about the context in which the study was conducted might lead some people to guess the identities of the participants" (Maxfield & Babbie, 2011, p. 96). In this case, the context includes the study's unique program features, school demographics, and the distinctive district policies that may have affected program participants.

In future studies, participant privacy can be protected through multi-site recruitment, drawing participants not just from one district but from several districts or regions. This will—through the dilution effect, make it nearly impossible to identify participants based solely on the specifics of the context. Additionally, descriptions of participants can be rendered in more generalized terms, which will again serve to make identification nearly impossible – for example, describing the context in broad strokes as "a district located in the southeastern region of the United States" as opposed to naming the particular district or going with the euphemistic: educational system in the South." (Creswell & Poth, 2017).

The strategies would increase the confidentiality of identities of research participants and allow secrecy of responses but would still permit full and meaningful analysis and reporting of results. By keeping clear participant privacy as a priority, researchers are better ensuring not only the integrity of the research but also the integrity of the trust that is foundational to all high-quality and nearly all responsible research.

Recommendations for Future Research

Although this study offers useful perspectives on the lived experiences of special education teachers enacting interdisciplinary STEM education, much more research is needed to crease a robust comprehension of this relatively new endeavor. The findings of this study hint at several obvious places (e.g., curriculum development, longitudinal studies) where future investigations could go and that could contribute to a real enhancement of STEM education for students with disabilities. Here, the researcher outlines the essential recommendations for future research.

Developing a Structured STEM Curriculum for Special Education

This study found that there was no structured framework in place for integrating STEM into special education instruction in this specific district. To fill this void, future research should concentrate on creating, testing, and assessing an integrated STEM curriculum for students with disabilities. This curriculum should:

1. Align with Individualized Education Plans (IEPs) Services: Explore successful methods of integrating STEM instruction to satisfy the singular goals and needs stated in students' IEPs. This means pinpointing particular tactics that work well for the student population, such as differentiating instruction, scaffolding tasks, and providing accommodations that ensure accessibility (Basham et al., 2018). It also means connecting it to the content areas that IEPs address, such as math, reading, writing, social emotional, motor, communication, etc.
2. Tailor Instruction to Disability Categories: Cultivate and evaluate proof-grounded STEM teaching models fit for a range of categories of disabilities – autism spectrum disorder, learning disabilities, and physical disabilities for instance. Research should look into

ways of making STEM content and ways of delivering that content adaptive to the particular strengths and peculiarities of each disability group (Bouck & Park, 2018).

3. Incorporate Effective Pedagogical Strategies: Investigate how well project-based, inquiry-based, and experiential learning strategies work in STEM instruction for special education. Research has indicated that these strategies enhance engagement, critical thinking, and problem-solving in all students, making them especially valuable for those with disabilities (National Research Council, 2011).

A well-defined, research-based curriculum would standardize best practices, ensuring consistency and effectiveness in STEM instruction across special education settings. It would also provide teachers with clear guidelines and resources, reducing the barriers to implementation and enhancing student outcomes. By addressing these areas, future research can help create a more equitable and inclusive STEM education system for students with disabilities.

A curriculum that is based on solid research and is clearly defined can standardize the best practices. This gives teachers the kinds of directives and resources that make it mandatory to implement certain practices and reduce the number of students that slip through the cracks, as is too often the case now.

Longitudinal Studies on the Impact of STEM Education for Students with Disabilities

This research presents a snapshot of the view of teachers' experiences. It does not provide any report on the long-term tracking of the outcomes of STEM education for students with disabilities. Future research can fill this gap by conducting longitudinal studies with the following specifics:

1. Investigate Academic and Cognitive Development: Investigate the effects of extended exposure to STEM on students' scholastic standing and mental growth over several years.

This might encompass evaluating whether such exposure has led to enhancements in the areas of math and science, as well as in their capacity to think on a high level and to function in an executive way. (National Research Council, 2011).

2. Track Skill Development and Workforce Readiness: Investigate the ways that students with disabilities demonstrate problem-solving abilities, STEM literacy, and workforce readiness as a result of ongoing STEM instruction. This may involve determining how well they apply STEM principles in authentic, real-world situations and assessing how ready they are for STEM jobs (Basham et al., 2018).
3. Study if and how early and ongoing interaction with the STEM educational environment boosts the proportions of disabled students who sign up for college, obtain a degree in STEM, and go on to work in a STEM career. This might shed some light on the potential of the STEM educational enterprise to change the trajectory of disabled students toward greater equity in higher education and in the labor market (Thurlow et al., 2020).

Robust empirical evidence from longitudinal research would attest to the long-term payoffs of STEM education for students with disabilities. Such evidence could inform policy decisions, influence where resources get allocated and serve as a shining example of why we should invest in initiatives that make inclusive STEM a reality.

Exploring Administrative and Policy Support for STEM in Special Education

This study's findings shine a light on the real-world problems teachers encounter when they try to implement STEM education. Even when teachers had the institutional knowledge required to implement the kinds of initiatives found in a typical STEM education classroom, they often lacked the basic conditions (like adequate funding and institutional support) needed to effectively make changes in their classrooms. This leads to the clear implication that any initiative (like STEM education) that is going to rely heavily on teachers enacting it in their classrooms is going to need to also work on providing those teachers with adequate support. Specifically, future studies should:

1. Assess the Role of School Administrators: Investigate the impact school leadership has on STEM integration in special education. This encompasses how they go about ensuring professional development that hits the mark, resource allocation that makes sense, and collaboration that pays off between special education teachers and their general education counterparts (Friend & Cook, 2016).
2. Evaluate State and Federal Policies: Evaluate how effective the current state and federal STEM education policies are in assisting students with disabilities. Policies should identify any existing disparities and propose research-based recommendations to create a more inclusive and equitable STEM education environment (Thurlow et al., 2020).
3. Explore Professional Development for Leaders: Look into whether inclusive STEM education can be furthered by working with the professional development of administrators and policymakers. These groups are trained to understand STEM education, and they need to understand why inclusion is vital to their work. Professionals in these programs must learn about the systemic changes necessary for a truly inclusive STEM education (Basham et al., 2018).

Future research can furnish actionable insights that drive reforms in policy and increase investment in STEM education for students with disabilities. It can do this by addressing the kinds of data that need to be collected and how to collect them. Also, the use of the data that are already available, and the kinds of venues where one can effect policy change.

