2022

A Survey of Elementary Educators' Self-Efficacy Related to STEM Education

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Digital Object Identifier: https://doi.org/10.13023/etd.2022.246

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A SURVEY OF ELEMENTARY EDUCATORS' SELF-EFFICACY RELATED TO STEM EDUCATION

THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in Education in the
College of Education
at the University of Kentucky

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2022

ABSTRACT OF THESIS

A SURVEY OF ELEMENTARY EDUCATORS' SELF-EFFICACY RELATED TO STEM EDUCATION

While the call for STEM and engineering design has increased since the release of the Next Generation Science Standards, the implementation of STEM in elementary grades has been slow. A variety of factors play a role in why educators, schools, or districts make the informed decisions they do regarding curriculum and instruction. Identifying strengths and challenges elementary educators face in implementing STEM into the curriculum can guide schools and districts in creating supports for increasing STEM in the elementary grades. This study sought to create and test a survey instrument for use with elementary educators in a large urban district in the southeastern US. The instrument was designed to examine elementary educators' perceptions regarding STEM education, specifically analyzing how educators feel regarding their own preparation and confidence in teaching STEM. These findings focus on the specific district in question to gain understandings of what is happening in the schools. Analysis of district provided materials, resources available to educators, Professional Development opportunities, as well as honest feedback on challenges and obstacles that educators face are investigated. This study shows a glimpse of what is happening in some elementary schools within this district.

KEYWORDS: STEM Education, Educator Self-Efficacy, Educator Preparedness, Pedagogy, Elementary Education, Urban District

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DEDICATION

This thesis is dedicated to my children, Mattie, Henry, and Nolan. I hope that your curiosity continues to lead and inspire you!

ACKNOWLEDGEMENTS

First, I must express the deepest gratitude to Dr. Rebecca Krall. Dr. Krall has not only been an advisor and a mentor, but an encouraging friend throughout the entire process of completing this thesis. Dr. Krall has spent countless hours sharing suggestions and helpful feedback at each stage of this thesis process. She helped to hold me accountable to ensure that I completed everything in a timely manner. I must also acknowledge the other members of my thesis committee, Dr. Sahar Alameh and Dr. Lin Xiang, who have provided their time and help along the way.

I would not have been able to complete this thesis without the love and support from my family and friends as well. All my closest friends and family members have not only offered words of encouragement when it was needed but aided by providing feedback throughout the entire process of completing my thesis. I am so grateful for their support. My husband, DJ, and children, Mattie, Henry, and Nolan, have sacrificed so much to help me achieve this goal. I am extremely grateful for their continued love and understanding throughout the preparation, research, and writing process.

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CHAPTER 1. INTRODUCTION

1.1 The Problem

Education is a field that is ever-growing as educators learn new methods and strategies to reach their students each year. It is also a field that has a reputation for introducing a lot of fancy named initiatives. With public eyes on K-12 education, there is often a lot of pressure on school systems and educators to ensure their students succeed. However, what defines success? Some might say that the answer to that question is how well a student performs on a specific standardized test, such as Hanushek (2008) who states that there are correlations between cognitive skills measured by test scores and positive later in life outcomes. With a heavy focus on student test scores, fancy initiatives, and the public eye on school officials, a school system must delegate funding to their schools in a way that is fair and just, which all adds up to a big problem faced by many school systems in America- teaching to the test and ignoring other critical aspects of a student's educational journey, such as those moments that cannot be measured by a test. "Historically, most achievement tests have neglected to measure important aspects of academic competence (Greeno, Pearson, & Schoenfeld, 1997; NRC, 2001) and, generally speaking, standardized achievement tests are not designed to assess the reasoning and problem-solving skills emphasized by instructional interventions in K–12 science or mathematics (Darling-Hammond et al., 2013; DeBarger, Penuel, Harris, & Kennedy, 2016; Pellegrino, Wilson, Koening, & Beatty, 2014)" (Sussman & Wilson, 2019).

When schools and educators focus solely on how well a school's performance is on a standardized test, education loses its luster and is no longer about sharing knowledge with students and watching as they have their "aha moment" when the lightbulb clicks, and connections are made. A study conducted by John Farvis and Stephen Hay, analyzed the outcomes of high stakes testing in New York schools (2020). They found that in schools were the educators had less control in instructional planning and where the content and curriculum taught were narrowed into what content would be on the test, there was a significant decrease in collaboration and an increase in educator and administrator stress, along with negative effects on student outcomes. So how do we get education back to its roots? How do we effectively encourage students to explore and learn at their own pace, while still providing deep connections that meet mandatory standards? One method is to focus on providing students with more hands-on experiences. This can be accomplished through STEM Education.

The researcher has seen many educators struggle with balancing standardized testing and try to empower their students through knowledge and understanding in hopes that their students can use the skills taught and apply them to different situations, which in theory is what educators are supposed to be doing every day. Educators are drowning in paperwork and meetings. Many educators choose to relocate from high needs schools, such as schools with a large population of low socio-economic status (SES) families and schools with many students receiving special education services, to a school where students are spending more time in the general education classroom and less time being pulled out of the classroom to receive outside services and where students tend to have more support at home and come from a higher SES. Unfortunately, there are educators who only teach reading and math skills to their students year after year, leaving out science, social studies, writing, social skills, and many other necessary components that shape a students' educational identity. Everything that an educator chooses to do in their classroom is a result, directly or indirectly, of how leaders in their schools and school systems view education. During an educator's pre-service years, they spend a lot of time focusing on encouraging and facilitating deeper understandings, but somewhere in between pre-service years and an educator being in their own classroom, something gets lost or pushed to the side. This is where STEM education may offer a vital piece of the puzzle. The focus of this study is to collect and analyze elementary educators' perceptions about their preparation and implementation of STEM education in the elementary grades.

1.2 Purpose of Study

The purpose of this study was to gain an understanding of STEM education at the elementary level across a large urban public school district. More specifically, this research looks at elementary educators' perceived preparedness to teach STEM education; educator confidence when implementing STEM education. materials, resources, and teaching strategies used to implement STEM education, and commonalities and disparities across a large, urban public school district in Kentucky. The district in question serves over 100,000 students. This study aimed to answer the question, "How prepared are in-service elementary educators to teach STEM education in their classrooms?" Critical information was collected from elementary school educators and analyzed to help identify strengths across the district regarding STEM education, as well as identify any areas of weakness within the district.

This study took information gained from an online educator survey addressing educator efficacy, educator support, and educator knowledge of STEM at the elementary level to analyze what methods and materials are being implemented. The second component of this study is the educator interviews. The educator interviews were an opportunity to gain deeper insight into educator's understandings and beliefs surrounding STEM education. This provided educators an opportunity to share their personal pedagogy and explain their thoughts on topics surrounding STEM education.

1.3 Significance of Study

This study is significant because it explores an important aspect of teaching science: elementary educators' perceived confidence, preparedness, and experience in teaching STEM. The large urban school district where data were collected also offered a diverse educator and student population that had the potential of representing a wide spectrum of educators' views. This investigation will also gather information on the materials used and teaching strategies preferred by elementary educators. Further, no formal investigation into the current practices being used in the district in question have been performed before. The information gained from this study will provide an array of information that will shape the future of STEM education for elementary students, especially in this specific district.

1.4 Research Questions

The overarching research question that guided this study is "How prepared are in-service elementary educators to teach STEM education in their classrooms?" In order to answer this question, five sub-driving questions were crafted. These sub-driving questions are: 1) How did the educator's education, preservice and professional development, address STEM education? This question will analyze the educators' preparedness and preparation programs that deal with STEM education, as well as any Professional Development that educators have participated in regarding STEM education. 2) How confident do elementary educators feel teaching STEM in their classrooms? Survey data were analyzed to identify educators' self-efficacy or their judgment on their own ability to effectively provide STEM education opportunities to their students. 3) What pedagogies do elementary educators prefer when teaching STEM education? To answer this question, survey data were analyzed to identify what teaching and learning practices are used in elementary STEM classrooms and educators' perceived level of effectiveness of those strategies. 4) What teaching strategies do educators identify they are utilizing when they are implementing STEM? This question compiled the data to demarcate preferred strategies educators implement in elementary classrooms across the district. 5) How do the views of elementary educators regarding STEM compare across the district? For this question, analysis of the demographics portion of the online survey led to identifying any common areas of strengths or weaknesses across the district. This required analysis of similar subgroups, such as special populations in schools or the number of free and reduced lunch students, in order to see which school settings, have similar populations. This allowed the researcher to see if schools with similar populations are implementing the same methods for STEM education or lacking in any components of STEM education.

1.5 Hypothesis

The main research question guiding this study is a broad question that could be taken in different ways based on the reader, therefore the introduction of five sub-questions narrows the focus of the study on educators' perceptions of their competence and preferred strategies, and materials used when teaching STEM education curriculum. Based on anecdotal evidence from research literature and the researchers' experiences in elementary schools, the following hypotheses were posed for this study.

> Hypothesis 1: Educators must define STEM education per their own pedagogies prior to implementing STEM education in their classrooms. Therefore, the researcher expected over half of the educators would view the STEM components as stand-alone subjects, rather than integrated together. This hypothesis is derived from the researcher's years of experiences both in field experiences as a student and years teaching in elementary classrooms, in which the researcher witnessed over 75% of her colleagues planning and implementing these subjects independently of each other.

> Hypothesis 2: Most educator education programs do not require coursework in STEM education or offer a degree or certificate in STEM, especially at the Elementary level due to the fact that "educator education programs are rather general, it is particularly challenging for elementary school educators to build up knowledge on how to teach science (PCK) as well as to actually understand science phenomena (CK) (Appleton, 2008; Brobst et al., 2017; Gomez-Zwiep, 2008)." (Fauth et al., 2019, p.3). There are some STEM professional development opportunities for practicing educators to participate in each year. This hypothesis comes from researcher's experience in undergraduate studies in a broad Elementary Education program and experiences in attending over 170 hours of Professional Development during her teaching career.

Hypothesis 3: Educators who implement STEM education in their classrooms view themselves as a facilitator of learning, letting students guide their own learning. Educators who do not implement STEM education in their classrooms view themselves as the one who possesses knowledge and is giving that knowledge to their students. This hypothesis is derived from the researcher's observations of colleagues in both types of classrooms.

Hypothesis 4: "Elementary science educators are often hesitant to teach science which is probably due to their limited pedagogical content knowledge and low self-efficacy (Appleton, 2008; Johnston & Ahtee, 2006; Rice, 2005)", this along with the researcher's teaching experience led to the hypothesis that less than half of elementary educators in the district implement STEM education in their classrooms (Fauth et al., 2019, p.2).

1.6 Assumptions and Biases

The principal investigator for this study is an elementary educator who has worked in low-income, high poverty schools with little to no diversity as the schools have 80-90% African American student populations. The principal investigator has only worked in this specific school district but completed her undergraduate field hours and student teaching in a much smaller district in a more rural community. She was the science lead at her school, which required her to attend professional development sessions to gather knowledge from the district's science department and take the knowledge back to the educators at her school. As science lead, she was responsible for collecting, dispersing, and gathering the district science kits for all classrooms. This position was a voluntary leadership position that required work outside the regular instructional day and regular duties. During the 2020-2021 school year, the principal investigator took a step back from the classroom to focus on her family. She is not currently teaching but plans to return to the classroom.

Based on experiences in her role as science lead in her school, there are a few assumptions that the principal investigator made involving this study. These include: 1) all participants will answer the survey and interview questions honestly; 2) educators participating in this study are from different backgrounds, teaching positions, and schools across the district; and 3) data collected from this study will be able to guide future steps for the district and other Kentucky school systems to improve elementary educators' perceived competence and access to professional development to improve STEM education in K-12.

1.7 Standards and Frameworks

This study takes place in a large urban district. This district is departmentalized per subject area to aid in the planning process for educators. The science department uses The Next Generation Science Standards (NGSS) to develop units based around the content covered for each grade level. These units are made up of lessons that are designed to follow science and engineering practices and encourage cross-curricular engagement. The educators are given science kits that match their grade level standards and goals to provide a foundation of science lessons that can be implemented in the classroom. The knowledge of the science kits and district science department were essential in developing the educator survey and the interview protocol.

Math is an important part of STEM education. The district's math department provides a framework to implement the math practices from Kentucky Academic Standards for Math (KAS - Math) in a variety of settings. These math practices almost go hand in hand with the science and engineering practices of NGSS. For example, Math Practice #3 says "Construct viable arguments and critique the reasoning of others," which can be paired with Science and Engineering Practice #7, "Engaging in argument from evidence". Another pair would be Math Practice #4 "Model with mathematics" and Science and Engineering Practice #2 "Develop and use models". The skills found in the practices are critical to STEM education. Students must come up with an explanation for the phenomenon and justify their claims using evidence. Students also need to be able to design, model, and analyze their data when completing STEM units.

The district also utilizes Kentucky Academic Standards for Technology (KAS - Technology) which are based off of the International Society for Technology in Education (ISTE) standards for students. These standards are broken down based on seven concepts: Empowered Learner, Digital Citizen, Knowledge Constructor, Innovative Designer, Computational Thinker, Creative Communicator, and Global Collaborator. These concepts can be integrated and applied to all other subjects very easily. They also go hand in hand with STEM as they encourage deeper thinking and allow for opportunities of student design and creativity during lessons while students solve real-world problems to demonstrate understanding of the technology standards.

CHAPTER 2. REVIEW OF LITERATURE

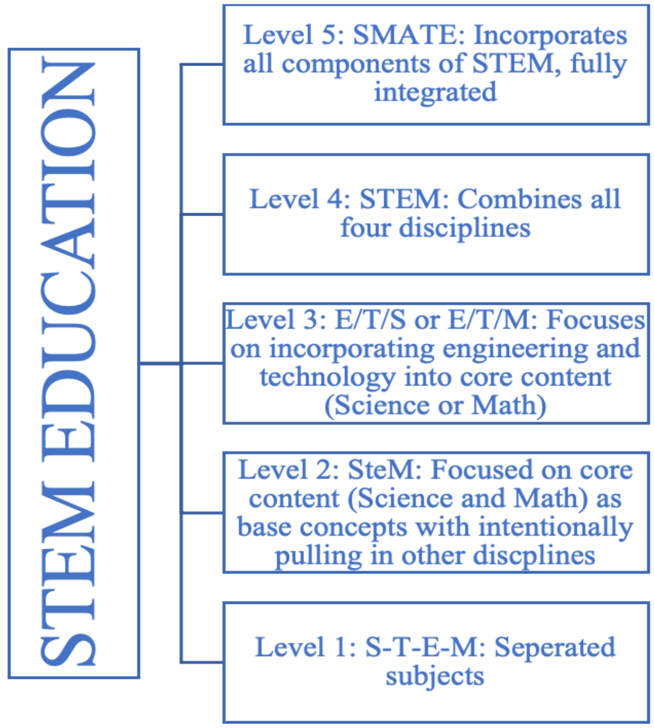
2.1 Defining "STEM"

The definition of STEM education is critical in the implementation and success of STEM in classrooms. STEM is known for the individual components that the acronym is composed of, but there is some discrepancy when it comes to a definitive definition of STEM education. A study conducted by Vinson Robert Carter at the University of Arkansas (2013) analyzed the definition of STEM education by practicing educators and analyzed STEM curricula looking for content integration, rather than a focus on a singular content area. Carter found that even when educators were presented with a thorough definition of STEM education, they still required that it be more clearly defined and explained to alleviate confusion about what STEM Education is and how it is modeled in the classroom (p. 108). Thus, this section explores the definitions of STEM education presented in the research literature and then outlines the definition used in the current study.

Science and Math are core concepts that legally must be taught daily and noted in an educator's lesson plan. Technology often gets thought of as a special area class that meets in the computer lab or what technological tools are available in the classroom. Engineering is commonly explained by use of the engineering practices that are a recent addition to The Next Generation Science Standards (NGSS). However, when STEM education is discussed the definition of what an educator implements for STEM could be one of many models of STEM education.

According to Mpofu's theoretical framework (2019), there are several different levels of STEM education that build off of each. The first of these levels is based on the disciplines of STEM: Science, Technology, Engineering, and Mathematics, being taught as stand-alone subjects with little to no integration between the content. The second level incorporates more integration between the content areas, such as a unit where students use science and math concepts to problem solve. The third level model includes the incorporation of engineering practices and technology to aid in problem solving when integrated with science or math. The fourth level is a true integration of all four disciplines within the unit that focuses on the knowledge, values, and practices of each area. The fifth and final level incorporates art - in the "A" - to make "SMATE" or "STEAM."

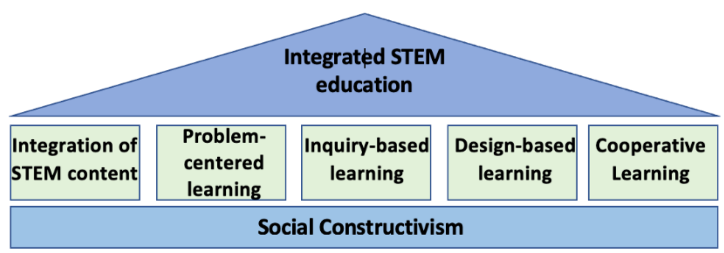
Figure 1 Mpofu's Theoretical Framework (2019)



There is not necessarily one correct level of STEM education that should be implemented, although the ideal integration would be the final level Mpofu described. Figure 1 maps out the different levels and what is comprised of each level. The level implemented by an educator would show their depth of understanding about what STEM education is and their effectiveness at planning, preparing, and implementing such a unit. The first model would be the basic level of STEM education where an educator is not comfortable enough with content, expectations, resources, etc. to integrate subjects together. As the models build off each other, implementation of STEM education would become increasingly more interactive for students and the rate at which students would be successful would increase as well. Simultaneously, as the progressively integrated levels build off each other, the educator begins relinquishing control and the students become more active members in their own education. This means that educators step out of the traditional role of content specialist who is the holder of knowledge and shares that knowledge with students, and step into a new role as facilitator, serving as a resource to students as the students inquire and learn at their own pace. Project-based STEM units allow for this shift in the traditional mindset of educator and student roles.

