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STEM Education in the Elementary School Classroom

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STEM Education in the Elementary School Classroom

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Abstract

There is a disparity in research conducted for STEM education across elementary, middle, high school, and college. STEM learning teaches students to ask questions, look at a problem through multiple lenses, work collaboratively with others, plan carefully, become flexible, embrace change, improve upon their idea, persevere through challenges, and open themselves up to discussing new ideas and differing points of view. The literature review revealed the differing schools of thought regarding STEM education, a variety of implementation methods, and the changes seen in classrooms detailing how students connect in class curricula to real world examples. The literature also highlighted a gap in knowledge as a result of a lack of research conducted on STEM education in elementary school classrooms. This qualitative research was conducted through the lens of constructivism and utilized a mixed methods phenomenological approach. The data was gathered by surveying and interviewing elementary school teachers incorporating STEM education in their classrooms. Findings identify that STEM education produces students with better conflict-resolution skills, self-taught teachers out of a lack of opportunity, and out of pocket expenses. These findings have implications for elementary educators and districts by outlining the skills instilled in students through STEM learning and raises awareness on the financial cost placed on educators. This thesis proposes that in order for STEM education to become interwoven in elementary education specific funding needs to be available for training opportunities and grade level curricula aligned with the Common Core State Standards (CCSS) and Next Generation Science Standards (NGSS).

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Chapter 1: Introduction

I was first introduced to STEM education when I was student teaching in a 5th grade classroom. I observed that STEM was the one time when all of the students would come together to eagerly participate in the project of the week. The students had varied interests, academic and ability levels, and differing levels of understanding regarding the grade level curricula. STEM created an atmosphere and a time where all of the students could use their individual abilities and talents in a collaborative way with the entire class. This allowed each student to put their best foot forward while demonstrating their content specific and real world knowledge.

The 5th grade classroom was comprised of a group of varied learners. Several had Individualized Educational Plans (IEPs), a few spent a portion of the day in special education, and several dealt with behavioral struggles; but as soon as it was time for STEM, none of that mattered. STEM became a leveling force for all of the students. This time allowed them to work collaboratively and put aside their differences to successfully complete the STEM activity. All of the students in the class eagerly came together to learn about the project of the week, excitedly waited for their groups to be announced, and began brainstorming and building as soon as the teacher said go.

The teacher created hands-on dynamic lessons that aligned with what the students were learning in class. Her teaching implemented the hands-on approach of STEM while taking the interests and talents of her students into consideration with each project she assigned. She carefully planned her lessons and wove her teaching into STEM instruction. She was an incredible role model and someone who's teaching style deeply inspired me. The STEM process can lead to a sort of controlled chaos, which can be overwhelming to teachers who have not seen

STEM learning in action before. While the classroom may have been loud and students may have been all over the room, she was able to get their attention and redirect the students who needed it in a consistent and efficient way. Her students were able to take their learning to a new level after taking the content taught in class and applying it to the task at hand. I was inspired by her passion, creativity, and approach to teaching.

When I began teaching, I took the lessons and ideas I observed in her classroom and applied them to my students. STEM inclusion was far from seamless, and felt akin to baptism by fire initially. As soon as I took a step back to reflect upon the learners in my classroom, the goals I hoped they would obtain, and tied their interests into the in class curricula; I noticed a world of change. I recognized more completely how STEM education requires deep thought, intensive planning, adaptability, and reflection for successful implementation. My experiences with STEM education during student teaching sparked my interested in STEM, which lead me to pursue the research that led to this study.

Statement of Purpose

This study was designed to examine how STEM education implementation at the elementary school level impacts student agency across science, technology, engineering, and math. Several studies have been conducted looking at different implementation styles, the benefits STEM education adds to classroom learning, and the challenges teachers have faced through the addition of STEM education in their classrooms (Plank, L., 2017, Shuda, J., Butler, V., Vary, R., Noushad, N., & Farber, S., 2019, and Stohlmann, M., Moore, T., and Roehrig, G., 2012). I was inspired by the current research but wanted to shift the lens to focus of this research on the student populations I had previously taught. I felt that I could learn from other educators working with similar age groups of students that I have worked with by gaining a deeper understanding of the ways in which they use STEM education, how it is implemented in their classrooms, and the obstacles they have faced and overcome in their teaching experiences.

The published literature on STEM education revealed a lack of research addressing STEM education in elementary schools (Hom, E., 2014). As I continued to dive deeper into the research, I discovered that not only was there a lack of research conducted at the elementary school level but also a lack of funding set aside for this age group. A limited amount of information was available at the elementary school level. Therefore, research that focused on other grade levels was reviewed at the middle school, high school, and college levels. Although several teachers utilize STEM education at the elementary school level, formal research on this population has not been conducted.