Expanding Research on STEM Professional Development for Special Education Teachers

The study identified a significant challenge: special education teachers lack professional development opportunities that are specific to STEM. This is an area that we need to research further to understand how to better serve not only the teachers but also their students in STEM fields. What was also interesting is that this seems to be a pervasive gap across many years of research. Specifically, future studies should:

1. Assess the Impact of Hands-On, Immersive Training Programs: Examine how effective hands-on STEM training programs are when instructed by special education teachers. These types of training deliver the following: immersive STEM experiences; the kind of training where the teacher leaves with not just the knowledge of the immersion technologies but also the kind of knowledge that allows him or her to effectively lead a class of students with diverse learning needs in a STEM project. This kind of training is not traditional professional development. (Desimone & Garet, 2015).
2. Explore Mentorship and Coaching Models: Investigate how models of mentorship and coaching can make STEM instruction more effective for teachers. When special education teachers are paired with experienced STEM educators or specialists, they not only receive ongoing support but also have the opportunity to collaborate with professionals who know how to do STEM well (Darling-Hammond et al., 2017).

Future research can ensure the development of specialized professional development programs that allow special education teachers to acquire the skills, knowledge, and resources to implement STEM successfully. In these areas, research can serve as a guide. What we have been able to discern from the literature is that these initiatives have the potential not only to improve special education teacher confidence and the quality of instruction but also to increase student engagement and motivation and enhance learning outcomes in STEM.

Examining the Role of Inclusion and Co-Teaching in STEM Education

In many schools, special education teachers work collaboratively with general education teachers to implement STEM. Future research should explore how co-teaching and inclusion models impact STEM learning outcomes for students with disabilities. Future research should investigate the benefits and challenges of co-teaching STEM lessons in inclusive classrooms, assess how collaborative planning between special and general educators improves STEM instruction, and examine how peer-assisted learning models (where students with disabilities work alongside their non-disabled peers in STEM projects) impact engagement and achievement. The findings could buttress policies aimed at achieving inclusive education so that students with disabilities can enjoy equal and equitable access to quality instruction in STEM. The instruction could occur in either a special education or a general education setting. The highlights from this study pinpoint exactly where more research is needed in the field of STEM education for students with disabilities. These areas are Curriculum development; Longitudinal impact; Policy support; and Teacher training.

Conclusion

This research inquiry investigated the perspectives and experiences of special education teachers concerning interdisciplinary STEM education for students with disabilities. It sought to understand how these teachers perceive the benefits of STEM education; the challenges they face in offering such an education; and the strategies they use to adapt STEM instruction for their students. The study was undertaken in a single site, with special educators as the research subjects.

The results emphasize that although STEM education makes good progress to increase student involvement, enthusiasm, and a positive disposition toward science and mathematics, the professional development in STEM education for teachers of students with disabilities is lacking. Additionally, teaching time is limited because of high-stakes testing and curricular demands, which forces teachers to prioritize what is in the tested curriculum. Even with all this adversity, some teachers implement STEM education integration, and those teachers tend to work and plan collaboratively. This research was led by an all-encompassing main question and three subsidiary questions. The main question, with its three sub-questions, guided us toward a richer understanding of the benefits, challenges, and instructional adaptations of STEM in special education. The key findings include: 1.) perceived benefits of stem in special education, 2.) challenges in implementing stem education, 3.) strategies for adapting stem for students with disabilities, and 4.) recommendations for improving stem integration.

The findings emphasize the need for a systematic approach to STEM education in special education settings. Including teachers, school administrators, policymakers, and curriculum developers, stakeholders must work together to accomplish four fundamental tasks:

1. Develop rigorous, research-based STEM curricula that accommodate the varied needs of students with disabilities.
2. Provide the necessary professional development to ensure that the teachers of all students possess the skills to adapt and modify STEM instruction effectively.
3. Fund and develop the resources necessary to make sure that students with disabilities have the same access to STEM opportunities as their nondisabled peers. This includes ensuring access to the kinds of spaces, adaptive tools, and technologies that make STEM possible for students with varied abilities.

4. Collaborate. Though often recommended, working individually appears to be more prevalent than previously known. Collaboration requires commitment and logistical support from all stakeholders. Educators in special and general education need to work together to teach all students inclusively.

STEM education holds the potential to reshape not just the learning outcomes of students with disabilities but also the very nature of their interactions with the educational system. Focusing on areas where systemic problems have long been embedded, such as the training of teachers, access to resources, and the level of institutional support afforded to at-risk students, this study zeros in on the real-world experiences of special education teachers working in today's STEM classrooms. It not only amplifies their voices but also serves as a useful written reminder for future researchers and policy wonks who will attempt to make STEM education more accessible, equitable, and meaningful for all students, regardless of their ability levels.

References

Abels, S. (2014). Inquiry-based science education and special needs–Teachers' reflections on an inclusive setting. Sisyphus—Journal of Education, 2(2), 124-154.

Ainscow, M. (2020). Promoting inclusion and equity in education: Lessons from international experiences. Nordic Journal of Studies in Educational Policy, 6(1), 7-16.

Alper, S., & Raharinirina, S. (2006). Assistive technology for individuals with disabilities: A review and synthesis of the literature. Journal of Special Education Technology, 21(2), 47-64.

Anney, V. N. (2014). Ensuring the quality of the findings of qualitative research: Looking at trustworthiness criteria.

Asghar, A., Sladeczek, I. E., Mercier, J., & Beaudoin, E. (2017). Learning in science, technology, engineering, and mathematics: Supporting students with learning disabilities. Canadian Psychology/psychologie canadienne, 58(3), 238.

Bakken, J. P., Uskov, V. L., & Varidireddy, N. (2019). Text-to-voice and voice-to-text software systems and students with disabilities: a research synthesis. Smart Education and e-Learning 2019, 511-524.

Barron, B., & Darling-Hammond, L. (2008). Teaching for Meaningful Learning: A Review of Research on Inquiry-Based and Cooperative Learning. Book Excerpt. George Lucas Educational Foundation.

Basham, J. D., Israel, M., & Maynard, K. (2018). An ecological model of STEM education: Operationalizing STEM for all. Journal of Special Education Technology, 33(3), 197-208.