Thibaut et al. (2018) assert that “A number of other researcher’s outline a framework that educators can utilize when seeking STEM curricula for their classrooms.”, Thibaut et al. suggest a framework that contains five key principles in order to aid in the analysis and selective process for curricula in a STEM classroom. The five principles suggested in the article are integration of STEM content, problem-centered learning, inquiry-based learning, design-based learning, and cooperative learning. Figure 2 models the foundational Social Constructivist mindset, with the five principles building off of that foundation, leading to an integrated STEM education. This framework for instructional practices can help lead to educators implementing a curriculum that encompasses the

Figure 2 Thibaut, et al. (2018)



goals of STEM education, especially if an educator is struggling to find an integrated and successful curriculum.

Stohlmann et al. (2012) suggested a similar model of criteria for STEM curricula, although their framework includes community support, such as from a university or professional development training, educator efficacy, and materials. By encompassing these elements into this suggested theoretical framework, as modeled in Figure 3, Stohlmann et al. assert educators utilizing this framework will find more than just a curriculum that meets the checklist, but a deeper understanding of their own pedagogy and self-efficacy related to STEM.

Figure 3 Stohlmann et al. (2012)

Support	
• Partner with a university or school • Attend professional development • Time for teacher collaboration • Curriculum training and contacts	
Teaching	
Lesson Planning	Classroom Practices
• Focus on connections • Translations of representations • Understand student misconceptions • Understand student capabilities • Problem solving based • Student centered • Build on previous knowledge • Focus on big ideas, concepts, or themes • Integrate technology • Real world and cultural relevancy	• Question posing and making conjectures • Justifying thinking • Writing on reflection • Focus on pattern understanding • Use of assessment as part of instruction • Cooperative learning • Effective use of manipulatives • Inquiry
Efficacy	
• Content knowledge and pedagogical knowledge contribute to positive self-efficacy • Commitment to STEM education is vital • Planning and organization are critical	
Materials	
• Technology resources • Broad view of technology • Material kits for activities • Room space and storage for materials • Tables for group work	

The district in this study designs science kits to distribute to every educator in every grade. These science kits seem to relate and be modeled following Stohlmann et al.'s framework more so than the other two frameworks mentioned. The science department for the district offers Professional Development sessions for every unit on the curriculum framework, which fulfils the 'support' section of the framework, if an educator chooses to attend. The lessons and teaching manuals provided check off several points in the 'teaching' section of the framework, such as "focus on connections", "focus on big ideas, concepts, or themes", "writing reflections", and "use of assessment as part of instruction" to name a few. The kits also provide materials needed for the units of study.

2.2 What STEM Looks Like in District Classrooms

In such a large district that serves so many students, no two schools will have the same population with the same needs. School-based decision making within the district gives each school agency to make the decision on what works best for their student population. The district recognizes that what works for one school may not work for a different school. For example, in elementary schools across the district, there is an expectation that Science and Math are core concepts that should be taught daily to students. Elementary schools may choose to incorporate STEM units and activities into their instruction in a self-contained classroom, or in departmentalized settings, the educator teaching science may incorporate STEM into the science curriculum. Some schools follow a departmentalized structure, especially in the intermediate grades (3-5) that allow one educator to teach Science/STEM to students in that specific grade level. There are also schools that provide students an opportunity to attend a STEM Lab. This can either be as a special area, meaning students only visit this classroom about once a week or for one term or this can be an additional lab available for classes to visit outside of the special area schedule.

Although the organization of grade levels and who teaches STEM may vary in elementary schools across the district, the district's elementary STEM units share the same major criteria. Following the STEM model (Mpofu, 2019), the overarching criterion for district STEM units is a real-world problem guides the unit so that as students explore solutions, they build stronger connections across content, interdisciplinary connections, and deeper critical thinking and metacognitive skills necessary for success in the real world. Another key criterion of a STEM unit is that students are working together, often up and moving in the classroom. When STEM is being implemented it is not common to see students sitting at individual seats reading from a textbook or completing a worksheet. This often breaks the mold on "traditional education.".

In addition to STEM unit materials and organization, classroom environment also is an important factor for the implementation and learning of STEM. It is important to note commonalities between successful STEM classrooms to see what factors may lead to a successful implementation of STEM education in elementary grades. There is substantially more research on STEM education in upper grade levels, secondary and post-secondary grades specifically. However, this does not mean that this research cannot be utilized for elementary grades.

A team of researchers (Sahin & Mohr-Schroeder, 2019) outlined what the defining characteristics were of a successful inclusive STEM high school. They found several different studies on what the characteristics of a successful inclusive STEM high school are and found the following compiled list; (a) a college-prep, stem focused curriculum; (b) reform instructional strategies and project-based learning; (c) integrated, innovative technology use; (d) STEM-rich informal experiences; (e) connections with business, industry, and the world of work; (f) college level coursework; (g) well prepared STEM educators and professionalized staff; (h) inclusive STEM mission, (i) flexible and autonomous administration; (j) supports for underrepresented students; (k) data driven decision making for continuous improvement; (l) innovative and responsive leadership;

(m) positive school community and culture of high expectations for all; and (n) agency and choice (Lynch, Peter-Burton, et al., 2017).

Simultaneously, another study was done to analyze the characteristics of successful inclusive STEM high schools (LaForce et al., 2014) which found 8 characteristics among a broad collection of high schools across the United States: (a) rigorous learning, (b) problem-based learning, (c) personalization of learning, (d) career, technology, and life skills, (e) school community and belonging, (f) external community, (g) staff foundations, and (h) essential factors. One commonality among the educators in this study is that they shared a constructivist ideology, where students construct their own knowledge, and inquiry was the primary implementation tool.

Another group of researchers, Barbara Means and colleagues have conducted a lot of research on inclusive STEM high schools (ISHS). This research identifies small differences in factors such as student test scores and grade point averages for a traditional high school versus an inclusive STEM high school, but it also outlines high positive outcomes for underrepresented minority students, including African American populations and female students.

> ISHS students in general and those from subgroups underrepresented in STEM fields appeared more likely to leave high school with strong interest in pursuing a STEM career than comparable students who attended one of the comparison schools. ISHS students also expressed higher aspirations for postsecondary education, and the overall samples and several subgroups expressed stronger identities as individuals who "do" science. (Means et al., 2017, p. 706)

In this study, researchers compared reports from students from an ISHS and a comparable high school without a STEM focus with similar student populations and found three very intriguing results. Students from the Texas ISHS reported math integration in other STEM areas at a higher rate than students from the Non-ISHS school. This study also found that ISHS students reported their educators having higher expectations for them as well as having greater respect for all students than those students from the Non-ISHS. Lastly, the ISHS students reported engaging in conversations with school counselors regarding their academic and career plans as well as using more college and career readiness supports more than the Non-ISHS students.

Some aspects of an inclusive STEM high school can be adapted into elementary grades to help ensure the success of K-5th grade students in STEM. The following list is a compilation of broad STEM characteristics come from the LaForce, et al. (2014) and Lynch, et al. (2017) ISHS articles mentioned earlier in this section. These characteristics are the ISHS characteristics that can be applied to all grade levels, especially elementary classrooms. Most of these characteristics are good practice ideas, meaning they are things that should be happening in education across all grade levels and across all content areas. They encourage and promote integrated STEM instruction through classroom management and instructional habits.

- reform instructional strategies and project-based learning
- integrated, innovative technology use
- STEM-rich informal experiences
- connections with business, industry, and the world of work
- well prepared STEM educators and professionalized staff
- flexible and autonomous administration
- supports for underrepresented students
- data driven decision making for continuous improvement
- innovative and responsive leadership
- positive school community and culture of high expectations for all

- agency and choice
- rigorous learning; problem-based learning
- personalization of learning
- technology, and life skills
- school community and belonging, external community, staff foundations, and essential factors

2.3 STEM Across Grade Levels

STEM, like other content areas, builds off of prior knowledge. STEM is also unique from other content areas in the application of a students' experiences and prior knowledge as they seek to explore solutions to real-world problems. This is one reason the district in the current study implements NGSS and KAS. These standards are broken down and thoroughly explained in terms of what previous grades should have learned, expectations for student outcomes at the current grade level, and where the learning goes for future grade levels. For example, KAS outlines Number and Operations in Base Ten across K-5. In this specific set of standards students in kindergarten begin working on this skill to achieve mastery in composing and decomposing numbers from 11 to 19 into tens and ones; which leads into second grade when students learn how to compose and decompose three-digit numbers; and in third grade when students use their knowledge of place value to round numbers, add and subtract within 1,000, and multiply one-digit whole numbers by 10s. NGSS also details progressions for each standard. For instance, 3-PS2-1 Motion and Stability: Forces and Interactions details that student who understand this standard can plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. This performance expectation goes on to clarify with examples and includes assessment criteria. Next the standard includes in the Science and Engineering Practices that planning and carrying out investigations in grades 3-5 builds on the experiences from K-2. NGSS also detail connections with other Disciplinary Core Ideas (DCIs) within the grade level, DCIs across all grade levels - even middle and high school standards, and connections to CCSS standards, such as writing, reading, and mathematics. This concept of vertically planning content is critical to student success across all content areas, but especially STEM. These progressions are critical in ensuring students gain a deep understanding of content and continue to build on prior knowledge.

Math is expected to be taught daily and educators are held accountable for this through lesson plan checks, classroom visits, observations, and Professional Learning Communities, etc. It is not uncommon for elementary educators to omit science or STEM from their curriculum to make more time for teaching mathematics or literacy. In a survey of educators, grades Kindergarten through sixth, Griffith and Scharmann (2008) found that 59% of participants stated that there has been a decrease in science instructional time in their own classrooms since the No Child Left Behind Act went into effect. The researchers also found that a significant number of participants stated that they needed to cut down the time spent on science in their classroom to address the extra time needed in reading and math for their students, among other reasons as well. The educators that do attempt to teach science or STEM in elementary grades struggle with a variety of factors, one being understanding the content, materials, and resources with little to no experience or professional learning on the content. This requires an educator to take a lot of time and energy outside their regular workday to find, figure out what and how to implement STEM, as well as trial and error with implementation in the classroom to figure out what works, doesn’t work, or what can be adjusted to see more student success. This is something that will be thoroughly outlined and discussed in the analysis section of this study. There are many reasons that educators may chose not to teach science concepts in their classroom, but one major issue occurs when a student in intermediate grade levels, specifically 4th grade – when science is on the state standardized test for the district, suddenly need to have prior knowledge but comes to these grades with minimal exposure to the content. This can result in students sitting in a fourth-grade classroom with little to no prior formal school instruction or understanding of basic science concepts needed for students to be successful with fourth grade standards and testing. Which can lead to a domino effect of fourth grade educators needing to get their students up to speed on science concepts, meaning they are neglecting other academic standards in fourth grade.

2.4 Defining "Educator Efficacy"

A common practice in teaching is self-reflection. This idea of standing back and looking at one's own actions, decisions, interactions, and ideas is a central part of the educator evaluation process. It is highly encouraged by districts as a way for educators to take time and devote energy to reflecting on the actions that guided their teaching. When an educator practices self-reflection, they are looking back on themselves. Here is where educators can identify their confidence level with content, lessons, assessments, and strategies. According to Tucker, et al. (2005), there is a direct correlation between student success and educator efficacy, in that educators hold the belief and mentality that they possess the talent and skill to aid student learning. When one breaks down the idea of efficacy in regard to general educators, especially on the elementary level, it must be taken into account which subjects an educator is teaching daily and their strength and confidence in each subject area. For example, an educator who believes that they are strong in educating their students on history may at the same time believe that they are weaker in educating students on mathematic skills. Self-reflection includes assessing instructional practices for strengths and areas for growth, which can guide educators in matching their needs with available professional development so they can successfully educate their students.

Albert Bandura introduced the term “self-efficacy” in 1977 (Bandura, 1977) which can be interpreted from four main sources of information: performance outcomes, verbal persuasion, vicarious experiences, physiological feedback. Both positive and negative experiences lead to a person’s interpretation of their self-efficacy. Performance outcomes are as it sounds, the ability to perform a task or teach a lesson and can also be shaped by student performance. Verbal persuasion comes from the feedback that an educator receives on their lessons, either from a peer colleague or an administrator. This type of self-efficacy could even be influenced by former students and parents and guardians of students, as they will also influence how an educator perceives their abilities. Vicarious experiences are heavily dependent on observation of peer colleagues in regard to their successes and failures. By witnessing a peer succeed with a unit, it could influence the observing educator’s own thoughts on their ability to teach that unit to their students. Physiological feedback focuses on a person’s mental and physical health and well-being. If an educator is dealing with depressive episodes or anxieties or even struggling with their physical health, they could feel less capable in the classroom and their confidence could suffer in the classroom with self-doubt. Bandura stated that “People’s beliefs about their abilities have a profound effect on those abilities. ability is not a fixed property; there is a huge variability in how you perform. People who have a sense of self-efficacy bounce back from failure; they approach things in terms of how to handle them rather than worrying about what can go wrong” (Bandura, 1997).

There is a phenomenon that involves math anxiety that affects some educators, in which educators have an emotional and sometimes physical response triggered by mathematics. There are two main types of anxiety centered around mathematics: general math anxiety (GMA) and anxiety about teaching mathematics (ATM) (Ganley, C. M., Schoen, R. C., LaVenia, M., & Tazaz, A. M., 2019). The main difference between these two phenomena is that GMA is about one’s self doing math whereas ATM is centered around a educator’s ability to teach mathematical concepts to their students. A study conducted by Ganley et al. (2019), the researchers used the Math Anxiety Scale for Educators (MAST) with in-service educators. They found a correlation between math anxiety and math knowledge; educators with higher math anxiety have lower mathematics knowledge. They also found that these educators with higher math anxiety have more traditional beliefs about mathematics teaching and learning in the classroom.

Another study consisted of 186 first year undergraduate students at the University of Western Ontario to analyze student academic transcript and math anxiety using a different scale, the Math Anxiety Rating Scale (sMARS) to identify any correlation between math anxiety, math ability, and STEM outcomes. (Daker, R. J. et al, 2021) The results from this study showed that a student’s math anxiety level was a significant predictor in a reduction of STEM coursework and lower STEM grades. The researchers state that the math anxiety predicts math-related academic achievement levels, including correlations between math ability and STEM outcomes. This study shows that a person’s math anxiety level is directly related to their success in STEM, which means that if an educator experiences math anxiety that has the potential to affect their success in teaching or incorporating STEM into their classroom.

2.5 The Importance of Professional Development

As mentioned in the previous section, professional development (PD), is the next step in an educator's journey. As educators get to know their students, and strengths and weaknesses of their instructional practice, they also find what they are capable of teaching naturally and what they must improve upon for the betterment of their students. Professional development comes in all shapes and sizes, in every content area. PDs can be district wide and required by every school or can be individualized and something just one educator at a school may need.

The district this research took place in sets the mandated amount of PD a certified educator must attend to 24 hours in each academic year. This district provides hundreds of professional development opportunities to educators throughout one academic year. Some of these PDs are workshops with multiple sessions, book studies, seminars with speakers, focused on teaching strategies, focused on content area, focused on relationships and management, and some are leadership meetings focused on school and student needs. Educators are provided some mandatory PDs in house either required by their administrators or superintendents, but most educators in this district have the choice in which PDs they want to attend. The PDs offered by the district happen at central locations around the district, mostly meeting rooms or lecture halls but sometimes school buildings are utilized when students are not present during an instructional day. PDs have the power to be one of the most beneficial aspects of an educator's journey each year, if used within the right scope, meaning an educator identifies an area of weakness, sought a

PD for support, attended the PD and walked away with strategies, resources, and ideas to implement in their own classroom, and repeated the cycle of teaching and learning to make adjustments and the cycle repeats.

According to STEM Integration in K-12 Education: Status, Prospects, and an Agenda for Research (2014), most educators receive training in mainly one area or discipline, therefore most educators come into their own classrooms with a disadvantage regarding STEM education; a gap in their own experiences and education. One method to close that gap for educators is to provide effective PDs that target STEM education. One study that involved in-service elementary educators in a partnership with a certification program at a small university (Nesmith & Cooper, 2019), found some key components of STEM PDs, particularly engineering, that enhanced educator efficacy and presented positive teaching outcomes:

- incorporating a longitudinal, multiyear PD experience
- including all campus educators and administrators in the PD experience
- beginning the STEM PD experience with a focus on elementary STEM prior to providing specific attention to elementary engineering
- incorporating hands-on, elementary-specific STEM activities within each session
- providing opportunities for the educators to discuss and reflect on each experience within campus and grade level teams
- providing multiple opportunities and settings for colleagues and researchers to coach and mentor
- highlighting the educators' efforts, growth, and creativity through a showcase event

(Nesmith & Cooper, 2019, p. 495)

There is a lot of research out there about STEM education, most commonly in upper grades or post-secondary, but are elementary educators aware of the current research in STEM? Are elementary educators using current research-based strategies in their classrooms? The current study aims to answer the question "How prepared are in-service elementary educators to teach STEM education in their classrooms?" by highlighting in-service educators' voices and allowing a safe space for educators to share what they are or are not doing in regard to STEM in their classrooms. The researcher hopes that this study will provide educator participants an opportunity to share their thoughts and opinions. This study will also analyze teaching tools, teaching strategies, educators' self-efficacy and educators' pedagogies.

CHAPTER 3. METHODOLOGY

3.1 Research Design

This study consists of two components aimed at answering the research question: How prepared are in-service elementary educators to teach STEM education in their classrooms? The two components include educator surveys and educator interviews. The first component is necessary to collect a variety of data from elementary educators, such as pre-service information, professional development information, history of teaching (length of teaching career, ages taught and content taught), and confidence levels with different aspects of STEM education, just to list off a few. The survey consists of about 35 questions for participants to answer. The second component of this study is the educator interviews. These were conducted virtually with open-ended questions aimed at exploring beliefs and perceptions associated with STEM education at the elementary level. These two components will be more thoroughly addressed later in this section.

3.2 Research Procedures

The researcher designed the questions on the educator survey to gather a comprehensive view and understanding of STEM education in the eyes of educators. To design an effective survey, the researcher first looked at what other researchers have done in the past regarding STEM data in surveys. By looking at the Report of the 2012 National Survey of Science and Mathematics Education (Banilower et al., 2013), the researcher was able to design a survey that gathered the intended data from participants including what type of question or what structures for participant answers would be most beneficial to the research. The questions were designed with a basic understanding of the current curriculum presented to educators from the district by the science department, knowing that the implementation of the curriculum is encouraged but not expected to be used by every educator or that educators may not use every module. The educator interview protocol was designed to gather more specific information from educators regarding their teachings and beliefs to answer the research question and sub-questions.