Overview of the Research Design

This mixed methods study was designed with the purpose of gaining a deeper understanding of the role STEM education plays into student behavior and agency in science, technology, engineering, and math in elementary education. The study was also designed as a way for STEM elementary school teachers to share their first person experiences to allow for insight into the how they use STEM in their classrooms, what they observe from their students, the obstacles they have faced during implementation, and how they have overcome them. The research design was created to first utilize any other research that had occurred which would add value. Then, the creation of a survey instrument was developed in order to obtain a greater amount of input from other elementary school educators across the United States. I surveyed and interviewed elementary teachers who utilize STEM education in their classrooms. The goal of conducting a survey and interviewing current teachers was to gain a deeper understanding of how they use STEM, what changes they notice in their students through the implementation of

STEM education, and the challenges that they face with incorporating STEM into their teaching. The survey included 50 teacher participants who contributed their STEM knowledge and experiences. In addition, four teachers who the researcher has personal history with agreed to be interviewed and to discuss the creation, implementation, and results of their STEM activities in order to obtain valuable first-hand data.

The survey was shared through a STEM elementary education Facebook group page. Fifty teachers self-selected to participate in the research by completing the short survey. These participants answered questions pertaining to the ways in which science, technology, engineering, and math are taught at their school sites, the level of choice they have in selecting curricula for their students, their feelings towards STEM education, and experiences with implementation in their classrooms. These questions were designed to gain a broader perspective of experiences across multiple sites while allowing the participants to share in a confidential way. Confidentiality allowed for teachers to discuss the struggles they have faced, the areas where they feel additional support is needed, and to talk about the experiences they and their students have while working on STEM activities.

The interviews took place over two, one on one meetings with each of the four educators. During their first interview, the teachers discussed their experiences and introduction to STEM education, the ways in which STEM is incorporated into their classrooms, observations about their students during STEM activities, and the challenges they have faced as educators with the implementation of STEM. Between the two interviews, teachers were asked to complete a STEM project with their students. The second interview focused on how the project went with the class, the successes of the project, the obstacles students faced while working on the project along with how they overcame them, the changes they would make if they were going to redo the activity, and their advice for other teachers considering branching out into STEM education. The two interviews allowed me to gain insight into their experiences and points of view of STEM as a whole and then gave me the opportunity to discuss a specific project with them which provided deeper insight and into problem solving strategies and conflict-resolution tactics that their students utilize.

Significance of the Study

The most important findings of this research show that STEM education increases student's conflict-resolution skills, that teachers are self-taught out of a lack of opportunities for STEM trainings, and the out of pocket expenses that teachers incur through the implementation of STEM education. This study advances the scholarly research already conducted by presenting the reader with information and data from the first person perspectives of elementary STEM educators. There is a lack of formal research done regarding this topic and it is something that future researcher should expand upon. This thesis provides insight into the ways elementary school teachers are adding STEM to their classrooms, the positive outcomes they see in their students, and the challenges they have worked to overcome during this process. The research conducted for this thesis can be used as a way to provide insight into the experiences of elementary teachers with varied opinions, backgrounds, and teaching experiences. This allowed me to draw out several connections between data gathered during the surveys and one on one interviews.

This thesis was conducted to collect data on STEM education in elementary schools, determine how STEM contributes to these classrooms, and to discover the challenges that have arisen during the implementation of STEM education. The research led to a deeper understanding of the common challenges that have arisen for elementary school STEM educators across the country. Teachers are facing the challenge of creating their own curricula, finding ways to connect STEM lessons to the CCSS and NGSS, in addition to funding and finding their own STEM trainings to attend. There needs to be a strong push for STEM funding to be focused on elementary aged students. Teachers need to have access to STEM training methods and there needs to be a concentrated effort to obtain funding so that STEM can be integrated into the current classroom curriculum. STEM education undertaken at the elementary school level positively impacts student behavior and agency across science, technology, engineering, and math. It also provides added benefits including the ability to work effectively with peers, the ability to listen to other thoughts and ideas, and more importantly to be able to use this added knowledge when presented with other learning opportunities.

Research Implications

The research identifies the need for additional research and quantitative study in elementary school classrooms. This research highlights how STEM education has been successful and that additional funding, training, and standardized curriculum needs to be developed before STEM can be interwoven as a part of the fabric of the educational system. Without providing educators with the ability to attend trainings on STEM education, the gap of inequity is continuing to expand. Schools that are interested in STEM and have the funding are able to purchase the limited costly curricula and trainings available, but schools without this kind of funding are left unable to support their students through STEM integration. This leads to continually growing gaps and sets students without these opportunities at a disadvantaged compared to their STEM inclusive peers.