Basham, J. D., & Marino, M. T. (2013). Understanding STEM education and supporting students through universal design for learning. Teaching Exceptional Children, 45(4), 8-15.

Berger, R. (2015). Now I see it, now I don't: Researcher's position and reflexivity in qualitative research. Qualitative Research, 15(2), 219-234.

Birt, L., Scott, S., Cavers, D., Campbell, C., & Walter, F. (2016). Member checking: a tool to enhance trustworthiness or merely a nod to validation?. Qualitative health research, 26(13), 1802-1811.

Bouck, E. C., & Park, J. (2018). A systematic review of the literature on mathematics manipulatives to support students with disabilities. Education and Treatment of Children, 41(1), 65-106.

Bowen, G. A. (2009). Document analysis as a qualitative research method. Qualitative Research Journal, 9(2), 27-40. https://doi.org/10.3316/QRJ0902027

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Brock, M. E., & Carter, E. W. (2016). Efficacy of teachers training paraprofessionals to implement evidence-based practices. Exceptional Children, 82(3), 354-371.

Browder, D. M. (2014). Evidence-based practices for students with severe disabilities.

Bruner, J. S. (2009). The process of education. Harvard university press.

Bryant, D. P., Bryant, B. R., & Smith, D. D. (2019). Teaching students with special needs in inclusive classrooms. Sage Publications.

Bybee, R. W. (2010). Advancing STEM education: A 2020 vision. Technology and Engineering Teacher, 70(1), 30-35. https://eric.ed.gov/?id=EJ898909

Bybee, R. W. (2013). The case for STEM education: Challenges and opportunities. NSTA Press.

Cameron, R. (2011). Mixed methods research: The five Ps framework. Electronic journal of business research methods, 9(2), pp96-108.

CAST (2018). Universal Design for Learning guidelines version 2.2. Center for Applied Special Technology. http://udlguidelines.cast.org

Chambers, D. (2020). Assistive technology supporting inclusive education: Existing and emerging trends. Assistive technology to support inclusive education, 1-16.

Churchill, A. (2023). Fine-Tuning Ohio's School Report Card: An Analysis of the State's Revamped Report Card in Its First Year of Implementation, 2021-22. Thomas B. Fordham Institute.

Clements, D. H., Vinh, M., Lim, C. I., & Sarama, J. (2023). STEM for inclusive excellence and equity. In Developing Culturally and Developmentally Appropriate Early STEM Learning Experiences (pp. 148-171). Routledge.

Corlu, M. S., Capraro, R. M., & Capraro, M. M. (2014). Introducing STEM education: Implications for educating our teachers for the age of innovation. Education & Science/Egitim ve Bilim, 39(171).

Courtade, G. R., Test, D. W., & Cook, B. G. (2014). Evidence-based practices for learners with severe disabilities. Focus on Exceptional Children, 46(3), 1-16.

Creswell, J. W. (2013). Qualitative inquiry and research design: Choosing among five approaches (3rd ed.). Sage Publications. ISBN: 978-1412995306

Creswell, J. W., & Poth, C. N. (2016). Qualitative inquiry and research design: Choosing among five approaches. Sage publications.

Creswell, J. W., & Poth, C. N. (2018). Qualitative inquiry and research design: Choosing among five approaches (4th ed.). SAGE Publications. ISBN: 978-1506330204

Czerniak, C. M., & Johnson, C. C. (2014). Interdisciplinary science teaching. In N. G. Lederman & S. K. Abell (Eds.), Handbook of research on science education (Vol. 2, pp. 395-411). Routledge.

Dalton, E. M. (2017). Universal Design for Learning: Guiding principles to reduce barriers to digital & media literacy competence. Journal of Media Literacy Education, 9(2), 17-29.

Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). Effective teacher professional development. Learning Policy Institute.

Davis, J. P., Chandra, V., & Bellocchi, A. (2019). Integrated STEM in initial teacher education: Tackling diverse epistemologies. Critical, transdisciplinary and embodied approaches in STEM education, 23-40.

Dell, A. G., Newton, D. A., & Petroff, J. G. (2012). Assistive technology in the classroom: Enhancing the school experiences of students with disabilities. Pearson Higher Ed. ISBN: 978-0131390409

Denzin, N. K. (2012). Triangulation 2.0. Journal of mixed methods research, 6(2), 80-88.

Desimone, L. M. (2009). Improving impact studies of teachers’ professional development: Toward better conceptualizations and measures. Educational Researcher, 38(3), 181-199. https://doi.org/10.3102/0013189X08331140

Desimone, L. M., & Garet, M. S. (2015). Best practices in teachers’ professional development in the United States. Psychology, Society, & Education, 7(3), 252-263.

Edyburn, D. L. (2020). Critical issues in advancing the special education technology evidence base. Journal of Special Education Technology, 35(2), 63-71.

English, L. D. (2016). STEM education K-12: Perspectives on integration. International Journal of STEM education, 3, 1-8.

Eredics, N. (2018). Inclusion in Action: Practical Strategies to Modify Your Curriculum. Brookes Publishing Company. PO Box 10624, Baltimore, MD 21285.

Finlay, L. (2002). Negotiating the swamp: The opportunity and challenge of reflexivity in research practice. Qualitative Research, 2(2), 209-230.

Florian, L. (2014). What counts as evidence of inclusive education? European Journal of Special Needs Education, 29(3), 286-294.

Fosnot, C. T. (2013). Constructivism: Theory, perspectives, and practice. Teachers College Press.

Friend, M., & Cook, L. (1992). Interactions: Collaboration skills for school professionals. Longman Publishing Group, 95 Church Street, White Plains, NY 10601.

Friend, M., & Cook, L. (2016). Interactions: Collaboration skills for school professionals (8th ed.). Pearson.

Friend, M., Cook, L., Hurley-Chamberlain, D., & Shamberger, C. (2010). Co-teaching: An illustration of the complexity of collaboration in special education. Journal of Educational and Psychological Consultation, 20(1), 9-27. https://doi.org/10.1080/10474410903535380

Fusch, P. I., Fusch, G. E., & Ness, L. R. (2018). Denzin's paradigm shift: Revisiting triangulation in qualitative research. Journal of Social Change, 10(1), 19-32.