3.2.1 Educator Surveys

The online educator surveys are the first component of research. Appendix 1 contains the questions from the educator survey. At the end of the educator surveys there is a section for demographic information, where educators list details about the school climate and population, without naming their school to maintain confidentiality. There is an optional section for educators to input their personal information, name, phone number, and email address. These items were only used to compile a list of participants for the second portion of the study, the educator interviews. If a participant was interested in being selected for the educator interview, they completed the optional section with contact information. If a participant was not interested in being interviewed, they left this section blank.

3.2.1.1 School Population

Educators who participated in this study were asked to share general information about the students that are serviced at their schools, such as students' ethnicities, genders, socioeconomic status, and about students who receive Exceptional Child Education (ECE) services. This section of the survey really helped to provide a clear picture of what the schools look like and the students they service. Seven educators (23%) did not provide answers in this section. All the educators (23) stated that their schools contained grades kindergarten through fifth grade, with one school specifying that their building also housed some pre-kindergarten classes as well. Then the educators were asked to provide the number of student population present in their schools. Four educators are at school that serves more than 600 students, twelve educators are at schools that serve 401-600 students, six educators are at a school that serves 251-400 students, and one educator is at a school that serves 101-250 students. This tells us that of the schools represented, most are larger schools. The educators went on to provide their student to educator ratio in their classrooms. Twelve educators have a ratio of 24:1 in their classroom. One educator had a ratio of 30:1, Three educators had 28:1, One educator had 26:1, Two educators had 25:1, One educator had 23:1, and Three educators had 18:1. These data suggest that the average number of students per class is 24. Seven participants (23%) have more than the average number of students in their classroom. When students are present in a learning environment with a smaller student to educator ratio, the student is able to have more one-on-one support from the educator, as well as thorough individualized instruction catered to each student and their needs. It is promising that there are schools in this district enforcing a smaller student to educator ratio, especially at the elementary level.

Educators were then asked what percentage of their student population receives free and reduced lunch. 14 educators stated that 91-100% of their student population receives free and reduced lunch, four educators stated that 71-90% receive free and reduced lunch, two educators stated that 51-70% receive free and reduced lunch, and three educators stated that less than 50% of their student population receives free and reduced lunch. Educators who participated in the survey were also asked what percentage of students in their classroom are special education students with cognitive disabilities. 13 educators said 0-15%, six educators stated that 16-35%, three educators stated that 36-50%, and one educator said 91-100% of their classroom consists of students with cognitive disabilities. The demographic information listed above can provide insight into what motivates educators to teach or not teach certain things or incorporate certain strategies into their lessons.

3.2.2 Educator Interviews

From the list of educators who volunteered their contact information from the educator surveys, the researcher used purposeful sampling (Patton, 1990) to gather a list of interviews to conduct. The researcher selected educators to interview based on the school population, school climate, and educator experiences in order to strategically interview educators from different school environments. The district is large and encompasses a variety of schools with different special populations, for example, some educators have few to no special education students in their classrooms; 13 educators (43% of participants) noted that 0-15% of the students in their classroom are special education students and 4 educators (13% of participants) noted that 36-100% of the students in their classroom are special education students. The district also serves a wide variety of students based on their socioeconomic status, for example 18 educators (60% of participants) noted that 71-100% of their student population receives free and reduced lunch while 3 educators (10% of participants) noted that 50% or less of their student population receives free and reduced lunch. By implementing purposeful sampling here, the researcher can gather a glimpse at the district as a whole by comparing schools across the entire district.

3.2.3 Data Collection

The survey data was collected virtually. The link to the survey was sent out via social media. The link was posted to two educator groups on Facebook, where administrators approved the posting, which are for active educators from the specified district. The link was shared through an advertisement (Appendix 2) approved by the university. Educators were encouraged to share the survey link and advertisement in order to reach as many participants as possible.

At the end of the survey was a section for participants to complete if they were interested in being contacted for an interview. After the research window closed, the researcher used purposeful sampling to gather a sampling of educators from across the district. The researcher contacted the educators and sent them the informed consent form and coordinated a time to meet virtually to host the interview.

3.2.4 Data Analysis

The raw survey data was taken from the software it was collected on and transferred into a Microsoft Excel spreadsheet. The responses with the same or similar answers were tallied together. The blank responses were also tallied for each individual question and section as a whole. The researcher combed through each grouping of questions to identify any trends or interesting percentages. The specific data is shared below.

The interviews were recorded, both audio and visual, with verbal permission from each participant. The raw interview data is qualitative in nature. The researcher did a quick transcribe just to summarize or write down key quotes from the participants. Then the data were analyzed using a Grounded theory following the constant comparative method (Corbin & Strauss, 2008). This was accomplished by looking at the three transcribed interviews and going over each participant's answers to questions side by side, using inductive coding (Miles & Huberman, 1994) to identify views, strengths and challenges educators identified. This method worked well for this study because it highlighted similarities and differences between the participants' answers.

CHAPTER 4. RESULTS

4.1 Summary of Results

Thirty elementary school educators from the district completed the online survey. The number of years of experiences vary between 2 years and 32 years of experience. The number of elementary grade levels taught vary from 1 to all 6 grade levels. Of the thirty educators who completed the survey, 12 shared what school they are currently working at, while 18 chose to not state their school by name. There are at least 10 schools represented by educator responses. Eleven educators volunteered to participate in the educator interviews, with five educators being selected for interviews. Of those five educators, three scheduled and completed educator interviews. The other two educators failed to follow through with scheduling an interview after receiving the consent forms. One educator stated that scheduling conflicts were the reasoning, the other educator ignored all communication from the researcher.

4.2 Educator Survey Analysis

4.2.1 Educator Background

When analyzing how STEM is implemented in education it is important to look at factors that may play a role in an educator's understanding, application, and implementation of the content as well as their "Educator Toolkit" or sets of skills they have that come from their own pre-service educator experiences and time spent as an educator. In order to look into these factors, a section of the educator survey provides educators an opportunity to share their teaching and non-teaching experiences that may factor into their teaching pedagogy. Of the 30 educators who took part in this survey, 27 (90%) responded to this section.

Beginning with pre-service time, more specifically undergraduate degrees held by the educators in this study, 63% of participants have a degree in education. Of those participants, 36% hold an undergraduate degree or minor in a content specific area, with 13% of participants holding a degree in math education and 6% holding a degree in science education. This means that more than half of the educators surveyed hold an education degree. This is important to note since most undergraduate education programs include multiple content specific methodology classes to provide a deep level of understanding in the major disciplines and implementation strategies.

Unfortunately, 47% of the educators surveyed stated that they had not taken any undergraduate level courses that address STEM education or any of the STEM disciplines. These data stand out as we cannot expect educators to have the knowledge of STEM content or strategies that lead to successful implementation if STEM is missing from their Educator Toolkit. Twenty percent of educators surveyed have taken at least one undergraduate level course in STEM or it's disciplines. Only 6% of educators surveyed have taken five or more undergraduate level courses in STEM or it's disciplines. These data suggest that about half of the educators fall into the category of having some exposure prior to the start of their career in STEM education.

In addition, 19 (63%) participants had completed other college degrees outside elementary education. The other degrees held by the participants in this study included, special education (13%), English (13%), math (6%), technology (3%), educator leader (10%), and administrative/curriculum (9%). One participant holds a middle school math certificate or endorsement. This data shows that the elementary educators in this district have a diverse background in preservice and educational studies. Sixty percent of educators surveyed did not have any graduate level courses that addressed STEM or it's disciplines and twenty percent of the educators surveyed had taken one or two graduate level courses in STEM.

Another factor that needs to be taken into account when analyzing an educator's background is how many years of experience they have in the classroom and what grade levels they have taught in the past. In the current study, 20% of educators surveyed have 5 or less years teaching experience, 36% of educators surveyed have 6-19 years teaching experience, and 20% of educators surveyed have 20 or more years teaching experience. 73% of the educators surveyed have experience in primary grades (Kindergarten, first, and second grade) and 67% of the educators surveyed have experience in intermediate grades (third, fourth, and fifth grade). Most of the educators have experience in multiple grade levels; only 7% have spent their entire educational career in the same grade level. Six educators have taught all 6 grade levels (Kindergarten-Fifth grade) with an average length of experience being 11.67 years. Three educators have taught five grade levels with an average length of experience being 22 years. Two educators have taught four grade levels with an average length of experience being 22.5 years. Five educators have taught three grade levels with an average length of experience being 19.67 years. Five educators have taught two grade levels with an average length of experience being 8.67 years. Two educators have taught only one grade level with an average length of experience being 3.5 years.

On one note, the more time an educator spends in the same grade level, the more of an expert they become on the content they are teaching. On another note, the more exposure an educator has with different grade level's standards and expectations can help build up a complex understanding of the content and skills associated with their current grade level. With every year of teaching experience under their belt, an educator gains many strategies, activities, and lessons to add to their "Teaching Toolkit". A study was conducted in New York City Schools by Atteberry, Loeb, Wyckoff (2017) to analyze the effect of educators switching grade levels and its effect on student outcomes. This study found that there is evidence that by having educators switch grade levels can cause negative implications on student success. This study also found that students of historically underserved are more likely to be placed in the classroom of a recently switched educator. While this study noted a difference between a brand-new educator and a new-to-this-school educator, the outcomes are similar in terms of the length of time it takes for educators to get adjusted to their grade levels, schools, or even districts after a switch.

A similar study was conducted on schools in Michigan by Brummet, Gershenson, & Hayes (2017) and noted that there is a level of administrator-initiated and educator-initiated grade switching in which the outcomes are positive on student success as well as positive outcomes for more experienced educators who remain in the same grade level for a longer duration of time, but simultaneously there are potentially harmful outcomes on student success when educators who are less effective or less qualified are placed or reassigned to low-stakes early grades. This study found that educators who switch grades are less likely to teach in a rural or high performing school and more likely to teach at an urban school with a high volume of students who qualify for free or reduced lunch. Another group that is more likely to change grades is first, second, third, and fourth grade educators, meaning Kindergarten and fifth grade educators are less likely to switch grade levels. Both of these studies mentioned above discuss turnover rates and found that schools with higher turnover rates also have higher rates of educators switching grade levels.

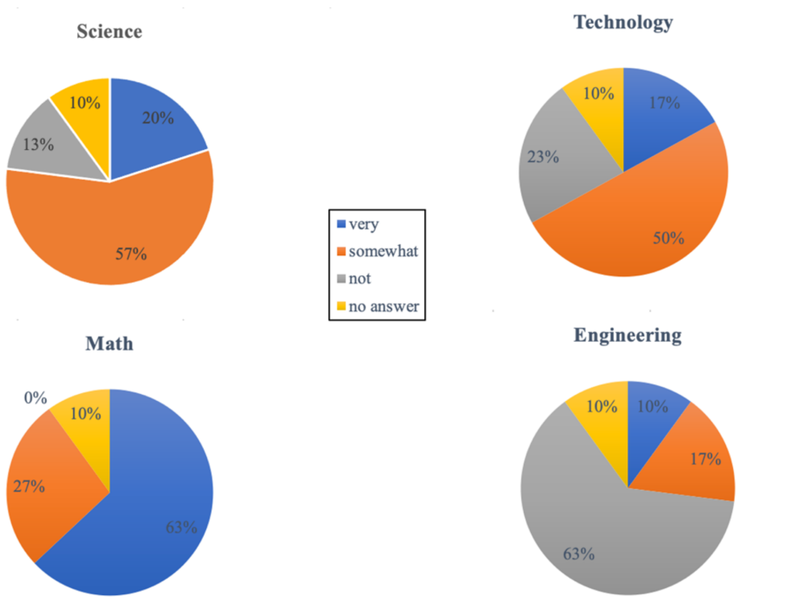
When unpacking how important the length of an educator's career is, it is important to keep in mind that every year educators are growing as educators by participating in Professional Development (PD) sessions. The district in question requires all certified educators to attend at least 24 hours of PD each academic year. Educators are allowed to choose PD sessions that fit their goals as an educator. The educators surveyed were asked to reflect on how many hours of PD they participated in within the last four academic years that address STEM education. Of the educators surveyed, 23% said they did not attend any PD sessions that were addressed with STEM education. 23% said they attended about 3-6 hours worth of STEM Education PD over the last four academic years. Of the 30 educators, 27% said they attended about 7-18 hours of STEM education PD.

4.2.2 Educator Efficacy

The first section of the survey dealt with educator efficacy, or the educator's confidence in teaching the specified subject area. There are two distinct types of educator efficacy the researcher was looking into, educator preparedness and educator confidence. 30 educators completed the survey with three educators (10%) leaving the first section blank by not providing an answer to these questions.

When educators reflected on their own level of preparedness when it comes to the major disciplines within STEM education, 90% of educators surveyed said they felt prepared to teach mathematics in their grade level, and 76% said that they felt prepared to teach science to their students. In contrast, 67% of the educators surveyed said that they felt prepared to teach technology applications to their students. When educators reflected on their own level of preparedness to teach engineering design at their grade level, only 26% said they felt prepared. These data reflected in Figure 4, suggest that most educators surveyed felt prepared to teach mathematical standards in their classrooms, a significant portion of educators felt prepared to teach science with slightly fewer educators feeling prepared to teach technology concepts in their classrooms. In contrast, very few educators feel prepared to teach engineering design in their classrooms at the elementary level. Across all academic standards that are expected to be taught in elementary classrooms, it would seem that the educators surveyed do not

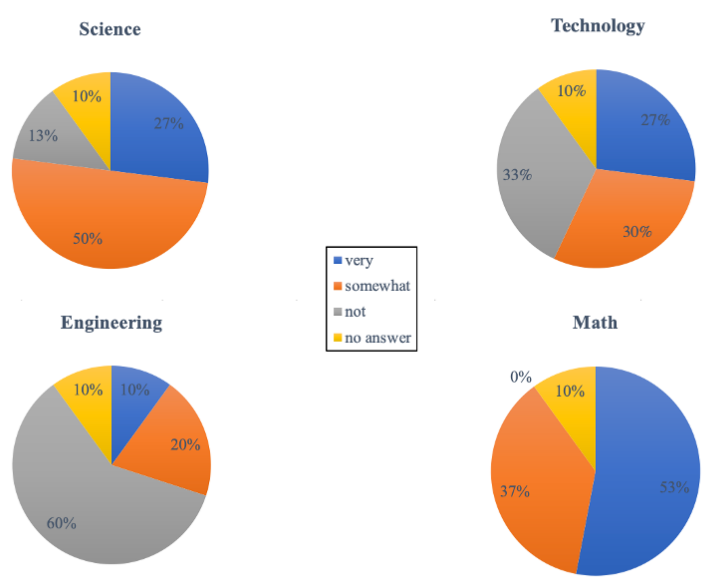
Figure 4 Educator Preparedness Results by Disciplines



feel that they have access, resources, or knowledge needed to ensure they are teaching engineering design standards effectively.

The second component of educator efficacy is the educator's confidence in teaching specific subject areas to students. 90% of educators surveyed felt confident to teach mathematics to their students, while 76% of educators surveyed felt confident to teach science to their students. These data shown in Figure 5, suggest that only 56% of educators were confident in teaching technology application to their students and 30% of educators were confident in teaching engineering design. The data from the survey suggests that educators' level of preparedness to teach a subject area is closely aligned to their level of confidence with teaching the topic.

Figure 5 Educator Confidence Results by Disciplines



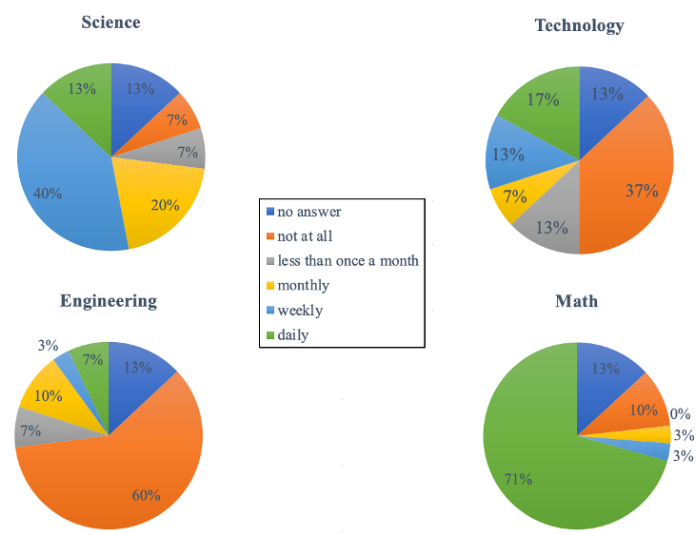
Teaching is an emotional and personal career, especially when working with young children. Educators often hear how critical it is to build relationships with their students, and while this is an important factor in student achievement, educators must also reflect on their own personal biases and relationship with subjects. It is not unreasonable to think that an educator has a strong connection to mathematics because they have a deep understanding of math from their own education as a student and years of utilizing math, where as an educator may feel less prepared and confident to teach engineering practices and design due to a lack of exposure to integrating engineering in an elementary classroom. The study mentioned previously that analyzed undergraduate students and their math anxiety and STEM outcomes, not only shows how important it is for anyone (educators especially) to identify their personal math anxieties but to also see how this type of subject related anxiety affects their teaching ability (Daker et al., 2021).

These results are critical numbers that reflect how educators feel about the content they are expected to be teaching their students. Research was recently conducted in Pakistan by Hassan (2019) to find that the self-efficacy of educators in Pakistani secondary schools has a strong effect on students' achievement. Similarly, Ross (1995) and Tournaki and Podell (2005) found that when educators believe in themselves as educators and when they believe in their students as learners that expectations can remain high and student success will increase. The data from the current survey suggests that educators have a low self-efficacy for teaching engineering design, which would likely lead to educators not incorporating engineering into their lessons.

4.2.3 STEM in the Schools

To adequately analyze what STEM education looks like in elementary classrooms and what areas of growth there are within the district, it is important to look at how STEM is currently being taught in elementary schools. The first component analyzed within the survey is the frequency the subjects are taught, shown in Figure 6. 30 participants took the survey and four (13%) of those educators did not provide an answer to this section.

Figure 6 Frequency of Teaching Disciplines



In an article published examining the implications of the No Child Left Behind Act regarding science education (Griffith, G., & Scharmann, L., 2008), the authors stated that during a 2006 meeting of the Council of State Science Supervisors a concern was voiced about a decrease in instructional time for science in elementary grades. One issue was stated that several educators reported a required [by administrations or district] decrease in instructional time for science and other academic areas that are not assessed by formal or standardized testing. The authors went on to address the concern of how science builds off the prior knowledge and knowledge gained in previous grade levels experiences. “This cumulative nature is why it is important for students to have an accumulation of knowledge over a number of years. Our research indicates the time needed to provide the foundation layer of this knowledge is being decreased by the majority of the elementary educators" (Griffith, G., & Scharmann, L., 2008, p. 44).

Another study broke down the connection between instructional time spent on science and accountability testing. This study conducted by Eugene Judson (2013) found that more instructional time within a week was devoted to science content in the states that have some type of accountability testing on science. More specifically, more time was allotted to science each week when fourth-grade students' success on a state-mandated science achievement test connected to accountability outcomes, including punitive consequences when students did not perform well on these assessments (Judson, 2013). For the current study, the district has the expectation of science being taught in elementary classrooms and proving this by putting science lessons in their lesson plans. The educators in this study reported that four (13%) indicated they taught science daily, 12 (40%) indicated they taught it weekly, and six (20%) indicated they taught it monthly. Although, over half of the educators surveyed (53%) indicated they taught science standards in their classroom at least weekly, two (7%) indicated they taught it once a month and two others reported they did not teach science at all.

Based on the participants' feelings toward teaching technology and engineering from the previous section of the survey, educators do not feel comfortable or competent with these standards. The data from the survey backs that statement up by outlining how frequently or infrequently the educators are engaging with students in these subject areas. Educators survey responses indicate that eleven (37%) educators do not teach technology to their students, four (13%) educators teach technology less than once a month, two (7%) teach it monthly, four (13%) teach it weekly, and five (17%) teach technology daily to their students. Similar numbers are present for the frequency at which educators are teaching engineering practices to their students. Eighteen (60%) educators do not teach engineering to their students, two (7%) teach it less than once a month, three (10%) are teaching it monthly, one (3%) is teaching it weekly, and two (7%) are teaching it daily. As stated above, when analyzing the educators' feelings toward technology and engineering in regard to their own teaching and the frequency at which these two subjects are taught, a trend is noticeable – that educators need more support in order to teach these subject areas.

When it comes to mathematics, the district has the same expectations as science; that math is to be taught daily. Twenty-one (70%) educators state that they teach math daily to their students, one (3%) educator taught math weekly, one (3%) taught math monthly, and three (10%) do not teach math at all. These educators teach other classes, such as special education, special area classes (art, library, etc.), or their team is departmentalized, meaning they teach one subject area to all the students within that grade level.

The survey also addressed how frequently educators have students engaging in STEM. Three (10%) educators provide STEM opportunities daily, two (7%) educators provide STEM opportunities weekly, six (20%) educators provide STEM opportunities monthly, four (13%) educators provide STEM opportunities less than once a month, and eleven (37%) do not teach STEM at all to their students. Integrated STEM opportunities are valuable learning opportunities for students. The data from this research shows that about 50% of educators who participated in this survey are engaging students in some STEM opportunities in their classrooms.

There are a variety of STEM models that can be implemented in elementary classrooms, so it is important to address how students are provided time to have STEM experiences. One model that many schools chose to follow is providing a STEM Lab as an extracurricular class for students or incorporating STEM as a special area class. Both of these models call for grade levels or classes to attend this class on a rotation throughout the year or semester. Another model that schools could follow would be to departmentalize in each grade level. This would mean the students rotate to different educators who teach different subjects to the class. By participating in these models, educators are ensuring that students are provided specific time in their academic schedule to allow for some type of STEM opportunities. Of the 30 educators who participated in this survey, eleven educators (37%) said there is another educator that teaches STEM content to their students. Four educators (13%) said they are unsure if there is another educator who teaches STEM to their students.

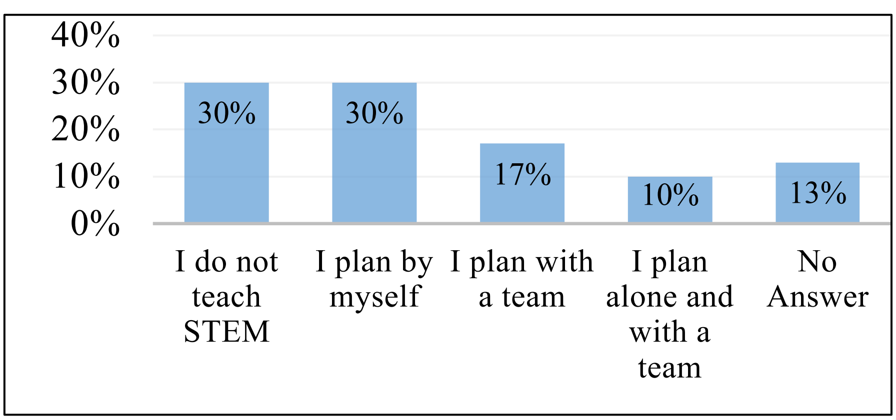
Educators were asked if there is a specific educator in their school who only teaches science or STEM content to all students or a particular group of students. sixteen educators (53%) said yes there is a specific science or STEM educator in their building. Those sixteen educators were then asked which students attended this class. One educator responded that only 4^{th} grade students attend the class. Fifteen educators (50%) responded that all grade levels attend the class. Then educators were asked how frequently students attend this class. Eight educators (27%) said that students attended this class once a week. This follows the traditional special area class model. One educator (3%) said the students attend this class daily. Seven educators (23%) said that the students attend this class one week per month. This could be a STEM lab model where classes rotate to attend this class on a different and unique schedule or this could be a modified special area model where classes attend the same special area for five consecutive days as opposed to having the same special area class on Mondays, the same special area class on Tuesdays, etc. One educator stated in the survey that there are some students who do not attend this science or STEM class but did not elaborate on that when provided an opportunity to do so.

4.2.4 Curriculum and Resources

This section asked for specific curriculum and resources that educators used when planning for STEM opportunities for their students. Of the 30 educators who participated in the survey, twenty-six (87%) responded to the questions in this section. When asked what set of standards educators utilize when planning STEM units, seventeen educators (57%) use Next Generation Science Standards, eight educators (27%) use Kentucky Academic Standards for Math, four educators (13%) use Kentucky Academic Standards for Technology. These standards are the ones outlined by the district that educators must use for lesson planning.

Collaboration is an important factor in successful and efficient education practices. When educators were asked whether they plan STEM experiences for

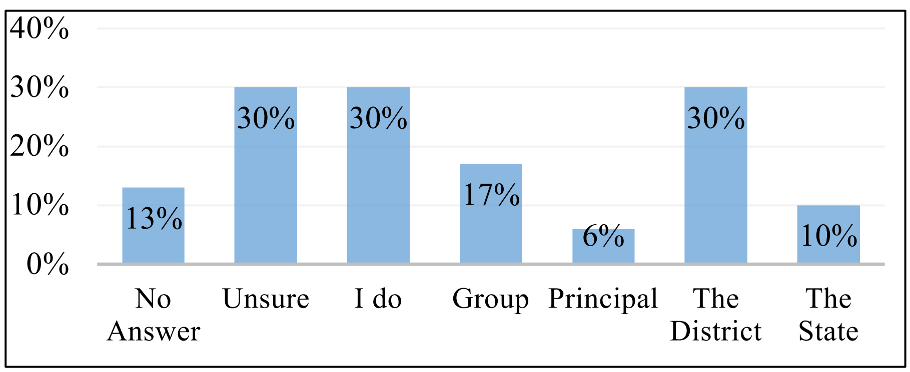
Figure 7 Who Plans STEM Experiences for Students?



their students alone or with a team of educators (Figure 7), nine educators (30%) state that they plan these STEM experiences alone. Five educators (17%) state that they plan these STEM experiences with a team of educators. Three educators (10%) state that they do both, plan alone and plan with a team of educators.

Another component identified in the Curriculum and Resources section of the survey was to find out who determines what resources can be used to teach STEM to their students (Figure 8). As mentioned previously, the district in which the study was conducted is flexible to support how STEM is taught in schools. Nine of the educators (6%) stated that their principal selects the resources, nine educators (30%) stated that the district chooses what resources they can use, three educators (10%) stated that the state chooses the resources, and five educators (17%) stated that a group comprised of these different individuals select the resources. Nine educators (30%) were unsure who determines what resources can be used to teach STEM. There are many factors that go into selecting what resources should be used in the classroom, some of which include the student population, student's prior knowledge, affordability, and how many consumables are involved to name a few. One thing that this district does that is unique is provide every school the opportunity to utilize science kits. These kits are put together by the science department and correlate with NGSS. Schools and educators have the option to

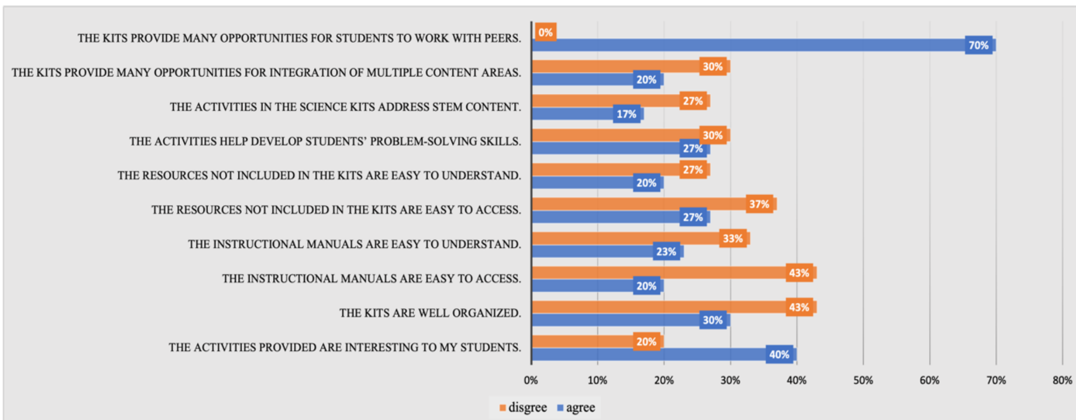
Figure 8 The Person(s) That Determines STEM Resources



opt out of using the district science kit or only utilize a portion of a unit. Ten educators (33%) state that they utilize the district science kits in their classroom to teach STEM. Eight educators (27%) state that they use other resources. Some of these other resources include creating their own units, finding resources online to implement, and using programs such as Code.org, Tinkercad, Minecraft, or Illustrative Math. One educator mentions using an engineering program but does not share the specific program they implement.

This district provides educators with science kits, as mentioned above. Educators were asked to share their opinions and experiences with these science kits, as shown in Figure 9. When asked about the science kits, five educators (17%) do not teach science to students, six educators (20%) do not use the science kits in their class, and fifteen educators (50%) utilize the science kits in their classrooms. The next section of the survey asks educators to respond to their knowledge and opinions regarding the district science kits that are provided to them through the science department. Twelve educators (40%) think that the activities provided in the science kits are interesting to students, while six educators (20%) do not think these activities are interesting to students. Nine educators (30%) think that the science kits are organized, whereas thirteen educators (43%) think that the science kits are unorganized. Six educators (20%) stated that the instruction manuals were easy to access, while thirteen (43%) disagreed with that statement. Seven educators (23%) said that the instruction manuals were easy to understand, with ten educators (33%) stating that they are not easy to understand. eight educators (26%) said that the resources that were not included in the kits but used for the units are easy to access, while eleven educators (36%) said that those resources are difficult to access. Six educators (20%) stated that the resources not included in the science kit are easy to understand while eight educators (26%) stated that they are difficult to understand. Eight educators (26%) said they believe the activities within the science kits help develop students' problem-solving skills, whereas nine educators (30%)

Figure 9 Educator Participant Opinions on District Provided Science Kits



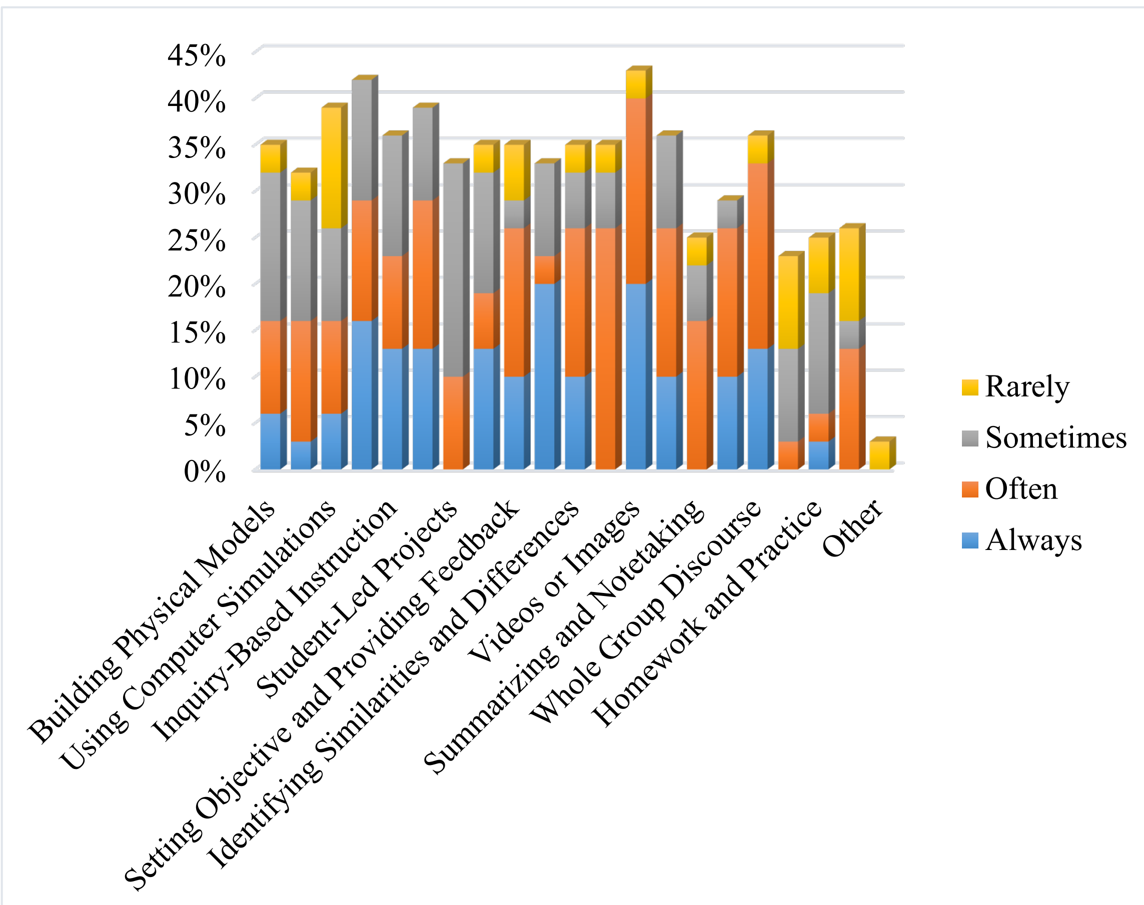
disagree with that statement. Twenty-one educators (70%) agree that the science kits provide many opportunities for students to work with their peers. None of the respondents disagreed with this view. Five educators (16%) stated that they believed the activities in the science kits address STEM, while eight educators (26%) stated that they do not believe the activities address STEM. six educators (20%) said they think the science kits provide many opportunities for the integration of multiple content areas, while nine educators (30%) think the kits do not provide many opportunities for cross-curricular integration.

The information gained from this section of the survey is vital in understanding the motive behind the implementation and understanding of elementary science and STEM within this district. While the district supplies these science kits to all elementary educators, it would seem there is some confusion centering around the ease of use with this resource and the curriculum. The educators who responded to this survey have outlined that the science kits are not organized well, and the instructional material is not easy to access or understand. This could be a factor in why some educators choose not to use the science kits in their classrooms. One positive note from this section is that so many of the educators agree that the science kits provide many opportunities for collaboration for their students. Collaboration and dedicating time in the classroom to allow for students to work together with their peers is an expectation across almost all content areas now, as this is highly integrated in most models of effective teaching and learning strategies. For example, Dean and Marzano's Classroom Instruction that Works (2012) includes cooperative learning, Gregory and Chapman's Differentiated Instructional Strategies (2002) outlines several different grouping methods for cooperative learning in the classroom, and there are even entire cooperative engagement and learning models that allow time for students to work together in different grouping techniques such as the Kagan Strategies (Kagan, S., & Kagan, M., 2009). Collaboration and cooperative learning are a critical part of Thibaut's (Thibaut et al., 2018) and Stohlmann's et al.'s (2012) theoretical frameworks mentioned in section 2.1 "Defining Stem".

4.2.5 Strategies

Educators are life-long learners, and the face of education evolves every year with new students, meaning new tools and strategies to help facilitate learning. When analyzing STEM education, it is important to investigate the strategies that are being utilized in the classroom. The survey, Appendix 1, listed specific research-based strategies for educators to mark which ones they use to teach STEM content and how frequently they utilize the strategy, as shown in Figure 10. This section provides a glimpse into what is currently happening inside elementary classrooms across the district

Figure 10 STEM Strategies and Frequency of Implementation



in regard to which research-based strategies are being implemented. 13 educators (43%) use Cooperative Learning strategies and Videos or Images; 12 educators (40%) use Computer Simulations/Apps and Problem-Based Learning; 11 educators (36%) Build Physical Models, Inquiry-Based Instruction, Differentiation, Setting Objectives and Providing Feedback, Identifying Similarities and Differences, Graphic Organizers, Direct Instruction, and Whole Group Discourse; ten educators (33%) use Physical Models, Student-Led Projects, Reinforcing Effort and Providing Recognition; nine educators (30%) use Small Group Discourse; 8 educators (26%) use Summarizing and Note Taking, Guest Speakers and Experts in the Field, Homework and Practice, and Writing a Scientific Argument; one educator (3%) uses other strategies, but did not identify what strategies they utilize; seven educators (23%) did not answer this section of the survey; nine educators (30%) surveyed noted that they do not teach STEM content to their students.