Gargiulo, R. M., & Metcalf, D. J. (2010). Teaching in today's inclusive classrooms: A universal design for learning approach. (No Title).

Glaser, B., & Strauss, A. (2017). Discovery of grounded theory: Strategies for qualitative research. Routledge.

Halcomb, E. J., & Davidson, P. M. (2006). Is verbatim transcription of interview data always necessary?. Applied nursing research, 19(1), 38-42.

Hall, T. E., Meyer, A., & Rose, D. H. (Eds.). (2012). Universal design for learning in the classroom: Practical applications. Guilford press.

Hanline, M. F., Nunes, D., & Worthy, M. B. (2018). Enhancing the problem-solving skills of students with developmental disabilities in inclusive settings. Journal of Early Intervention, 40(4), 323-338.

Haury, D. L., & Rillero, P. (1994). Perspectives of Hands-On Science Teaching.

Heward, W. L. (2000). Exceptional children: An introduction to special education. Pearson. ISBN: 13-9780135756522

Hitchcock, C., Meyer, A., Rose, D., & Jackson, R. (2002). Providing new access to the general curriculum: Universal design for learning. Teaching exceptional children, 35(2), 8-17.

Holmlund, T. D., Lesseig, K., & Slavit, D. (2018). Making sense of "STEM education" in K-12 contexts. International journal of STEM education, 5, 1-18.

Honey, M., Pearson, G., & Schweingruber, H. (Eds.). (2014). STEM integration in K-12 education: Status, prospects, and an agenda for research. National Academies Press. https://doi.org/10.17226/18612

Israel, M., Maynard, K., & Williamson, P. (2013). Promoting inclusive practices in inquiry-based STEM instruction for students with disabilities. Teaching Exceptional Children, 45(4), 18-25. https://doi.org/10.1177/004005991304500402

Israel, M., Wherfel, Q. M., Pearson, J., Shehab, S., & Tapia, T. (2015). Empowering K–12 students with disabilities to learn computational thinking and computer programming. Teaching Exceptional Children, 48(1), 45-53.

Katz, J., & Sokal, L. (2016). Universal Design for Learning as a bridge to inclusion: A qualitative report of student voices. International Journal of Whole Schooling, 12(2), 36-63.

Klimaitis, C. C., & Mullen, C. A. (2021). Including K-12 Students with Disabilities in STEM Education and Planning for Inclusion. Educational Planning, 28(2), 27-43.

Korstjens, I., & Moser, A. (2018). Series: Practical guidance to qualitative research. Part 4: Trustworthiness and publishing. European Journal of General Practice, 24(1), 120-124.

Kumar, S. (2019). An Investigation of Teachers' Attitudes, Concerns and Self-Efficacy toward Inclusive Education in STEM Classrooms. Online Submission.

Kvale, S., & Brinkmann, S. (2009). InterViews: Learning the craft of qualitative research interviewing (2nd ed.). SAGE Publications.

Larson, L. C., & Miller, T. N. (2011). 21st century skills: Prepare students for the future. Kappa Delta Pi Record, 47(3), 121-123.

Learn, H. P. (2000). Brain, mind, experience, and school. Committee on Developments in the Science of Learning.

Lim, W. M. (2024). What is qualitative research? An overview and guidelines. Australasian Marketing Journal, 14413582241264619.

Lincoln, Y. S., & Guba, E. G. (1985). Naturalistic inquiry. Newberry Park.

Marino, M. T. (2009). Understanding how adolescents with reading difficulties utilize assistive technology software in inclusive science classrooms. Journal of Special Education Technology, 24(1), 35-46. https://doi.org/10.1080/09362830902805848

Mastropieri, M. A., & Scruggs, T. E. (2010). The inclusive classroom: Strategies for effective differentiated instruction. Pearson. https://archive.org/details/inclusiveclassro0000mast_k7v8

Mastropieri, M. A., & Scruggs, T. E. (2017). The inclusive classroom: Strategies for effective differentiated instruction (6th ed.). Pearson.

Maxwell, J. A. (2013). Qualitative research design: An interactive approach (3rd ed.). Sage.

McCollough, C. A., & Ramirez, P. (2012). STEM education for students with disabilities: Challenges and opportunities. Journal of Science Education for Students with Disabilities, 16(1), 21-27.

McCollough, C., & Ramirez, O. (2012). Cultivating culture: Preparing future teachers for diversity through family science learning events. School Science and Mathematics, 112(7), 443-451.

McDonald, C. V. (2016). STEM Education: A review of the contribution of the disciplines of science, technology, engineering and mathematics. Science Education International, 27(4), 530-569.

McDonald, M. A. (2016). Implementing STEM education for students with disabilities: Barriers and supports. STEM Education Journal, 3(2), 45-58.

Mcguire, J. M., Scott, S. S., & Shaw, S. F. (2006). Universal design and its applications in educational environments. Remedial and special education, 27(3), 166-175.

McLeskey, J., Rosenberg, M. S., & Westling, D. L. (2013). Inclusion: Effective practices for all students. Pearson Higher Ed. ISBN: 97801134530031

Merriam, S. B., & Tisdell, E. J. (2015). Qualitative research: A guide to design and implementation. John Wiley & Sons.

Meyer, A., Rose, D. H., & Gordon, D. (2016). Universal design for learning: Theory and practice. CAST Professional Publishing. https://www.cast.org/news/2022/read-universal-design-learning-udl-theory-practice-free-clusive

Meyer, G., Vicaut, E., Danays, T., Agnelli, G., Becattini, C., Beyer-Westendorf, J., ... & Konstantinides, S. V. (2014). Fibrinolysis for patients with intermediate-risk pulmonary embolism. New England Journal of Medicine, 370(15), 1402-1411.

Miles, M. B., Huberman, A. M., & Saldana, J. (2014). Qualitative data analysis: A methods sourcebook (3rd ed.). SAGE Publications. ISBN: 978-1452257877

Mohamad Hasim, S., Rosli, R., Halim, L., Capraro, M. M., & Capraro, R. M. (2022). STEM professional development activities and their impact on teacher knowledge and instructional practices. Mathematics, 10(7), 1109.

Moomaw, S. (2024). Teaching STEM in the early years: Activities for integrating science, technology, engineering, and mathematics. Redleaf Press.