This snapshot of data provides some interesting insight into gaps that can be occurring throughout the district, when compared to the Next Generation Science Standards. NGSS is the curriculum used by the district and state and NGSS outlines science practices, such as “Developing and Using Models”, “Planning and Carrying Out Investigations”, “Engaging in Arguments from Evidence”, “Obtaining, Evaluating, and Communicating Information”. These practices go hand in hand with some of the strategies listed above. For example, Engaging in Arguments from Evidence can be achieved through having students engage in Writing Scientific Arguments, and Planning and Carrying Out Investigations can be achieved through Student-Led Projects. With that alignment to the standards and science practices, one would hope for more engagement with those strategies than can be seen from the data.

The educators rated the frequency at which strategies were implemented in STEM by using “always”, “often”, “sometimes”, and “rarely”. Figure 10 not only shows the percentage of participants who state that they use those strategies during STEM instruction in their classroom, but Figure 10 also shows how often educators state that they use those strategies. Of the nine educators that utilize small group discourse, three of them do so always when teaching STEM, five of them do so often, and one of them do so sometimes. Of the 11 educators that utilize whole group discourse, four of them do so always when teaching STEM, six of them do so often, and one of them does so rarely. When analyzing the data for these two questions, it was noted that the educators that use small group discourse are also the educators using whole group discourse.

Inquiry-Based Instruction, Problem-Based Learning, and Student-Led Projects are three models of STEM education that are very popular in education. Problem-centered learning (Problem-Based Learning), Inquiry-based learning, and Design-based learning (Student-Led Projects) are three of the five principles of STEM education, according to Thibaut et al.’s theoretical framework (2018). These three models also show up in Stohlmann et al.’s theoretical framework (2012) as well. Inquiry is a classroom practice, as well as posing questions with solving real world, culturally relevant problems that are student centered involved with lesson planning. According to The Inquiry Synthesis Project (D. D. Minner, A. J. Levy, & J. Century, 2010), which studied and synthesized 138 research projects that dealt with the impact of inquiry science on K-12 science education, 51% of their studies showed positive impacts of inquiry education on student achievement. This synthesis showed that students engaged in deeper, active thinking when engaged in Inquiry-Based Instruction. The authors also mentioned that students engaged with many opportunities to experience Inquiry-Based Instruction did statistically better than students who engaged in fewer opportunities with the same experiences. Of the 11 educators in the current study who utilize Inquiry-Based Instruction (IBI), four of those educators always use IBI, three of those educators use IBI often, and four of those educators use IBI sometimes.

Problem-Based Learning (PBL) is not a new concept within education. Commonly, PBL involves teams of students working and learning together to solve realistic problems. This exploration into complex problems allow for students to think critically, form memorable connections, and collaborate with peers. According to Allen, Donham, and Bernhardt (2011), PBL requires the educator to step back from the traditional lecture and lab structure to a facilitator of the problem-solving process while students dive into the role of self-directed learner. With this shift the educator monitors, provide support when students need it, and probe with thought-provoking questions. "The PBL classroom is, after all, a place that is lively with controversy, debate, and peer-to-peer communication-providing both faculty and students with immediate and unmistakable evidence of their competencies and understandings of and about what matters." (Allen et al., 2011, p.27) Of the 12 educators in the current study who utilize Problem-Based Learning, four of those educators always use PBL, five of those educators use PBL often, and three of those educators use PBL sometimes.

Student-led Projects (SLP) is a common part of elementary education. They often are used as culminating experiences at the end of an instructional sequence to extend learning. Students may produce artifacts such as posters, presentations, reports, plays to demonstrate learning. The educators frequently assigns students to groups and may assign a topic for students to investigate. Specific instructions are created by the educators for the students along with rubrics that identify expectations. Students often select groups based on an interest in pursuing a sub-driving question. Students also plan their investigations with feedback from the educator and class peers. Of the 10 educators in the current study who utilize Student-led Projects (SLP), three of those educators use SLP often and seven use SLP sometimes.

The data gathered from educators on these strategies they report are implemented in the classroom, suggests that educators are utilizing student-centered strategies for STEM. More data would be needed here to identify the true purpose and implementation of these strategies and projects in action in their classrooms. For example, observations or collection of student project data could be utilized here for more insight into exactly how these strategies are put to use in the classroom. The data here is promising in that we see some engagement in STEM student project design strategies, even if it has not reached the highest level of implementation.

The participants, whether intentional or not, follow some components of both Thibaut’s (2018) and Stohlmann et al.’s (2012) theoretical frameworks when it comes to their implementation of STEM education. The data suggest that educators in the district are attempting to incorporate some of the key principles within Thibaut’s framework. Specifically, they identified incorporating cooperative learning strategies frequently. There seems to be some degree of the remaining three principles: problem-centered learning, inquiry-based learning, and design-based learning. However, there is a limitation of the survey where educators did not elaborate on their understanding of these terms and activities or explain the full extent of what these might look like in their classrooms. Due to district guidelines for safety during the COVID-19 pandemic, observational data could not be collected from educators at this time. Future studies would benefit from incorporating observations data to support survey data results.

In regards to Stohlmann et al.'s framework (2012), there are some Teaching components present within the district, such as problem solving based, student centered, real world and cultural relevancy within the scope of Lesson Planning, and Classroom Practices such as cooperative learning and inquiry. The Support section of Stohlmann et al.'s (2012) framework is what seems to be lacking from the educators in this district, with only 26% of educators surveyed using vital community resources such as guest speakers or experts in the field. The data is inconclusive as to which framework the educators prefer or know about, but it is evident that the groundwork is present. The educators seem to be working toward the goal of integrated STEM. Educators noted that they may not be actively using the district provided resources, but they are teaching to some degree the STEM disciplines utilizing STEM activities and strategies in their classrooms, with 70% of those surveyed stating that they implement STEM to some degree in their classroom.

4.2.6 Strengths and Challenges

This section of the survey probed participants to identify their own personal strengths and challenges are when it comes to teaching STEM to their students. This is where the educator's self-efficacy and knowledge of the content along with classroom management come together with the expectations from school administrators and district school board. Of the 30 educator surveys, six educators (20%) did not complete this section, two educators (6%) stated that they were unsure or did not feel like they had any strength, two educators (6%) stated that they had interest in the content, seven educators (23%) stated that creating or implementing engaging and hands-on lessons/experiments were a strength in their classroom, 14 educators (46%) stated that specific components of the STEM content was a strength when implementing STEM in their classroom. By breaking these responses up and classifying them based on the main STEM components, five educators (17%) felt that their understanding of the science content or their science background is a strength in their classroom, four educators (13%) felt their knowledge of a variety of technological resources is a valuable asset to their classroom, one educator (3%) said that their ability to implement units with the engineering design process is a strength, and four educators (13%) stated that they believe that their understanding of the math content or their mathematics background is a strength in their classroom. These data shows that there is a foundation of basic concepts in educator's toolkits. The knowledge is present in classrooms every day. The next step would be to take a look at the challenges the educators face that may be hindering the implementation of STEM in their elementary classrooms.

Analyzing the challenges that educators face daily when implementing STEM help to uncover possible barriers limiting educator implementation of STEM in the classroom. Of the 30 educators who participated in the surveys, six chose not to answer the questions and eight educators felt that this question did not apply to them, 15 stated that they had limited time in the classroom, suggesting time allotted to other subjects might be hindering their ability to implement STEM curriculum. Other challenges educators noted were limited access to resources (13 educators). These responses suggest that although the district provides resources to elementary educators, the educators who are attempting to implement STEM may be struggling to find and implement effective and organized resources in their classrooms. In addition, six educators indicated they have limited knowledge of STEM and six educators noted they have limited experience when it comes to implementing STEM. One of the 16 educators who answered the question on challenges also noted that their own knowledge on technology is a challenge. One would hope that educators who fall in these categories will seek Professional Development or Professional Learning Communities (PLCs) that focus on STEM education to gather tools and resources, as well as learn from their colleagues. Other challenges educators noted included student behavioral issues (seven educators), limited support from administration (six educators), and teaching grade levels in which STEM is not tested (five educators). Three educators indicated their schools focused on reading, writing, and mathematics rather than STEM. These data illustrate common challenges educators face in the classroom.

Educators' responses reflect similar challenges reported in previous studies (e.g., Ejiwale, 2013; Margot & Kettler, 2019; Shernoff et al., 2017). Like educators in this sample, a review of the research literature identified pedagogical challenges, curricular challenges, educators' concerns about student behaviors, assessments challenge, and lack of educator support as common barriers to implementing STEM (Margot & Kettler, 2019).

This relates to an educator's management style and the school's protocol for student disruption. A huge factor in STEM education success is having good relationships with students and having students maintain a good relationship with their peers. That includes consequences both positive and negative for any disruptions to educational time. One educator mentioned that having students with disabilities can be a challenge when implementing STEM, six educators noted that they have limited support from administration when it comes to STEM, five educators mentioned that their grade level is not tested on STEM concepts (state standardized testing), and three educators mentioned that their school focuses on other subjects over STEM; reading, math, and writing are focused more than STEM. These numbers paint a picture that some schools within the district are lacking the support and understanding from administrators, whereas if the administrators were encouraging STEM in the classroom and making sure that educators of all grade levels were ensuring their students had STEM experiences in the classroom educators might feel differently about STEM.

All these challenges combined show where educators are struggling and what they need more support with inside the classroom when teaching STEM. This is just a snapshot of a handful of educators in the district who are implementing STEM in their classrooms. The educators who noted that they do not teach STEM in their classrooms can provide valuable information as to what challenges they face and why they do not teach STEM in their classrooms.

At first glance of the data, the numbers are similar, in regard to which challenges the most educators face. These educators said that the following challenges limit their ability to teach STEM in their classroom; limited time (12 educators), limited access to resources (11 educators), limited educator knowledge (eight educators), limited experience teaching STEM (eight educators), student behavior issues (five educators), a focus on other subjects (two educators); reading, math, writing, phonics, and that they only teach social studies and science when it is incorporated with other subject areas, their grade level is not tested by state standardized testing (three educators), special needs students (three educators), limited support from administration (three educators), limited space (one educator).

With time, resources, knowledge, and experience being the leading factors that affect if educators can implement STEM in the classroom, one thing that can be done to encourage more educators involved in the implementation of STEM in the Elementary grades would be to develop professional learning communities centered toward STEM and sciences. According to Schon (1983), educators should engage in on-going, critically reflective teaching. One group of researchers conducted a study to analyze the connection between educator knowledge development and STEM content in a PLC setting (Vossen, Henze, De Vries, & Van Driel, 2019). This qualitative, multi-case study found positive implications in the classroom when research and design are connected inside a classroom through PLCs. There are several different options for what PLCs can look like in a school or a district, which will be discussed later, in the section on recommendations for future research.

4.3 Educator Interview Analysis

In addition to the survey, three educators were interviewed to learn about their views and preferred pedagogies for teaching elementary STEM. The participants come from three different schools within the district and had unique perspectives to share regarding STEM in the district.

Interview #1

This educator is a fourth-grade educator. Her school departmentalizes in grades four and five. She teaches only science to the fourth-grade students. Her school has a technology class that students attend as a special area rotation, which covers robotics, 3-D printing, and coding. She has 15 years teaching experience.

Interview #2

This educator is a first-grade educator. Her school offers a STEM lab for all grade levels. STEM and science are not taught in her classroom, other than a couple units that are heavily integrated with other subject areas. She has 20 years teaching experience.

Interview #3

This educator is a second-grade educator. Her school offers a STEAM lab for all grade levels. She has taught science minimally during her teaching career. She has 8 years teaching experience.

What does STEM education mean to you?

All three of the educators agree that STEM means Science, Technology, Engineering, and Math. Only one educator addressed the integration of the four subject areas to provide a deeper understanding of the skills and concepts for students. The educators shared details about each component in their classrooms or schools if applicable. The three educators have varying opinions on the district-provided science kits. Educator #1 relies heavily on the district science kits to teach science. Educator #2 does not teach science, therefore does not use the district science kits. Educator #3 has used the science kits but not often. The explanation of what technology looks like in the classroom is a basic level of technology, with educators having computers, a SmartBoard, and maybe a class set of iPads. All the educators explained that engineering in elementary is having students work through the engineering process during a unit, traditionally this would be building a structure such as a bridge or a tower. Educator #1 does not teach Math to her students, as they departmentalize, but the other educators are engaging students in math lessons daily.

Why is it important for students to learn STEM?

These educators were asked why STEM is important for their students. They responded by stating that STEM is engaging, teaches critical thinking, problem solving, and exposes students to unique problems. Educator #1 expanded on those thoughts by saying that it is important for students to understand the reasons behind things that happen in the world we live in, such as how your car works and diagnose problems or reasons why the gas prices have increased as a non-renewable resource. They all addressed that in the world we live in today there is a high probability that their students may end up working in the STEM field.

If I walked into your classroom, and you were teaching a STEM lesson, what would I see?

At these three schools, students are engaging in some variation of STEM, although it may not be labeled STEM or a fully integrated STEM model. The educators all agree that a STEM lesson should be hands-on, active, and have students engaging in productive talk with their peers. All three addressed having students in various groups for the lesson and having the educator as a facilitator with all materials ready prior to the beginning of the lesson. Educator #2 mentioned the importance of having students planning, building, then testing and rebuilding to make any improvements.

What kinds of instructional resources do you use when planning your STEM lessons?

The educators addressed using the district science kits, but that does not fully involve all aspects of STEM in every lesson, so adjustments are made, or resources are pulled elsewhere. The educators explain that they may research and find ideas online from educator collaborative sharing websites since there is not a formal STEM curriculum provided by the district. The schools that have specific STEM/STEAM labs have some type of engineering curriculum that either the school has purchased, or the individual educator has purchased.

What kinds of professional development and coursework have you had related to STEM?

These educators have been engaged in very few professional development programs or coursework regarding STEM. Educator #1 has attended the professional development offered by the district. These PD sessions are separated by grade level and cover materials that come in the district provided science kits. During these PD sessions, the facilitators walk educators through the standards and content covered by the unit and provide time for educators to complete activities from the unit to help them see these activities through the eyes of their students. The district has four grading periods and supplies one science kit per grading period. Educator #1 stated that since she has been teaching science at her grade level for so long, she no longer needs this type of professional development as she is very familiar with her grade level standards, content, and kits. Educator #3 also mentioned having attended one of these professional development sessions in the past and she explained that it was very helpful in making sure the educators understood the content and understood the materials provided in the kit. Although Educator #3 stated that her school provides so much professional development in house that she rarely needs to attend district professional development sessions, especially since the incentive to complete these sessions is simply to meet the mandatory 24-hour requirement each year. She noted interest in receiving additional compensation for attending professional development opportunities beyond the 24 hours.

How do you address the specific needs of your students?

The educators all explained that the only way to truly plan for the specific needs of their students was to get to know them; what motivates them, who they work well with, what their levels are, etc. In general, they outlined assessing students and planning for modifications for students who need scaffolding and extra support. Every educator addressed the importance of vocabulary and prior knowledge by stating that they do a lot of front loading or more at the introduction of the lesson. They all outlined using supports such as fill in the blanks, sentence stems, or picture supports when needed. Every educator also mentioned how critical grouping students can be, especially with the varying levels in the class and their female students. Educator #3 stated that she has seen a high number of her female students tend to be shyer and more introverted. She explained that checking on those students and encouraging their participation within their groups is key to their success. Educator #1’s school offers a STEM for Girls group which meets during the school day and in the past has completed a book study and coding, robotics, and conducting experiments, make sure students see themselves represented in the work they complete and make it relatable to their experiences.

All three schools serve English as a Second Language students, which means some if not most of their students speak a different language outside of school. The educators explained that this critically impacts the students' understanding of vocabulary and terminology. Two of the educators stated that they have students from other countries or cultures as well and explained how important it is to allow those students time to share what experiences they can bring to the classroom.

One educator stated that their school grouped students in an “AP” class that allowed for the more advanced students to be in that class. Another educator expressed what it was like to teach non-readers and explained how difficult it can make STEM, much less any lesson since those non-readers need picture supports or directions to be read to them which means they are losing some independence during their activities. She also explained that the key is to find the sweet spot where students fall in the Zone of Proximal Development; meaning the work is challenging without pushing a student to the point of frustration.

What are your strengths when implementing STEM in your classroom?

The educators list planning hands on investigations, differentiating for students, flexibility and balancing the controlled chaos including having different groups of students in different stages of investigation within their classroom as some strengths. Educator #3 expressed her most valuable strength in regard to STEM education as understanding the science content. She had a background of chemistry and biology as she is certified to teach middle school science.

What are the challenges you face when implementing STEM in your classroom?

Educator #1 explained a huge challenge for her is access to resources including the increasing cost of technology. She explained that there are grants or workshops that educators can complete within the community and some of those from community stakeholders offer free resources to educators after completion. These do typically require educators to take time outside of their workday or use their personal time to complete.

Educator #2 outlined a huge challenge she faces in the classroom, which is the focus on other subjects. She said there is not enough time in the day to do it all and explained there have been times in her career where a lesson was moving, and students were immersed in it but as an educator you have to stop in order to change subjects because you have to hit all the essentials in a day. She said this was her experience with science in the past. She also explained that a challenge she sees with STEM is that you need to have all materials ready and available for students, which takes time outside of instruction and then space in order to keep materials in the classroom whether it is to store them when you are not using them or to keep them out and accessible during the time of the investigation.

Educator #3 shared her list of challenges which include limited time, limited experiences with STEM, limited access to resources that truly involve STEM and not just science, and little to no PD/trainings within the district. She went on to explain what she meant by limited time within the classroom, explaining that time gets chipped away with transition time, such as bathroom breaks, the playground being on the other side of the campus, moving the class from place to place, and the time it takes to complete STEM investigations. She explained that sometimes you can't rush these investigations, or they have time sensitive variables that you can't just let sit on the desk during a special area or overnight.

The educators then shared how they could overcome these obstacles. All three educators agree that one solution to solve the challenges and problems they have experienced in schools would be to have a specific STEM curriculum and dedicated materials that are provided to educators or money allocated from schools specifically to help educators acquire STEM resources and supplies. These educators expressed that there are funds out there or materials they could purchase themselves, but that is a lot of time and money on their part. Educator #3 stated that in a perfect world she could purchase things like that for her class or at least have easier access to reimburse educators for the material and supplies they purchase for their classroom. The educators all agreed having designated PD opportunities that covered STEM specifically would be good for the district but acknowledged that those PD sessions may be out there already, and they have missed them or aren't seeking them out. Educator #1 discussed that during the last school year she was in contact with another fourth-grade science educator from a different school within the district. They began organically working together almost in a Professional Learning Community (PLC). The idea of providing on-going guidance and support throughout the school year including ensuring educators to work in a PLC group that focused on STEM is something that Educator #3 discussed as well.

Educator #2 stated that allowing kids to learn at their own pace with support and reassurances but balancing that with the kids who already have it and need to move on to the next thing before they get bored is a struggle, especially on a strict schedule. One factor that she states that can combat that is using designated time to provide students the specific support or enrichment they need. She explained something called WIN Time (What I Need Time) that is based on assessments or baseline data. During WIN Time students are grouped based on similar gaps in their understanding or similar mastery levels on certain skills. Those groups are then given practice, extra lessons, supplemental activities, or independent studies based on what they need on the assessments or data.

Is there anything else you want to tell me about your experiences with teaching STEM?

Educator #1 stated that something she would need to be more successful with implementing STEM in her classroom would be smaller class sizes. She stated that this would be helpful in every subject, in every grade level, and help in all aspects of classroom management. Educator #3 also mentioned the importance of class sizes in regard to her experiences during the last school year. She explained the benefits she saw when she had less than 15 students each day, such as providing more one-on-one time to work with students and quicker transitions which in turn allow for more time to complete investigations in the classroom.

Educator #1 mentioned her thoughts on pre-service programs and on-going education in regard to STEM education. She mentioned wanting colleges to better prepare educators for implementing STEM in their classroom. She recognized that a lot of elementary education programs cover the basics in subject areas but don't go in depth with specific subjects and she mentioned that some colleagues of hers received a bachelor's degree in a different field and then received a master's in education or literacy or fall into this career with little to no background in STEM. She also explained how vital observations and collaboration among educators is when it comes to on-going learning by educators. She said that by allowing educators to see what others are doing in their classroom or meeting to discuss specific goals, they can share what works, what doesn't work, share new ideas, and encourage colleagues. She understood that ensuring that something like that is readily available to educators means time and money as well as logistically planning and ultimately taking an educator out of their classroom during their instructional time, which means planning for substitutes or classroom coverage. Educator #1 had one last thing to say about STEM education in elementary schools and that is what she sees happening in schools is a disservice to the students. She said that after whatever minimal exposure they have to STEM (and science), the students then go on to middle and high school and are "thrown into it". She said that she wishes there was space and time dedicated to vertical alignment between elementary educators with middle and high school educators, where elementary educators could ask what the most vital standards are that they need students to come in with an understanding, including what vocabulary they need.

Educator #2 shared that she has seen her students very enthusiastic about STEM. She shared some positive experiences she has seen from her students. She explained that in the beginning of the year the STEM Lab educator and the homeroom educators for her grade level collaborate on a plant unit. She stated that her students bring their knowledge back to the classroom and with them on their first field trip of the year, a farm, and even at recess. She also shared similar happenings with a big unit on shadows. Over the course of her teaching career, she has seen high interest and enthusiasm from students in STEM concepts at her current school with a STEM Lab, compared to the schools she has been at with no STEM Lab.

Educator #3 shared that she thinks that elementary schools should teach STEM more often. She went on to share her own experiences with science starting at a young age. Teaching at an inner-city school, she recognizes that she was able to experience science at home and in her community, where-as her students do not have the same life experiences outside of the classroom. She feels that her school, along with several others in the district, just don't have time due to behavior problems or the focus on reading. She expressed understanding of how critical it is for students to be able to read and in a school like hers, many students are behind grade level in reading. She stated that students must be able to read to understand and learn the other subject areas. She mentioned how supportive her principal is; that her administration understands why her time is divided like it is among the subjects, but that they also are starting to encourage educators to implement STEM by asking for the upcoming school year what STEM specific resources or materials they need.

CHAPTER 5. DISCUSSION, CONCLUSION, AND IMPLICATIONS

This study explored the preparedness and experiences of elementary educators to teach STEM in a large urban school district in the southeastern United States. The overarching research question guiding this study was, "How prepared are in-service elementary educators to teach STEM education in their classrooms?" Five sub-driving questions framed the data collection and analysis for this study. They include: 1) How did the educator's education, preservice and professional development, address STEM education? 2) How confident do elementary educators feel teaching STEM in their classrooms? 3) What pedagogies do elementary educators prefer when teaching STEM education? 4) What teaching strategies do educators identify they are utilizing when implementing STEM? 5) How do the views of elementary educators regarding STEM compare across the district? The answers to these questions are discussed in this chapter in the context of educators to the survey and interviews. The remaining sections of the chapter present the conclusions and implications of the results and identify limitations of the study.

5.1 Discussion

This study aimed to analyze the perceived preparedness of elementary educators in teaching STEM. The researcher's second hypothesis addressed this by stating that most educator education programs do not offer more than a basic understanding of STEM or its disciplines and there are a few PD opportunities throughout an academic year but that educators are not engaging in those sessions. Looking at the data from the educator survey and the analysis of the results suggest that the educator's education does not fully prepare them to teach STEM on the elementary level. Of the 19 participants (63%) who received a degree in education, 13 participants (68%) did not have any preparatory coursework in STEM or STEM disciplines. Majority of participants earned a broad education degree, elementary education to be specific. This means that the educator's step into their own classroom on day one of their career unprepared to teach STEM to their students. Looking into the educator's professional development history, we see a similar trend; with a little over half of the participants having had little to no PD sessions that covered STEM topics. This means that educators come into the profession unprepared to teach STEM content, then they are not seeking out or required to participate and learn current STEM curricula or methods. The data supported Hypothesis 2: Elementary educators in the district that were surveyed indicated they have little training to teach STEM topics.

This study also aimed to find common themes among the educators in regard to their perceived confidence in teaching STEM to their students. Based on the data from the survey, the participants felt fairly confident in teaching most of the STEM disciplines to their students, with the exception of teaching engineering. While the educators may have felt confident in teaching, they did not feel the same with preparation. Math and science are rated higher by participants than technology and engineering. During the educator interviews, all three participants stated that they feel unprepared to teach at least one component involved in STEM due to a lack of training or preparation. Educator #2 stated that if she had training, she would feel more comfortable attempting to include engineering in her lessons. This shows a huge gap in elementary STEM teaching across the district, educators perceived confidence in teaching technology and engineering.

This study sought to identify the pedagogy behind participants who implement STEM in the district. Three theoretical frameworks were described in the literature review chapter: Mpofu's (2019), Thibaut et al, (2018), and Stohlmann, Moore, and Roehrig (2012). There are strong similarities between each of these frameworks, but they are uniquely different as well. Mpofu's framework details the level of STEM disciplines integration with each other and other subject areas, Thibaut's framework focuses on what key principles should be included when STEM curricula is selected or created, and Stohlmann et al.'s framework dives deeper into criteria selection for STEM curricula by including supports outside the classroom, what happens in the classroom, educator efficacy, and materials needed for success. Based on the educator surveys and educator interviews, most of the participants who implement STEM to some degree reported following a level in Mpofu's theoretical framework. This framework allows educators to fall into different levels of STEM implementation from Level 1 S-T-E-M to Level 5 SMATE (STEAM as it is more commonly known in the United States). There is some evidence of Thibaut et al.'s framework being present within the district by analyzing the units that educators are implementing. Thibaut's five principles showed up in this study when educators shared which strategies they implement and what they expect to see during a STEM lesson, such as collaborative work and design-based learning. The researcher's third hypothesis states that educators who teach STEM view themselves as a facilitator, while the educators who do not teach STEM view themselves as the one possessing and passing on knowledge. This hypothesis is rejected based on educators' survey responses. Specifically, participants shared that they are using inquiry-based instruction, problem-based learning, and student-led projects in the classroom. These strategies are key in allowing students to guide their own learning. However, these are self-reported data. Further study is needed that includes classroom observations of educators during STEM units to learn how closely their implemented instructional strategies match those they reported in the survey.

The researcher's first hypothesis addressed the strategies educators most often utilized in STEM instruction, by stating that every individual educator must use their own pedagogy to understand what STEM education is. The hypothesis was that over half the educator's would view STEM as stand-alone subjects (Mpofu's first level) rather than full integration of all disciplines (Mpofu's fourth and fifth levels). This hypothesis is rejected due to the fact that participants were able to explain that STEM is most effective when the disciplines are integrated. Educators on the survey showed an understanding of the difference between teaching science and teaching STEM. However, observational data is needed to provide evidence that the level(s) of integration of disciplines is implemented in educators' STEM instruction.

This study aimed to collect and compare elementary educator's views towards STEM education. The district mandates that science instruction should happen daily in elementary classrooms, or at least weekly. Participants reported the frequency at which they teach each discipline and STEM, which showed that most participants are engaging students in math (77%) and science (73%) at least monthly in their classroom. Only a few participants are engaging students in technology (37%) and engineering (20%) and STEM (37%) at least monthly in their classroom. The researchers fourth hypothesis stated that less than half of the educators are implementing STEM in their classrooms. This hypothesis is supported with these numbers.

Analyzing the educator's perceptions of their strengths and challenges also provides valuable insight into their views and self-efficacy. The participants in this study provided their strengths when teaching STEM in the survey. The researcher found it interesting that 13 participants did not provide a strength or did not know what their strength was in regard to teaching STEM. This suggests that 13 of the 30 educators surveyed do not feel that they have any strengths in regard to STEM, including general educator skills such as lesson planning, assessment, organization, etc.

The participants had several more challenges to share, although six participants did not respond to these questions. Limited time and limited access to resources were the most commonly reported challenges that educators face when implementing STEM. The participants who do not implement STEM in their classroom shared what barriers prevent them doing so such as limited access to resources, limited knowledge, and limited experience. It is intriguing to note that both subgroups of participants (those who teach STEM and those who don't) responded that limited access to resources is a barrier.

The district in which the surveyed elementary educators work provides them with science kits as a way to support science and STEM being taught in the elementary grades. Educators were asked to give honest feedback on the effectiveness and ease of access of the science kits. The majority of participants noted that the science kits spark interest within students and that they provide many opportunities for peer-to-peer collaboration. However, a majority of participants also noted that the kits are unorganized, instructional materials and resources outside the kit are difficult to access, and the resources are difficult to understand. The majority of participants also shared that the kits do not develop a student's problem-solving skill, do not provide many opportunities for cross-curricular integration embedded in the lessons, and the kits do not address STEM as a whole. This could explain why when asked if they utilize the science kits in their classroom, 36% of participants did not respond or stated that they do not utilize the science kits.

There were some unexpected results that occurred during this study. One challenge listed by educators who do teach STEM and those who do not teach STEM was an emphasis on other subjects. These educators reported they feel that subjects such as reading, math, writing, and phonics take precedent over science (one educator even mentioned social studies also). Similar to the findings in the study by Griffith and Scharmann (2008), one educator mentioned they attempt to overcome this obstacle by imbedding science (and social studies) into other subjects throughout the day. Another surprising bit of data was that 11 educators reported that there is another educator in their grade level that teaches STEM content to their students and 16 educators reported that their school holds an educator who only teaches science or STEM content to students. A follow up question that the researcher would love to be able to ask the participants in the survey would be "Do schools that have a designated STEM (or science) educator mean educators should not try to incorporate STEM into their own classrooms?"

5.2 Limitations

There are a few limitations that existed in this study. First the number of participants in this study, 30, is just a small sampling of the entire district. The district serves over 90 elementary schools, and with each elementary school having multiple educators in grades K-5, 30 is just a small fraction of the educators currently working within this district. When analyzing the answers provided in the survey, blank answers were noted in different sections by different participants. It is unknown if these blank answers were due to a technological error or if a participant was unsure how to answer a question.

There is also some degree of differentiation in how educators interpret questions on the survey. For example, the questions regarding the science kits allow for participants to respond one of five ways (Strongly Agree, Agree, Neither Agree nor Disagree, Disagree, Strongly Disagree). These answers are subjective and difficult for participants to explain why they “strongly” disagree versus just disagree with a statement, or if a participant feels indifferent about a statement they could choose “Neither Agree nor Disagree”. When responding to the section about the district science kits, if educators have not attended the PD provided by the science dept or implemented the kits for a full unit (meaning they may have pick and chosen a couple of lessons out of the entire unit to use) that may have some effect on their understanding of the kits.

Throughout the survey the same educators marked “I don’t teach stem” in one question and then reported teaching STEM in another answer choice on the survey. For example, on Question #10 “How frequently do you teach STEM?”, 11 educators selected “Not at all”, but then on Question #16, “Which set of standards do you use when teaching STEM?”, nine educators selected “I do not teach STEM.” When analyzing the results, it should also be noted that the participants who selected whole group discourse as an instructional strategy that is utilized in their classroom, are also the same participants who selected small group discourse as well, suggesting that these educators implement both small group and whole class discourse strategies. Lastly, the data from this study address educator’s perceptions and opinions, not what is observed happening inside the classroom. Due to the time constraints and district policies during the COVID-19 pandemic, classroom observations were not an option for this study.

5.3 Conclusion

This study aimed to answer the question "How prepared are in-service elementary educators to teach STEM education in their classrooms?" Given the sampling of educators from 10 of the district's 91 elementary schools, it seems that elementary educators feel knowledgeable on what STEM education is and how vital it is for their students to be engaged in STEM opportunities, but many are not following an integrated STEM theoretical framework. Many elementary educators reported not teaching STEM in their classrooms. There are many reasons for the lack of STEM across the district's elementary schools, but there are two huge factors that limit the implementation of STEM across the district; educators are not prepared or equipped to teach STEM to their students and educators do not feel that they have enough time to hit all the targets they need to for every subject they are responsible for teaching.

5.4 Recommendations for Future Research

Taking the information gained from this research, there are several things that can be implemented moving forward. One area of future research that can be conducted would be to survey elementary aged students and gain perspective on their feelings and attitudes toward STEM education experiences and the frequency of their experiences. Another aspect of future research could be to compare a specific educator's efficacy with their students' success to see any correlation between those two factors. The district could also put a focus on making sure educators are ready to teach STEM education in their grade level by providing resources, professional development, and ensuring enough support for educators throughout the school year. Specifically looking at how educators feel in regard to STEM disciplines, there is a definite need for support in elementary classrooms to ensure that educators understand and can implement the engineering standards effectively.

A thorough investigation into the Professional Development sessions attended by elementary educators in this district could provide valuable information to guide the district in their goals for elementary educators for years to come. If the entire district's elementary educators were surveyed or records were pulled to categorize and analyze which PD sessions were most commonly attended and which were not, one might see gaps that can be addressed. Based on the responses from participants in this study, educators may not be aware of the PD opportunities regarding STEM education, especially in elementary grades. By getting to the root of how elementary educators chose which PDs to attend could help plan for future STEM PDs with the expectation of higher attendance of elementary educators.

Looking at the frequency in which the subjects are taught by educators who participated in the survey there is a need to provide knowledge, resources, and on-going support for elementary educators in regard to engineering (only 27% of educators are teaching engineering to students). Even though 50% of educators say they are providing technology experiences and STEM opportunities in the classroom, there is still a need to ensure educators have the tools necessary to provide more frequent learning opportunities for students. One strategy that might help with the frequency of STEM implementation would be to have district leaders work with pilot schools to create integrated thematic units that intertwine STEM with other subjects for grade levels.

To further gather research on the district's STEM education in elementary schools, an analysis of student achievement would be beneficial. This could take the form of looking into the strategies implemented for a specific grade level and unit by tracking throughout the year, then analyzing the students' understanding and achievement of those skills by use of a common assessment or standardized test district wide. This assessment or test could be given to classes participating in the study and classes that are not participating in the study for comparison. The working hypothesis would be that certain researched based strategies would provide students with a deeper understanding of the skills and knowledge within a unit.

It would be interesting to take a look at the units these educators implement that engage students in strategies such as Inquiry-Based Instruction, Project-Based Learning, and Student-Led Projects. An analysis on the effectiveness of these units that are being implemented on the elementary level would provide great insight but analyzing which standards and science or engineering practices these units are implemented with, and which grade levels are engaging in these units would be insightful as well. This could provide an opportunity for the district to analyze what areas could be focused on to encourage more involvement in elementary classrooms across the district.

Implementing Professional Learning Communities could help remove some of the barriers hindering an educator's ability to effectively implement STEM in their classroom. By setting up a true collaborative PLC educators can conduct observations, review student work, learn together what works and what doesn't work. PLCs could be set up in a couple different ways. They could involve a couple representatives from each school or better yet one from each grade level. They could meet as vertical teams within the school, meaning one educator from each grade level is on this team or they could meet with other educators of the same grade level from different schools. This could also take the form of a collection of educators meeting with someone from the district's science department. Involving administrators and curriculum coaches in PLCs or in training would also be a great way to improve the implementation of STEM in elementary schools. Based on the prevalence of mathematics and literacy instruction in the elementary grades and de-emphasis on science and social studies, having administrators and curriculum coaches encouraging and expecting educators to incorporate STEM, science and even social studies in their daily instruction could only lead to a higher rate of implementation.

In all of these recommendations there are a few ideas that continue to pop up: educator observations, sharing knowledge, and sharing resources. The researcher understands from her own experiences in an elementary school setting that time is of the essence and coverage for classrooms often is difficult to find. Even so, prioritizing the sharing of knowledge and tools through whatever means possible is the best way for educators to learn. Educators who sit in a fellow educator's classroom and observe what STEM looks like for that educator will walk out with at least one new strategy to implement in their own classroom, and often it is several ideas to bring to their own classroom. These observations could take place during the school day if administrators supported this and ensured educators had the resources available in order to step out of their own classroom and into a colleague's classroom. To prioritize educator's sharing is to prioritize student achievement.

APPENDIX 1. EDUCATOR SURVEY AND RESPONSES

STEM Research Survey

How prepared do you feel to teach each of the major disciplines within STEM (e.g., science, technology, engineering, mathematics) to students?

	Not Prepared	Somewhat Prepared	Very Prepared
Preparedness to teach science at your grade level(s)	○	○	○
Preparedness to teach technology applications at your grade level(s)	○	○	○
Preparedness to teach engineering design at your grade level(s)	○	○	○
Preparedness to teach mathematics at your grade level(s)	○	○	○

How confident are you in teaching to students each of the major disciplines within STEM (e.g., science, technology, engineering, mathematics)?