Moustakas, C. (1994). Phenomenological research methods. SAGE Publications.

Mueller, R. A. (2019). Episodic narrative interview: Capturing stories of experience with a methods fusion. International journal of qualitative methods, 18, 1609406919866044.

Mutohhari, F., Sutiman, S., Nurtanto, M., Kholifah, N., & Samsudin, A. (2021). Difficulties in Implementing 21st Century Skills Competence in Vocational Education Learning. International Journal of Evaluation and Research in Education, 10(4), 1229-1236.

National Research Council. (2011). Successful K-12 STEM education: Identifying effective approaches in science, technology, engineering, and mathematics. The National Academies Press. https://doi.org/10.17226/13158

Omosule, J. (2024). Perceptions of STEM Faculty on Training Needs to Support Students with Disabilities in Distance Learning (Doctoral dissertation, Gwynedd Mercy University).

Orb, A., Eisenhauer, L., & Wynaden, D. (2001). Ethics in qualitative research. Journal of nursing scholarship, 33(1), 93-96.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. Review of Educational Research, 62(3), 307-332.

Palincsar, A. S. (1998). Keeping the metaphor of scaffolding fresh—A response to C. Addison Stone's The metaphor of scaffolding. Journal of Learning Disabilities, 31(4), 370-373.

Patton, M. Q. (2015). Qualitative research and evaluation methods (4th ed.). SAGE Publications.

Penuel, W. R., Fishman, B. J., Yamaguchi, R., & Gallagher, L. P. (2007). What makes professional development effective? Strategies that foster curriculum implementation. American Educational Research Journal, 44(4), 921-958. https://doi.org/10.3102/0002831207308221

Piaget, J. (1970). Science of education and the psychology of the child. Orion Press.

Piaget, J. (1970). The child's conception of the world. Rowman & Littlefield.

Pugach, M. C., Blanton, L. P., & Boveda, M. (2014). Working together: Research on the preparation of general education and special education teachers for inclusion and collaboration. In Handbook of research on special education teacher preparation (pp. 143-160). Routledge

Rapp, W. H., & Arndt, K. (2012). Teaching everyone: An introduction to inclusive education. Paul H. Brookes Publishing.

Roehrig, G. H., Dare, E. A., Ellis, J. A., & Ring-Whalen, E. (2021). Beyond the basics: A detailed conceptual framework of integrated STEM. Disciplinary and Interdisciplinary Science Education Research, 3, 1-18.

Rose, D. H., & Meyer, A. (2002). Teaching every student in the digital age: Universal Design for Learning. ASCD.

Rose, D. H., Meyer, A., & Hitchcock, C. (2006). The universally designed classroom: Accessible curriculum and digital technologies. Harvard Education Press.

Sabayleh, O. A., & Sakarneh, M. A. (2023). Effective Teaching Strategies for Students with Learning Disabilities in Inclusive Classroom: A Comparative Study: Teaching strategies. Educational Administration: Theory and Practice, 29(1), 209-220.

Saldaña, J. (2016). Goodall's verbal exchange coding: An overview and example. Qualitative Inquiry, 22(1), 36-39.

Sanders, M. (2008). STEM, STEM education, STEMmania. The Technology Teacher, 68(4), 20-26. Retrieved from https://eric.ed.gov/?id=EJ821633

Sapon-Shevin, M. (2007). Widening the circle: The power of inclusive classrooms. Beacon Press. ISBN: 978-0807032829

Schneider, S. L. (2001). In search of realistic optimism: Meaning, knowledge, and warm fuzziness. American psychologist, 56(3), 250.

Schunk, D. H. (2012). Learning theories from an educational perspective. Pearson Education, Inc.

Scruggs, T. E., Mastropieri, M. A., & Okolo, C. M. (2008). Science and social studies for students with disabilities. Focus on Exceptional Children, 41(2), 1-24. https://eric.ed.gov/?id=EJ836934

Shernoff, D. J., Sinha, S., Bressler, D. M., & Ginsburg, L. (2017). Assessing teacher education and professional development needs for the implementation of integrated approaches to STEM education. International journal of STEM education, 4, 1-16.

Szwed, K., & Bouck, E. C. (2013). Clicking away: Repurposing student response systems to lessen off-task behavior. Journal of Special Education Technology, 28(2), 1-12.

Thomas, D. R. (2006). A general inductive approach for analyzing qualitative evaluation data. American journal of evaluation, 27(2), 237-246.

Thurlow, M. L., Lazarus, S. S., & Liu, K. K. (2020). Successfully transitioning students with disabilities to STEM careers. National Center for Educational Outcomes.

Tomlinson, C. A. (2001). How to differentiate instruction in mixed-ability classrooms (2nd ed.). ASCD.

Tomlinson, C. A. (2014). The differentiated classroom: Responding to the needs of all learners (2nd ed.). ASCD. ISBN: 978-0871203427

Tomlinson, C. A. (2017). Differentiated instruction. In Fundamentals of gifted education (pp. 279-292). Routledge.

Tschannen-Moran, M., & Hoy, A. W. (2001). Teacher efficacy: Capturing an elusive construct. Teaching and Teacher Education, 17(7), 783-805.

Turnbull, A., Turnbull, R., Wehmeyer, M. L., & Shogren, K. A. (2020). Exceptional lives: Special education in today's schools (8th ed.). Pearson.

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Harvard University Press.

Webb, D. (2013). STEM Lesson Essentials, Grades 3-8: integrating Science, Technology, Engineering, and Mathematics. Teacher Education and Practice, 26(2), 358-364.

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem-solving. Journal of Child Psychology and Psychiatry, 17(2), 89-100.

Woolverton, L. J. (2021). Teachers’ Attitudes and Perceptions of the Inclusive Classroom (Doctoral dissertation, McKendree University).

Yin, R. K. (2018). Case study research and applications: Design and methods (6th ed.). SAGE Publications.

APPENDICES

Appendix A

INFORMED CONSENT for
Teacher Perspectives on Interdisciplinary STEM Education in Special Education: A Phenomenological Case Study (eIRB 27367)
Principal Investigator: Chris Boakye, cboakye@ncsu.edu, 919.633.5535
Faculty Point of Contact: Dr. Cameron Denson, cddenson@ncsu.edu, 336.254.7978

You are invited to participate in a research study to investigate teacher perspectives on interdisciplinary STEM education in special education in a rural district in the Southeast region of the United States of America.

This study is being conducted by Chris Boakye, under the supervision of Dr. Cameron Denson, Associate Professor at North Carolina State University. You were selected as a possible participant because you are a special education teacher, in a district that has a STEM initiative in the Special Education Department, have at least 3 years experience in teaching, and have an interest or experience in implementing interdisciplinary education.

If you decide to participate, we will collect data regarding your implementation of interdisciplinary STEM education in special education. We also ask that you participate in an interview with the researcher. The collection of this data, through observations and interviews, is anticipated to last no longer than five weeks and should take no more than five hours of your time (for observations and interviews).

Your participation in this study may involve potential risks or discomforts. These include potential stress from being observed or schedule conflicts from participating in an interview. However, this study may provide the benefit of making you feel more supported in the process of implementation.

Any information obtained in connection with this study that can be identified with you will remain confidential. Information collected through your participation may be used to complete a dissertation and potentially be published in a journal. If so, none of your identifiable information will be included.

Confidential data that could be directly identifiable or through code lists will be protected and all identifying data or codes will be destroyed within six months of the completion of this study. You may withdraw from participation at any time, without penalty, and may withdraw any data that has been collected about you, as long as that data is identifiable.

Your decision whether or not to participate will not jeopardize your future relations with North Carolina State University.

If you have any questions, I invite you to ask them now. If you have questions later, Chris Boakye, 919-633-5535, cboakye@ncsu.edu or Dr. Cameron Denson at cddenson@ncsu.edu will be happy to answer them. You will be provided a copy of this form to keep.

If you have questions about your rights as a participant or are concerned with your treatment throughout the research process, please contact the NC State University IRB Director at IRB-Director@ncsu.edu, 919-515-8754.

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE WHETHER OR NOT YOU WISH TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO PARTICIPATE.

______________________________ ______________________________
Participant's signature Date Investigator's signature Date

______________________________ ______________________________
Print Name Print Name

Appendix B

Semi-Structured Interview Protocol

The following is a scripted Interview Questions for In-Depth Semi-Structured Interviews. The research will be able to follow-up with additional questions as it is semi-structured.

- ☐ Introduction: "Thank you for agreeing to participate in this interview. The purpose of this study is to explore your perspectives on interdisciplinary STEM education in special education. Your insights will help us understand the challenges and opportunities associated with integrating STEM education in special education settings. Your responses will be kept confidential and will be used solely for research purposes. The interview will last approximately 60-90 minutes and will be audio-recorded with your consent. Do you have any questions before we begin?"
- ☐ Consent Confirmation: "Do I have your consent to audio-record this interview?"

Background Information

1. Professional Background and Current Role
   - "Can you please describe your professional background and current role?"
   - "How many years have you been working in special education?"
   - "What subjects do you teach?"
   - "Can you elaborate on your current position and responsibilities?"
2. Educational Background and Training
   - "What is your educational background and training in special education and STEM?"
   - "What degrees have you obtained?"
   - "Have you attended any special certifications or training programs related to special education or STEM?"

Perspectives on STEM Education

3. Defining STEM Education
   - "How do you define STEM education in the context of your teaching practice?"
   - "What do you consider to be the key components of effective STEM education?"
4. Specific STEM Programs or Initiatives
   - "Can you describe any specific STEM programs or initiatives you have implemented in your classroom?"
   - "What types of activities and projects have you conducted?"
   - "What were the outcomes and how did the students engage with these activities?"

Integration of STEM and Special Education

5. Views on Integration
   - "What are your views on integrating STEM education into special education?"
   - "What do you perceive as the benefits for students with disabilities?"
   - "What potential challenges and barriers do you foresee?"
6. Success Stories
   - "Can you share any success stories or positive experiences with integrating STEM in special education?"
   - "Can you provide specific examples and discuss the impact on student learning and engagement?"
7. Major Obstacles

- "What are the major obstacles you face when trying to integrate STEM education in special education?"
- "How do resource constraints, training, and professional development needs affect your efforts?"
- "Do you receive adequate support from the administration and colleagues?"

Teaching Strategies and Methods

8. Effective Strategies
    - "What teaching strategies do you find most effective when integrating STEM into special education?"
    - "How do you incorporate inquiry-based learning, project-based activities, and interdisciplinary instruction?"
9. Tailoring Instruction
    - "How do you tailor your instructional methods to meet the diverse needs of students in your special education classroom?"
    - "Can you discuss your approaches to individualized instruction, differentiated instruction, and collaborative learning?"
10. Technology and Assistive Tools
    - "How do you use technology and assistive tools to support STEM learning in your classroom?"
    - "Can you provide examples of specific tools and software you utilize?"
    - "How do these tools impact student learning and participation?"

Professional Development and Support

11. Professional Development
    - "What types of professional development have you received related to STEM education and special education?"
    - "Can you describe workshops, courses, and training programs you have attended?"
    - "Do you receive ongoing support and resources for professional development?"
12. Additional Training Needs
    - "What additional training or resources would you find helpful for integrating STEM education in special education?"
    - "Are there specific topics or skills you feel need more focus?"
    - "What are your preferred formats and delivery methods for professional development?"

Collaboration and Support

13. Collaboration
    - "How do you collaborate with other teachers, specialists, and stakeholders to support STEM education in special education?"
    - "Can you provide examples of successful collaboration?"
    - "What challenges do you encounter in collaborative efforts?"
14. Administrative Support
    - "What kind of support do you receive from your school administration regarding STEM education in special education?"
    - "Can you discuss any administrative policies and initiatives that support your work?"

- "How do resources and funding from the administration impact your efforts?"

Closing Questions

17. Additional Insights
    - "Is there anything else you would like to share about your experiences with STEM education in special education?"
    - "Do you have any additional thoughts or reflections?"
18. Suggestions for Future Research
    - "Do you have any suggestions for future research on this topic?"
    - "Are there specific areas needing further investigation or potential research questions you would recommend?"

"Thank you for your time and valuable insights. Your contributions are greatly appreciated and will be instrumental in advancing our understanding of interdisciplinary STEM education in special education settings."