	Not Confident	Somewhat Confident	Very Confident
Confidence in teaching science at your grade level(s)	○	○	○
Confidence in teaching technology applications at your grade level(s)	○	○	○
Confidence in teaching engineering design at your grade level(s)	○	○	○
Confidence in teaching mathematics at your grade level(s)	○	○	○

How many hours of Professional Development that you participated in over the last four academic years addressed teaching STEM in some way?

○ None

○ 1-2 hours

○ 3-6 hours

○ 7-18 hours

○ 19-30 hours

○ More than 30 hours

How many undergraduate level courses have you taken in the STEM disciplines?

◯ 0 classes

◯ 1-2 classes

◯ 3-4 classes

◯ 5 or more classes

How many graduate level courses have you taken in the STEM disciplines?

◯ 0 classes

◯ 1-2 classes

◯ 3-4 classes

◯ 5 or more classes

What is your undergraduate degree? Include the degree and any majors or minors you earned.

____

What other college degrees have you earned? If none, write "N/A".

____

Do you have any STEM certificates or endorsements? If yes, what are they?

◯ Yes ____

◯ No

How often do you teach each of the following subjects?

	Not at all	Less than Once a Month	Monthly	Weekly	Daily
Science	○	○	○	○	○
Technology	○	○	○	○	○
Engineering	○	○	○	○	○
Mathematics	○	○	○	○	○
STEM	○	○	○	○	○

Does another teacher in your grade teach STEM content to your students?

○ Yes

○ Unsure

○ No

Is there a teacher in your school that only teaches science or STEM?

○ Yes

○ No

Which students attend this teacher's classes? Mark all that apply.

- ☐ All grade levels
- ☐ Kindergarten
- ☐ First Grade
- ☐ Second Grade
- ☐ Third Grade
- ☐ Fourth Grade
- ☐ Fifth Grade
- ☐ Only Gifted and Talented Students

What is the frequency that the students visit this class?

- ○ Daily
- ○ About once a week
- ○ About one week each month
- ○ One quarter
- ○ One semester

Are there some students that do not attend this class? If yes, please explain.

- ○ Yes ____
- ○ No

Which set of standards do you use when planning STEM units for your students? Mark all that apply.

- ☐ Next Generation Science Standards (NGSS)
- ☐ Kentucky Academic Standards - Mathematics
- ☐ Kentucky Academic Standards - Technology
- ☐ Other: ____
- ☐ I do not teach STEM

Indicate the persons or groups who helped determine what resources you use to teach STEM. Mark all that apply.

- ☐ I do
- ☐ The principal
- ☐ A group of teachers from my school
- ☐ The district
- ☐ The state
- ☐ Other (please list): ____
- ☐ I am unsure

What resources do you use to teach STEM?

- ◯ District Science Kits
- ◯ Other (please list them): ____
- ◯ I do not teach STEM

When planning STEM experiences for your students, do you plan activities by yourself or with a group of teachers?

- ◯ I do not teach STEM
- ◯ I plan myself
- ◯ I plan with a team
- ◯ I plan alone and with a team

The district provides teachers with science kits to teach the elementary science curriculum. Do you utilize the science kits in your classroom?

- ◯ Yes
- ◯ No
- ◯ I do not teach science

Reflect on the science kits that are provided to your classroom. Please respond to each statement by selecting the most appropriate answer choice based on your experience with the science kits.

If you are a special area teacher or a classroom teacher who does not currently utilize the science kits, but have used them in the past four years, please answer based on your previous experiences with the kits.

If you have never utilized the science kits in your classroom, please note that by selecting "Strongly Agree" for the statement "I have never utilized the science kits in my classroom" and then proceed to the next question.

	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree
I have never utilized the science kits in my classroom.	○	○	○	○	○
The activities provided are interesting to my students.	○	○	○	○	○
The kits are well organized.	○	○	○	○	○
The instructional manuals are easy to access.	○	○	○	○	○
The instructional manuals are easy to understand.	○	○	○	○	○
The resources not included in the kits are easy to access.	○	○	○	○	○
The resources not included in the kits are easy to understand.	○	○	○	○	○
The activities help develop students' problem-	○	○	○	○	○

solving skills.					
The kits provide many opportunities for students to work with peers.	○	○	○	○	○
The activities in the science kits address STEM content.	○	○	○	○	○
The kits provide many opportunities for integration of multiple content areas.	○	○	○	○	○

What strategies do you utilize when teaching STEM? How often do you use each strategy?

If you are a special area teacher or a classroom teacher who does not currently teach STEM, but have taught STEM in the past four years, please answer based on your previous experiences with teaching STEM.

If you have never implemented STEM in your classroom, please note that by marking the box in column 1 for the statement "I have not taught STEM", then proceed to the next question.

	Mark all strategies you utilize when teaching STEM.	Select the most appropriate response for how often you utilize this strategy for teaching STEM.			
		Rarely	Sometimes	Often	Always

I have not taught STEM					
Building Physical Models					
Using Physical Models					
Using Computer Simulations/Apps					
Cooperative Learning					
Inquiry-Based Instruction					
Problem-Based Learning					
Student-Led Projects					
Differentiation					
Setting Objective and Providing Feedback					
Reinforcing Effort and Providing Recognition					
Identifying Similarities and Differences					
Graphic Organizers					

Videos or Images	☐	○	○	○	○
Direct Instruction	☐	○	○	○	○
Summarizing and Note Taking	☐	○	○	○	○
Small Group Discourse	☐	○	○	○	○
Whole Group Discourse	☐	○	○	○	○
Guest Speakers/Experts in the Field	☐	○	○	○	○
Homework and Practice	☐	○	○	○	○
Writing a Scientific Argument	☐	○	○	○	○
Other: (Please explain)	☐	○	○	○	○

What are your strengths when implementing STEM in your classroom?

____

What are the challenges you face when implementing STEM in your classroom? Mark all that apply.

- ☐ Limited time
- ☐ Focus on other subjects. Please list: ______________________________
- ☐ Limited knowledge
- ☐ Limited experience
- ☐ Behavior issues
- ☐ Limited access to resources
- ☐ Science/STEM is not tested at my grade level
- ☐ I teach special needs students
- ☐ Limited support from administrators
- ☐ Other: (Please list) ____
- ☐ I do not teach STEM

If you do not teach science or STEM, what challenges limit your ability to teach these subjects? Mark all that apply.

- ☐ Limited time
- ☐ Focus on other subjects. Please list: ________________________________
- ☐ Limited knowledge
- ☐ Limited experience
- ☐ Behavior issues
- ☐ Limited access to resources
- ☐ Science/STEM is not tested at my grade level
- ☐ I teach special needs students
- ☐ Limited support from administrators
- ☐ Other: (Please list) ____

How many years teaching experience do you have?

____

What grade levels have you taught? Mark all that apply.

- ☐ Kindergarten
- ☐ First
- ☐ Second
- ☐ Third
- ☐ Fourth
- ☐ Fifth

What are the grade levels in your school? Mark all that apply.

- ☐ Kindergarten
- ☐ First
- ☐ Second
- ☐ Third
- ☐ Fourth
- ☐ Fifth
- ☐ Other: (Please list) _______________________________

In what school do you teach? (Optional):

____

What is the student population of your school?

- ○ 0-100
- ○ 101-250
- ○ 251-400
- ○ 401-600
- ○ More than 600

What ethnicities are represented in your school population? Mark all that apply.

- ☐ Hispanic or Latino or Spanish Origin of any race
- ☐ Native American or Alaskan Native
- ☐ Asian
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ Black or African American
- ☐ White
- ☐ Two or more races
- ☐ Other

What percentage of your school student population is female?

◯ 0-25%

◯ 26-50%

◯ 51-75%

◯ 76-100%

What percentage of your student population receives free and reduced lunch?

◯ 0-15%

◯ 16-35%

◯ 36-50%

◯ 51-70%

◯ 71-90%

◯ 91-100%

What is the student to teacher ratio in your classroom: ___:1

____

What is the percentage of special education students in your classroom? (developmentally delayed, functional mental disability, mild mental disability, or other cognitive disabilities)

◯ 0-15%

◯ 16-35%

◯ 36-50%

◯ 51-70%

◯ 71-90%

◯ 91-100%

Thank you for completing this survey.

If you would be willing to participate in a brief virtual interview on teaching STEM at the elementary level, please include your contact information below.

- ☐ Name: ____
- ☐ Email: ____
- ☐ Phone Number: ____

Participants' Responses to the Survey

How prepared do you feel to teach each of the major disciplines within STEM (e.g., science, technology, engineering, mathematics) to students?

	Preparedness to teach science at your grade level(s)	Preparedness to teach technology at your grade level(s)	Preparedness to teach engineering design at your grade level(s)	Preparedness to teach mathematics at your grade level(s)
Very	20%	17%	10%	63%
Somewhat	57%	50%	17%	27%
Not at all	13%	23%	63%	0%
No Answer	10%	10%	10%	10%

How confident do you feel to teach each of the major disciplines within STEM (e.g., science, technology, engineering, mathematics) to students?

	Confidence in teaching science at your grade level(s)	Confidence in teaching technology applications at your grade level(s)	Confidence in teaching engineering design at your grade level(s)	Confidence in teaching mathematics at your grade level(s)
Very	27%	27%	10%	53%
Somewhat	50%	30%	20%	37%
Not at all	13%	33%	60%	0%
No Answer	10%	10%	10%	10%

How many hours of Professional Development that you participated in over the last four academic years addressed teaching STEM in some way?

0	23%
1-2	17%
3-6	23%
7-18	27%
19-30	0%
More than 30	0%
No Answer	1%

How many undergraduate level courses have you taken in the STEM disciplines?

0	47%
1-2	20%
3-4	17%
5 or more	6%
No Answer	10%

How many graduate level courses have you taken in the STEM disciplines?

0	60%
1-2	20%
3-4	7%
5 or more	3%
No Answer	10%

What is your undergraduate degree? Include the degree and any majors or minors you earned.		What other college degrees have you earned?		Do you have any STEM certificates or endorsements?		If yes, what are they?
Other than education	27%	Other than Education	6%	Yes	3%	middle school math
Early Childhood	10%	Early Childhood	0%	No	87%	
Special Education	10%	Special Education	13%	No Answer	10%	
Science	6%	Science	0%			
English	13%	English	13%			
Math	13%	Math	6%			
Arts	3%	Arts	0%			
No Answer	10%	Technology	3%			
		Teacher Leader	10%			
		Administration	6%			
		Curriculum and Instruction	3%			
		No Answer	10%			

How often do you teach each of the following subjects?

Science		Technology		Engineering		Mathematics		STEM	
Not at All	7%	Not at All	37%	Not at All	60%	Not at All	10%	Not at All	37%
Less than once a month	7%	Less than once a month	13%	Less than once a month	7%	Less than once a month	0%	Less than once a month	13%
Monthly	20%	Monthly	7%	Monthly	10%	Monthly	3%	Monthly	20%
Weekly	40%	Weekly	13%	Weekly	3%	Weekly	3%	Weekly	7%
Daily	13%	Daily	17%	Daily	7%	Daily	70%	Daily	10%
No Answer	13%	No Answer	13%	No Answer	13%	No Answer	13%	No Answer	13%

Does another teacher in your grade teach STEM content to your students?		Is there a teacher in your school that only teaches science or STEM?		Which students attend this teacher's classes? Mark all that apply.	
Yes	37%	Yes	53%	All Grade Levels	50%
Unsure	13%	No	33%	Fourth Grade	3%
No	37%	No Answer	13%	No Answer	47%
No Answer	13%				

What is the frequency that the students visit this class?		Are there some students that do not attend this class? If yes, please explain.		Are there some students that do not attend this class? If yes, please explain.
Daily	3%	Yes	3%	(Left Blank)
Once a Week	27%	No	50%	
One week a month	23%	No Answer	47%	
One Quarter	0%			
One Semester	0%			
No Answer	47%			

Which set of standards do you use when planning STEM units for your students? Mark all that apply.	
Next Generation Science Standards	57%
Kentucky Academic Standards - Math	27%
Kentucky Academic Standards - Technology	13%
Other	0%
I do not teach STEM	30%
No Answer	13%

Indicate the persons or groups who helped determine what resources you use to teach STEM. Mark all that apply.	
I do	30%
Principal	6%
A group of teachers from my school	17%
The District	30%
The State	10%
Other	0%
Unsure	30%
No Answer	13%

What resources do you use to teach STEM?	
District Science Kits	33%
Other	27%
I do not teach STEM	27%
No Answer	13%

What resources do you use to teach STEM? - Other (please list them):	
create own	6%
found online	20%
illustrative math	3%
code.org	3%
Minecraft	3%
Tinkercad	3%
engineering program	3%

When planning STEM experiences for your students, do you plan activities by yourself or with a group of teachers?	
I do not teach STEM	30%
I plan by myself	30%
I plan with a team	17%
I plan alone and with a team	10%
No Answer	13%

The district provides teachers with science kits to teach the elementary science curriculum. Do you utilize the science kits in your classroom?	
Yes	50%
No	20%
I do not teach science	17%
No Answer	13%

Reflect on the science kits that are provided to your classroom. Please respond to each statement by selecting the most appropriate answer choice based on your experience with the science kits.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	No Answer
I have never utilized the science kits in my classroom.	0%	17%	6%	27%	37%	13%
The activities provided are interesting to my students.	6%	33%	20%	10%	10%	20%
The kits are well organized.	10%	20%	6%	30%	13%	20%
The instructional manuals are easy to access.	7%	13%	17%	20%	23%	20%
The instructional manuals are easy to understand.	10%	13%	23%	13%	20%	20%
The resources not included in the kits are easy to access.	7%	20%	13%	23%	13%	23%
The resources not included in the kits are easy to understand.	7%	13%	30%	13%	13%	23%
The activities help develop students' problem-solving skills.	10%	17%	20%	27%	3%	23%
The kits provide many opportunities for students to work with peers.	17%	53%	7%	0%	0%	23%
The activities in the science kits address STEM content.	6%	10%	30%	10%	16%	26%
The kits provide many opportunities for integration of multiple content areas.	7%	13%	27%	23%	7%	23%

What strategies do you utilize when teaching STEM? How often do you use each strategy?

Strategies	Rarely	Sometimes	Often	Always

I have not taught STEM	30%				
Building Physical Models	30%	3%	16%	10%	6%
Using Physical Models	26%	3%	13%	13%	3%
Using Computer Simulations/Apps	26%	13%	10%	10%	6%
Cooperative Learning	36%	0%	13%	13%	16%
Inquiry-Based Instruction	30%	0%	13%	10%	13%
Problem-Based Learning	30%	0%	10%	16%	13%
Student-Led Projects	20%	0%	23%	10%	0%
Differentiation	36%	3%	13%	6%	13%
Setting Objectives and Providing Feedback	23%	6%	3%	16%	10%
Reinforcing Effort and Providing Recognition	26%	0%	10%	3%	20%
Identifying Similarities and Differences	26%	3%	6%	16%	10%
Graphic Organizers	26%	3%	6%	26%	0%
Videos or Images	30%	3%	0%	20%	20%
Direct Instruction	33%	0%	10%	16%	10%
Summarizing and Note Taking	20%	3%	6%	16%	0%
Small Group Discourse	23%	0%	3%	16%	10%
Whole Group Discourse	26%	3%	0%	20%	13%
Guest Speakers/Experts in the Field	10%	10%	10%	6%	0%
Homework and Practice	10%	6%	13%	3%	3%
Writing a Scientific Argument	13%	10%	3%	13%	0%
Other: (Please Explain) Left Blank	3%	3%	0%	0%	0%

What are your strengths when implementing	What are the challenges you face when implementing	If you do not teach science or STEM, what challenges

STEM in your classroom?		STEM in your classroom? Mark all that apply.		limit your ability to teach these subjects? Mark all that apply.	
Math Content	13%	Limited Time	50%	Limited Time	40%
Science Content	16%	Limited Access to Resources	43%	Limited Access to Resources	36%
Engineering	3%	Limited Knowledge	20%	Limited Knowledge	26%
Technology	13%	Limited Experience	20%	Limited Experience	26%
Interest in STEM	6%	Behavior Issues	23%	Behavior Issues	16%
Engaging Lessons	23%	Limited Support from Administration	20%	Limited Support from Administration	10%
Unsure/No strength	6%	Grade Level Not Tested	16%	Grade Level Not Tested	10%
N/A	16%	Special Needs	3%	Special Needs	10%
No Answer	20%	Focus on Other Subjects (reading, math, writing)	10%	Focus on Other Subjects (reading, math, writing, phonics, only teach science and social studies embedded in other subjects)	6%
		Technology Knowledge	3%	Space	3%
		Limited Supplies	3%	No Answer	20%
		N/A	26%		
		No Answer	20%		

How many years teaching experience do you have?

5 and fewer	20%
6-10	13%
11-19	23%
20-29	13%
30 and more	7%
No Answer	23%

What grade levels have you taught? Mark all that apply.

Primary	73%	One Grade Level	6%
Intermediate	66%	Two Grade Levels	16%
No answer	23%	Three Grade Levels	16%
		Four Grade Levels	13%
		Five Grade Levels	3%
		Six Grade Levels	20%

What are the grade levels in your school? Mark all that apply.

Kindergarten-5th	83%
Pre-Kindergarten-5th	3%
No Answer	16%

In what school do you teach? (Optional):

School #1	3%
School #2	3%
School #3	3%
School #4	3%
School #5	3%
School #6	3%
School #7	10%
School #8	3%
School #9	3%
School #10	3%
No Answer	60%

What is the student population of your school?

100 or less	0%
101-250	3%
251-400	20%
401-600	40%
More than 600	13%
No Answer	23%

What ethnicities are represented in your school population? Mark all that apply.		What percentage of your school student population is female?		What percentage of your student population receives free and reduced lunch?	
Hispanic or Latino or Spanish Origin	63%	0-25%	0%	0-15%	0%
Native America or Alaskan	3%	26-50%	53%	16-35%	6%
Asian	53%	51-75%	23%	36-50%	3%
Native Hawaiian or Pacific Islander	20%	76-100%	0%	51-70%	6%
Black or African American	76%	No Answer	23%	71-90%	13%
White	73%			91-100%	46%
Two or more races	67%			No Answer	23%
Other	13%				
No Answer	23%				

What is the student to teacher ratio in your classroom: ___:1		What is the percentage of special education students in your classroom? (developmentally delayed, functional mental disability, mild mental disability, or other cognitive disabilities)	
30	3%	0-15%	43%
28	10%	16-35%	20%
26	3%	36-50%	10%
25	6%	51-70%	0%
24	40%	71-90%	0%
23	3%	91-100%	3%
18	10%	No Answer	23%
No Answer	23%		

APPENDIX 2. ADVERTISEMENT

YOU ARE INVITED!

We are seeking participants for a voluntary research study about the implementation of STEM in elementary classrooms in Jefferson County Public Schools in Louisville, KY.

Who: Current Elementary Teachers – General Education, Special Area, and ECE teachers are welcome to participate.

What: An online survey and a virtual interview. The survey is required of all participants. The interview is optional.

When: Before June 30, 2021.

Why: To provide insight and feedback on how STEM is implemented in elementary schools and share your personal experiences in a safe environment.

How: Follow the link below to access the survey.

https://uky.az1.qualtrics.com/jfe/form/SV_ewxMNN5ZwlFO3Ax

Contact: Elizabeth Johnson is the researcher from University of Kentucky conducting this study. If you have any questions, feel free to contact her via email (Elizabeth.johnson19@uky.edu).

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BIBLIOGRAPHY

Allen, D. E., Donham, R. S., & Bernhardt, S. A. (2011). Problem-based learning. New Directions for Teaching and Learning, 2011(128), 21–29. https://doi.org/10.1002/tl.465

Appleton, K. (2008) . Elementary science teaching. In S. K. Abell, & N. G. Lederman (eds.), Handbook of research on science education (pp. 493-535). New York, NY: Routledge.

Atteberry, A., Loeb, S., & Wyckoff, J. (2017). Teacher churning: Reassignment rates and implications for student achievement. Educational Evaluation and Policy Analysis, 39(1), 3-30.

Bandura, A. (1977). Self-efficacy: Toward a Unifying Theory of Behavioral Change. Psychological Review, 84(2), 191-215.

Bandura, A. (1977). Social Learning Theory. New York: General Learning Press.

Bandura, A. (1997). Self-efficacy: the exercise of control. New York: Freeman.

Banilower, E. R., Smith, P. S., Weiss, I. R., Malzahn, K. A., Campbell, K. M., & Weis, A. M. (2013). Report of the 2012 national survey of science and mathematics education. Chapel Hill, NC: Horizon Research, Inc.

Bencze. J. L., (2008). Promoting student-led science and technology projects in elementary teacher education: entry into core pedagogical practices through technological design. International Journal of Technology and Design Education, 20(1), 43–62. https://doi.org/10.1007/s10798-008-9063-7

Brobst, J., Markworth, K., Tasker, T., & Ohana, C. (2017). Comparing the preparedness, content knowledge, and instructional quality of elementary science specialists and self-contained teachers. Journal of Research in Science Teaching, 54, 1302-1321.

Brummet, Q., Gershenson, S., & Hayes, M. S. (2017). Teachers' grade-level reassignments: evidence from Michigan. Educational Policy, 31(2), 249-271.

Capraro, R. M., Capraro, M. M., & Morgan, J. R. (Eds.). (2013). STEM project-based learning: an integrated science, technology, engineering, and mathematics (stem) approach. Rotterdam, The Netherlands: Sense Publishers.

Carter, V. R. (2013). Defining Characteristics of an Integrated STEM Curriculum in K-12 Education. Graduate Theses and Dissertations Retrieved from https://scholarworks.uark.edu/etd/819

Chin, C., & Chia, L.-G. (2006). Problem-based learning: Using ill-structured problems in biology project work. Science Education (Salem, Mass.), 90(1), 44–67. https://doi.org/10.1002/sce.20097

Chu, HE., Martin, S.N. & Park, J. A Theoretical Framework for Developing an Intercultural STEAM Program for Australian and Korean Students to Enhance Science Teaching and Learning. Int J of Sci and Math Educ **17,** 1251–1266 (2019). https://doi.org/10.1007/s10763-018-9922-y

Clarke, D., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. Teaching and Teacher Education, 18(8), 947–967. https://doi.org/10.1016/S0742-051X(02)00053-7

Corbin, J. M. & Strauss, A. L. (2008). Basics of qualitative research techniques and procedures for developing grounded theory. (3e [ed.] / Juliet Corbin, Anselm Strauss.). SAGE.

Council N. R., Engineering, N. A. of, Education, C. on I. S., Schweingruber, H., Pearson, G., & Honey, M. (2014). STEM Integration in K-12 Education: Status, Prospects, and an Agenda for Research. National Academies Press.

Craig, Tara & Marshall, Jill. (2019). Effect of project-based learning on high school Students' state-mandated, standardized math and science exam performance. Journal of Research in Science Teaching. 56. 10.1002/tea.21582.

Daker, R. J., Gattas, S. U., Sokolowski, H. M., Green, A. E., & Lyons, I. M. (2021). First-year students' math anxiety predicts STEM avoidance and underperformance throughout university, independently of math ability. NPJ Science of Learning, 6(1), 17–17. https://doi.org/10.1038/s41539-021-00095-7

Dare, E. A., Ellis, J. A., & Roehrig, G. H. (2018). Understanding science teachers' implementations of integrated STEM curricular units through a phenomenological multiple case study. International Journal of STEM Education, 5(1), 1–19. https://doi.org/10.1186/s40594-018-0101-z

Darling-Hammond, L., Herman, J., Pellegrino, J., Abedi, J., Aber, J. L., Baker, E., ... Steele, C. M. (2013). Criteria for high-quality assessment. Stanford, CA: Stanford Center for Opportunity Policy in Education.

Dean, C. B., & Marzano, R. J. (2012). Classroom instruction that works research-based strategies for increasing student achievement (2nd ed.). ASCD.

DeBarger, A. H., Penuel, W. R., Harris, C. J., & Kennedy, C. A. (2016). Building an assessment argument to design and use next generation science assessments in efficacy studies of curriculum interventions. American Journal of Evaluation, 37, 174–192. doi:10.1177/1098214015581707

Dikilitaş, K. (2016). Innovative professional development methods and strategies for STEM education. IGI Global. https://doi.org/10.4018/978-1-4666-9471-2

Ejiwale, J. (2013). Barriers to successful implementation of STEM education. Journal of Education and Learning, 7(2), 63–74.

Eshach, H., & Fried, M. N. (2005). Should Science Be Taught in Early Childhood? Journal of Science Education and Technology, 14(3), 315–336. https://doi.org/10.1007/s10956-005-7198-9

Farvis, J., & Hay, S. (2020). Undermining teaching: How education consultants view the impact of high-stakes test preparation on teaching. Policy Futures in Education, 18(8), 1058–1074. https://doi.org/10.1177/1478210320919541

Fauth, B., Decristan, J., Decker, A.-T., Büttner, G., Hardy, I., Klieme, E., & Kunter, M. (2019). The effects of teacher competence on student outcomes in elementary science education: The mediating role of teaching quality. Teaching and Teacher Education, 86, 102882. https://doi.org/10.1016/j.tate.2019.102882

Ganley, C. M., Schoen, R. C., LaVenia, M., & Tazaz, A. M. (2019). The Construct Validation of the Math Anxiety Scale for Teachers. AERA Open. https://doi.org/10.1177/2332858419839702

Goldhaber, D., & Özek, U. (2019). How Much Should We Rely on Student Test Achievement as a Measure of Success? Educational Researcher, 48(7), 479–483. https://doi.org/10.3102/0013189X19874061

Greeno, J., Pearson, P., & Schoenfeld, A. (1997). Implications for the National Assessment of Educational Progress of research on learning and cognition. In R. Glaser, R. Linn, & G. Bohrnstedt (Eds.), Assessment in transition: Monitoring the nation's educational progress, background studies (pp. 151–215). Stanford, CA: National Academy of Education.

Gregory, & Chapman, C. (2002). Differentiated instructional strategies : one size doesn't fit all. Corwin Press.

Griffith, G., & Scharmann, L. (2008). Initial Impacts of No Child Left Behind on Elementary Science Education. Journal of Elementary Science Education, 20(3), 35–48. https://doi.org/10.1007/BF03174707

Gomez-Zwiep, S. (2008). Elementary teachers' understanding of students' science misconceptions: Implications for practice and teacher education. Journal of Science Teacher Education, 19, 437-454.

Hanushek, E. A., (2008). The Economic Value of Education and Cognitive Skills. In Handbook of Education Policy Research.

Johnson, C.C., Mohr-Schroeder, M.J., Moore, T.J., & English, L.D. (Eds.). (2020). Handbook of Research on STEM Education (1st ed.). Routledge. https://doi.org/10.4324/9780429021381

Johnston, J., & Ahtee, M. (2006). Comparing primary student teachers' attitudes, subject knowledge and pedagogical content knowledge needs in a physics activity. Teaching and Teacher Education, 22, 503-512.

Judson, E. (2013). The Relationship Between Time Allocated for Science in Elementary Schools and State Accountability Policies. Science Education (Salem, Mass.), 97(4), 621–636. https://doi.org/10.1002/sce.21058

Kagan, Spencer & Kagan, Miguel. (2009). Kagan Cooperative Learning. San Clemente, CA: Kagan Publishing.

Kentucky Department of Education. 2015. Kentucky Academic Standards Mathematics. Retrieved from https://education.ky.gov/curriculum/conpro/Math/Pages/default.aspx

Kentucky Department of Education. 2015. Kentucky Academic Standards Technology. Retrieved from https://education.ky.gov/curriculum/standards/kyacadstand/Documents/KAS_Technology.pdf

Kim, K. (2019, May 7). Inclusive STEM Education: Theoretical Framework for Examining the Experienes of Women Students of Color in STEM Education. https://doi.org/10.31235/osf.io/tj4yk

Laforce, M., Noble, E., King, H., Holt, S., & Century, J. (2014). The 8 elements of inclusive STEM high schools. Chicago, IL: Outlier Research and Evaluation, CEMSE, The University of Chicago.

Lynch, S. J., House, A., Peters-Burton, E., Behrend, T., Means, B., Ford, M., Spillane, N., Matray, S., Moore, I., Coyne, C., Williams, C., & Corn, J. (2015). A logic model that describes and explains eight exemplary STEM-focused high schools with diverse student populations. Washington, DC: George Washington University OSPrI Project.

Lynch, S. J., Burton, E. P., Behrend, T., House, A., Ford, M., Spillane, N., Matray, S., Han, E., & Means, B. (2017). Understanding inclusive STEM high schools as opportunity structures for underrepresented students: Critical components. Journal of Research in Science Teaching, 55(5), 712-748.

Margot, K. C., & Kettler, T. (2019). Teachers' perception of STEM integration and education: a systematic literature review. International Journal of STEM Education, 6(1), 2. https://doi.org/10.1186/s40594-018-0151-2

Means, B., Wang, H., Wei, X., Lynch, S., Peters, V., Young, V., & Allen, C. (2017). Expanding STEM opportunities through inclusive STEM-focused high schools. Science Education, 101(5), 681–715.

Miles, M. B., & Huberman, A. M. (1994). Qualitative data analysis. Sage. https://doi.org/10.1177/002076409704300109

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry-based science instruction-what is it and does it matter? Results from a research synthesis years 1984 to 2002. Journal of Research in Science Teaching, 47(4), 474–496. https://doi.org/10.1002/tea.20347

Mitchem, A. L. (2011). Diane Ravitch. The Death and Life of the Great American School System: How Testing and Choice Are Undermining Education. New York: Basic Books, 2010. 296 pp. Hardcover $26.95. History of Education Quarterly, 51(3), 424–426. https://doi.org/10.1111/j.1748-5959.2011.00351.x

Morgan, P. L., Farkas, G., Hillemeier, M. M., & Maczuga, S. (2016). Science Achievement Gaps Begin Very Early, Persist, and Are Largely Explained by Modifiable Factors. Educational Researcher, 45(1), 18–35. https://doi.org/10.3102/0013189X16633182

Mpofu, V. (2019). A Theoretical Framework for Implementing STEM Education. In (Ed.), Theorizing STEM Education in the 21st Century. IntechOpen. https://doi.org/10.5772/intechopen.88304

National Center for Education Statistics. Common core of data: School district locator. http://nces.ed.gov/ccd/districtsearch

National Governors Association. (2007). Innovation America: Building a science, technology, engineering and math agenda. Washington, DC: National Governors Association Center for Best Practices, Council of Chief State School.

National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). Common Core State Standards for Mathematics. Washington, DC: Authors.

National Research Council. (2001). Knowing what students know: The science and design of educational assessment. Washington, DC: The National Academies Press. doi:10.1037/e302582005-001

National, R. C., National, A. O. E., & Committee, O. I. S. E. (2014). Stem integration in k-12 education: Status, prospects, and an agenda for research. National Academies Press.

Nesmith, S. M., & Cooper, S. (2019). Engineering process as a focus: STEM professional development with elementary STEM-focused professional development schools. School Science and Mathematics, 119(8), 487–498. https://doi.org/10.1111/ssm.12376

NGSS Lead States. 2013. Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press.

Patton, M. Q. (1990). Qualitative evaluation and research methods. Sage.

Pellegrino, J. W., Wilson, M., Koenig, J., & Beatty, A. (Eds.). (2014). Developing assessments for the next generation science standards. Washington, DC: National Academies Press.

Peters-Burton, E. E., Lynch, S. J., Behrend, T. S., & Means, B. B. (2014a). Inclusive STEM high school design: 10 critical components. Theory into Practice, 53, 64–71.

Reagan, M. T., (2016). STEM-Infusing the Elementary Classroom. SAGE Publications.

Rice, D. C. (2005). I didn’t know oxygen could boil! what preservice and inservice elementary teachers’ answers to ‘simple’ science questions reveals about their subject matter knowledge. International Journal of Science Education, 27, 1059-1082.

Rousmaniere, K. (2013). The principal's office: A social history of the american school principal. State University of New York Press.

Ryu, M., Mentzer, N., & Knobloch, N. (2018). Preservice teachers’ experiences of STEM integration: challenges and implications for integrated STEM teacher preparation. International Journal of Technology and Design Education, 29(3), 493–512. https://doi.org/10.1007/s10798-018-9440-9

Saçkes, M., Trundle, K. C., Bell, R. L., & O’Connell, A. A. (2011). The influence of early science experience in kindergarten on children’s immediate and later science achievement: Evidence from the early childhood longitudinal study. Journal of Research in Science Teaching, 48(2), 217–235. https://doi.org/10.1002/tea.20395

Sahin, A., & Mohr-Schroeder, M. J. (2019). STEM education 2.0: myths and truths--what has K-12 STEM education research taught us? Brill.

Schon, D. A. (1983). The reflective practitioner. NewYork: Basic Books.

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), 13–13. https://doi.org/10.1186/s40594-017-0068-1

Stohlmann, M., Moore, T. J., & Roehrig, G. H. (2012). Considerations for Teaching Integrated STEM Education. Journal of Pre-College Engineering Education Research (J-PEER), 2(1), Article 4. https://doi.org/10.5703/1288284314653

Sussman, J., & Wilson, M. R. (2019). The Use and Validity of Standardized Achievement Tests for Evaluating New Curricular Interventions in Mathematics and Science. American Journal of Evaluation, 40(2), 190–213. https://doi.org/10.1177/1098214018767313

Thibaut, L., Ceuppens, S., De Loof, H., De Meester, J., Goovaerts, L., Struyf, A., Boeve-de Pauw, J., Dehaene, W., Deprez, J., De Cock, M., Hellinckx, L., Knipprath, H., Langie, G., Struyven, K., Van de Velde, D., Van Petegem, P. and Depaepe, F. (2018). Integrated STEM Education: A Systematic Review of Instructional Practices in Secondary Education. European Jourrnal of STEM Education, 3(1), 02. https://doi.org/10.20897/ejsteme/85525

Trygstad, P. J. (2013). 2012 National Survey of Science and Mathematics Education: Status of elementary school science. Chapel Hill, NC: Horizon Research, Inc.

Tucker, C. M., Porter, T., Reinke, W. M., Herman, K. C., Ivery, P. D., Mack, C. E., & Jackson, E. S. (2005). Promoting Teacher Efficacy for Working With Culturally Diverse Students. Preventing School Failure, 50(1), 29–34. https://doi.org/10.3200/PSFL.50.1.29-34

Urban, W. J., & Wagoner, J. L. J. (2013). American education: A history. Taylor & Francis Group.

Vossen, T. E., Henze, I., de Vries, M., & van el, J. A. (2019). Finding the connection between research and design: The knowledge development of STEM teachers in a professional learning community. International Journal of Technology and Design Education, 30(2), 295–320. https://doi.org/10.1007/s10798-019-09507-7

Wendt, J. L., & Apugo, D. L. (Eds.). (2019). K-12 STEM Education in Urban Learning Environments. IGI Global. https://doi-org.ezproxy.uky.edu/10.4018/978-1-5225-7814-7

Wieselmann, J. R., Dare, E. A., Ring-Whalen, E. A., Roehrig, G. H. “I just do what the boys tell me”: Exploring small group student interactions in an integrated STEM unit. J Res Sci Teach. 2020; 57:112–144. https://doi.org/10.1002/tea.21587

Wojnowski, B. S., & Pea, C. H. (2014). Models and approaches to STEM professional development. National Science Teachers Association.

Zhao, Y. (2009). Catching up or Leading the Way: American Education in the Age of Globalization. Association for Supervision & Curriculum Development.

Zhou, S.-N., Zeng, H., Xu, S.-R., Chen, L.-C., & Xiao, H. (2019). Exploring changes in primary students' attitudes towards science, technology, engineering and mathematics (stem) across genders and grade levels. Journal of Baltic Science Education, 18(3), 466–480. https://doi.org/10.33225/jbse/19.18.466

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PROFESSIONAL POSITIONS

October 2013-2014	Maupin Elementary	1st & 2nd Reading Interventionist
August 2014-2015	Maupin Elementary	1st grade teacher
August 2015-2017	Foster Traditional Elementary	3rd grade teacher
August 2017-2020	Foster Traditional Elementary	Kindergarten teacher