Appendix C

STEM Observation Protocol

The following STEM Observation Protocol was by National Institute for STEM Education based on research three meta-analysis and the National Research Council. The following Likert rating scale was added to the domains and actions that they created to establish a manner to report levels of implementation.

Observers will respond to the items below using the following Likert scale:
0=Skills not Demonstrated/Missed Opportunity
1=Improperly Implemented
2=Somewhat Properly Implemented
3=Appropriately Implemented
N/A= The Skill did not Apply to the Observation (Does not Impact Fidelity Score)

Indicator	Notes	Score
Domain 1: Creating an Environment for Learning (E)		
Action 1: Creating a Positive Classroom Culture (E-1) ● The teacher demonstrates positive, respectful interactions with students. ● Classroom rules and routines promote emotional and physical safety. ● Students feel comfortable asking questions and expressing ideas.		
Action 2: Establishing Cooperative Learning (E-2) ● Group tasks encourage collaboration and shared responsibility. ● Teacher facilitates positive peer interactions and conflict resolution. ● Students demonstrate engagement and teamwork in cooperative activities.		
Action 3: Integrating Technology (E-3) ● Technology tools are used to support and enhance learning objectives. ● Students actively engage with technology to explore and apply concepts. ● The teacher integrates technology without diminishing direct instruction.		

Action 4: Connecting Learning Outside the Classroom (E-4) ● Lessons include examples or activities tied to real-world contexts. ● Students discuss or apply classroom content to external situations. ● Teacher encourages exploration of community or global connections related to learning.
Domain 2: Building Scientific Understanding (U)
Action 1: Implementing Inquiry (U-1) ● Teacher encourages student-generated questions and investigations. ● Students actively participate in exploring and constructing their own learning. ● Teacher minimizes direct instruction in favor of guiding inquiry processes.
Action 2: Addressing Student Misconceptions (U-2) ● Teacher identifies and addresses common student misconceptions during lessons. ● Students are guided to critically evaluate and revise their preexisting ideas. ● Activities promote accurate conceptual understanding through evidence and reasoning.
Action 3: Facilitating Questioning and Discourse (U-3) ● Teacher uses open-ended questions to stimulate student thinking. ● Students engage in discussions that clarify and extend their understanding. ● Teacher listens actively and probes student responses to deepen dialogue.
Action 4: Utilizing Assessment (U-4) ● Teacher uses formative assessments to monitor student progress and understanding. ● Assessment data informs real-time adjustments to instruction. ● Students demonstrate understanding through authentic, performance-based assessments.
Action 5: Building Scientific Literacy (U-5) ● Lessons integrate skills such as analyzing data, interpreting results, and drawing conclusions. ● Students use scientific terminology and concepts accurately in their work.

• Teacher connects scientific concepts to real-world applications and current events.
Domain 3: Engaging Students in Scientific and Engineering Practices (P)
Action 1: Cultivating Scientific Investigations (P-1) • Teacher guides students in formulating testable questions and hypotheses. • Students demonstrate skills in observing, collecting, and analyzing data. • Students communicate findings and draw logical conclusions based on evidence.
Action 2: Developing Engineering Solutions (P-2) • Teacher introduces and facilitates the iterative engineering design process. • Students identify problems, brainstorm solutions, and test prototypes. • Activities emphasize creativity, problem-solving, and refinement of designs.
Action 3: Fostering Data Utilization (P-3) • Students use mathematical tools to analyze data quantitatively and qualitatively. • Teacher emphasizes interpreting data to make meaningful conclusions. • Students effectively communicate data findings using appropriate formats (e.g., graphs, tables).
Action 4: Implementing Project-based Learning (P-4) • Teacher designs and facilitates integrated, real-world project-based tasks. • Students engage in multidisciplinary projects that require mastery of content and process standards. • Projects include clear objectives, collaborative opportunities, and reflective components.
Action 5: Facilitating Claim-Evidence-Reasoning (P-5) • Teacher models the Claim-Evidence-Reasoning (CER) framework during instruction. • Students construct arguments supported by evidence and logical reasoning.

• CER is used as a tool for authentic assessment and classroom discussions.
Action 6: Promoting Scientific Argumentation (P-6) • Teacher fosters discussions where students present and critique claims using evidence. • Students practice constructing alternative explanations based on shared data. • Classroom activities highlight the iterative and collaborative nature of scientific argumentation.
Total Score: earned/possible (possible calculated as 3 per item not considered N/A)

Appendix D

Request to Include Special Education Teacher in Dissertation Research

Dear [removed for anonymity],
I hope this email finds you all well. My name is Chris Boakye, and I am currently working on my dissertation titled "Teacher Perspectives on Transdisciplinary STEM Education in Special Education: A Phenomenological Case Study." My research aims to explore the lived experiences and perspectives of special education teachers in implementing STEM education.
I am writing to request the inclusion of your district's special education teachers in my study. Their insights and experiences would provide valuable contributions to understanding the integration of STEM education for students with learning disabilities. Participation would involve an interview, classroom observation, and document analysis, with all information being handled confidentially and in line with institutional review board (IRB) protocols. I believe this collaboration would benefit both the research community and the broader educational practices within your district by shedding light on innovative approaches to special education and STEM integration.
I would be happy to provide any additional information and address any questions or concerns you might have. Your support in this matter would be greatly appreciated.

Thank you for your time and consideration. I look forward to your response.

Warm regards,
Chris Boakye

Appendix E

Reflexive Journal

Entry 1: Initial Thoughts and Positionality

As I embark on this research, I recognize my positionality as both an observer and an interpreter of special education teachers' experiences. My own background in educational research at Betabox Learning and at FullSTEAM influences my perspectives, and I remain cognizant of how my assumptions may shape data collection and analysis. I am committed to an open-minded approach, ensuring that the voices of special education teachers take precedence in shaping the study's outcomes.

Entry 2: Engaging with the Research Question

The overarching research question – exploring special education teachers' lived experiences and perspectives on interdisciplinary STEM education – requires deep engagement with both theoretical and practical dimensions. I anticipate uncovering rich narratives that highlight not only professional insights but also emotional and social dimensions of their work. The qualitative nature of this study will allow for an in-depth understanding of their challenges, successes, and innovative practices.

Entry 3: Considering the Benefits of Interdisciplinary STEM Education

While reviewing literature and preliminary conversations with educators, I notice a recurring theme: the potential of interdisciplinary STEM education to enhance problem-solving, critical thinking, and engagement among students with disabilities. Many teachers see value in hands-on, inquiry-based STEM learning, which aligns with diverse learning needs. However, I must remain attentive to whether these perceived benefits translate into measurable student outcomes and how they vary across different educational settings.

Entry 4: Challenges in Implementing Interdisciplinary STEM Education

One significant challenge that emerges in early discussions is the lack of access to adequate resources and training. Many special education teachers express frustration over insufficient professional development in STEM methodologies tailored to students with disabilities. Additionally, standardized curricula and assessment constraints often hinder the full integration of interdisciplinary STEM education. My reflections lead me to question how systemic barriers influence teachers' capacity to innovate within their classrooms.

Entry 5: Adapting Strategies for Effective STEM Instruction

Teachers who have successfully integrated interdisciplinary STEM education often employ creative adaptations, such as hands-on manipulatives, assistive technologies, and scaffolded learning experiences. As I analyze their strategies, I recognize the importance of flexibility and differentiation in instruction. These educators leverage multi-sensory approaches, collaboration with specialists, and student-centered learning models to ensure accessibility and engagement.

Entry 6: Ethical Considerations and Researcher Reflexivity

Throughout the research process, I remain mindful of ethical considerations, particularly in representing teachers' experiences authentically and respectfully. My role as a researcher requires me to balance my interpretations with fidelity to their narratives. I also acknowledge the potential emotional labor involved for participants as they reflect on their professional challenges and aspirations.

Entry 7: Emerging Themes and Future Directions

As I progress with data collection, several key themes begin to surface: the transformative potential of STEM for students with disabilities, systemic barriers that limit implementation, and the ingenuity of teachers in adapting STEM content. I find myself increasingly drawn to exploring how institutional support structures can enhance interdisciplinary STEM education. Moving forward, I will continue to refine my analysis, ensuring that findings contribute meaningfully to both scholarly discourse and practical applications in special education.

Final Reflections

This reflexive journaling process has been invaluable in deepening my understanding of the complexities surrounding interdisciplinary STEM education in special education. By continually interrogating my assumptions and interpretations, I strive to maintain rigor and authenticity in my research. Ultimately, my hope is that this study not only amplifies teachers' voices but also informs policies and practices that foster inclusive and effective STEM learning for students with disabilities.

Appendix F

Initial Contact Email/Letter:

Dear [Teacher's Name],
I hope this message finds you well. My name is Chris Boakye, and I am conducting a research study on the implementation of transdisciplinary STEM education in special education settings. The purpose of this study is to explore the experiences, beliefs, and attitudes of special education teachers regarding this innovative educational approach.
I am seeking special education teachers who are currently involved in or interested in transdisciplinary STEM education to participate in this study. Participation will involve an in-depth interview, classroom observations, and sharing relevant instructional materials. Your insights and experiences are invaluable and will contribute significantly to understanding how to effectively integrate STEM education into special education.
If you are interested in learning more about this study and potentially participating, please join me for an informational meeting/webinar on [Date] at [Time]. You can also contact me directly at cboakye@ncsu.edu or 919-633-5535 for more information.
Thank you for considering this opportunity to contribute to important educational research. I look forward to your participation.

Best regards,
Chris Boakye
North Carolina State University

Informational Meeting/Webinar Talking Points:

Welcome and introduction
Overview of the research study: purpose, importance, and goals
Explanation of what participation involves: interviews, observations, document sharing
Discussion of confidentiality, voluntary participation, and the right to withdraw
Q&A session to address any questions or concerns
Next steps: signing consent forms and scheduling interviews/observations

Appendix G

Member Checking Document: Validation of Findings

Dear Participant,
Thank you for your valuable contribution to our study on interdisciplinary STEM education in special education classrooms. As part of the research process, we are conducting a member-checking exercise to ensure that the findings accurately reflect your experiences and insights. Your feedback is crucial in validating the themes identified from the data collected.
Purpose of This Document: This document provides a summary of the key themes that emerged from the analysis of the interviews. Please review the findings and provide your feedback regarding their accuracy, clarity, and relevance.
Key Findings:

1. **Perceived Benefits of Interdisciplinary STEM Education**
    - o Enhanced student engagement through hands-on, inquiry-based STEM activities.
    - o Promotion of critical thinking and problem-solving skills.
    - o Encouragement of collaboration and teamwork among students.
    - o "Students are more motivated when they can apply what they learn in real-world situations."
2. **Challenges Faced in Implementing STEM Education**
    - o Limited access to necessary resources, technology, and funding.
    - o Insufficient professional development opportunities tailored to special education needs.
    - o Time constraints in balancing curriculum requirements with STEM activities.
    - o "We often lack the materials needed to fully implement STEM projects."
3. **Strategies Used to Adapt STEM Content**
    - o Differentiated instruction to cater to diverse learning needs.
    - o Incorporation of Universal Design for Learning (UDL) principles.
    - o Use of assistive technologies such as speech-to-text software and adaptive tools.
    - o "Providing visuals and hands-on activities helps bridge learning gaps."
4. **Emergent Themes**
    - o The role of peer collaboration in addressing resource limitations.
    - o Innovative uses of technology to create engaging learning experiences.
    - o Importance of teacher enthusiasm in promoting student engagement.
    - o "Collaboration with colleagues helps us share ideas and make the most of available resources."

Your Feedback: Please review the findings and provide feedback on the following questions:

1. **Accuracy:** Do these findings accurately represent your experiences? (Yes/No)
    - o If no, please specify any discrepancies.
2. **Clarity:** Are the themes and descriptions clear and understandable? (Yes/No)
    - o If no, please suggest improvements.
3. **Relevance:** Do the findings align with your expectations and experiences? (Yes/No)

- If no, please elaborate.

4. **Additional Comments:** Is there anything else you would like to add or clarify?

Please return your feedback by January 24, 2025, via email to cboakye@ncsu.edu Your responses will help me refine the analysis and ensure it accurately represents your perspectives. Thank you for your time and support.

Sincerely,
Chris Boakye
NC State University
919-633-5535