Educator’s need to emphasize the benefits of STEM education to their peers and administration which will allow teachers to work with their districts, school boards and other elected representatives to obtain more funding for these types of programs. There is an inequity in the funding dedicated to STEM education across grade levels. Districts and states can provide more equity to these schools by redistributing the funding set aside for STEM by allocating it to the interested teachers across all grade levels. There is also a large inequity in the training opportunities available for teachers. By creating trainings and making them available for all teachers, we can create a more equitable opportunity for all of our students.

Chapter 2: Literature Review

This study examines how the presence of STEM education implementation at the elementary school level impacts student agency across science, technology, engineering, and math. The literature review begins with an origin and history of STEM education by outlining how STEM education is defined, the Space Race which inspired the beginning of STEM, how it has evolved, and where it is today. The review then moves into the purpose and value added with the incorporation of STEM education through the discussion of student agency, 21st Century Skills, and the gaps in opportunity. This leads into models of successes and failures throughout implementation. The literature review concludes by identifying the gap in knowledge on STEM education and outlining areas of additional necessary research.

Origin and History

STEM education is broadly defined as an interdisciplinary and applied approach for teaching science, technology, engineering, and math (Hom, E., 2014). This approach focuses on teaching these four subject areas in a "cohesive learning paradigm based on real-world applications" (Hom, E., 2014). STEM curricula incorporates hands on learning, collaboration, and creativity in the classroom. It allows students to look at real world problems and come together to solve them in creative ways. This type of learning presents students with the opportunity to think outside of the box, let their imagination run wild, and build the skills to become 21st century learners.

The first wave of science, technology, engineering, and math began in 1957 when the Russian satellite Sputnik was successfully launched into space (Marick, 2016). This was the first satellite to orbit the Earth. The United States leaders, citizens, and scientific community were astonished by this massive technological achievement. They were caught off guard and came together as a nation in an effort to catch up with the Soviets. This marks the beginning of what is now known as the start of the Space Race (Marick, 2016). During the following year President Eisenhower proposed the creation of a federal agency responsible for aerospace research, aeronautics, and the civilian space program (Marick Group, 2016). This period pushed the spark that lead to the foundation of NASA on July 28th of 1958.

Although the call to action slowed during the 1970s and 1980s, technological advancements continued to move forward. The 1980s lead to the creation of the first cell phone, first artificial heart, and the first personal computer (Marick Group, 2016). These advancements awed the American people and lead to the continued push for more technology. During this time, companies began to realize the untapped potential of electronic devices in the American marketplace. Companies began competing with each other by working to hone in and improve upon these technological successes.

The beginning of STEM education, and the acronym it is known by, began in the early 1990s. STEM was originally referred to as SMET, before it was changed for sounding too similar to the word “smut” (Sanders, M., 2009). At this point in time, STEM education was not a commonly known term. When asked, many people believed that STEM was related to stem cell research and not the collaborative teaching of science, technology, engineering, and math.

In 2005, Virginia Tech launched the first STEM education graduate program (Sanders, M., 2009). When Virginia Tech first began referring to STEM education, they did not always implement all four areas of science, technology, engineering, and math but instead used the term when utilizing two of more of these subject areas in a collaborative way.

Virginia Tech created a pedagogy they refer to as Purposeful Design and Inquiry (PD&I). “PD&I pedagogy purposefully combines technological design with scientific inquiry, engaging students or teams of students in scientific inquiry situated in the context of technological problem-solving—a robust learning environment" (Sanders, M., 2009). This began the integration of utilizing all four areas of science, technology, engineering, and math in a collaborative way. The combination of these fields allowed for a deeper understanding and connection. This problem-based learning purposefully situates scientific inquiry and the application of mathematics in the context of technological designing/problem solving which allows for authentic inquiry embedded into the design challenges (Sanders, M., 2009).

The next wave of STEM education began in 2009 with the Obama Administration's initiative Educate to Innovate (Sakar, L., 2018). This initiative was created with the goal to increase STEM literacy, increase teaching quality, and expand educational and career opportunities for America's youth in the science, technology, engineering, and math fields (Burke, L., & McNeill, J., 2011). Obama's administration invested $3.1 billion in federal programs promoting STEM education (Hom, E., 2014). This money was given to fund STEM focused high schools, invest in advanced research projects, recruit and support STEM teachers, and to better understand the next-generation standards (Hom, E., 2014). The initiative addressed the lack of teacher training in STEM, but opted for hiring new STEM professionals instead of training current teachers. They created this initiative with the overarching goal to move American high school students from the middle of the road to the head of the pack internationally (Hom, E., 2014). When this plan was initiated American students ranked 22nd among their peers throughout the world in science and 31st in math (Burke, L., & McNeill, J., 2011).

In April of 2013, the Next Generation Science Standards (NGSS) were created by a team of experts and stakeholders in science and engineering in an open collaborative state lead process

(Achieve, 2014, August 5). These K-12 science content standards were developed to improve science education for all students. The standards provide an opportunity to improve student achievement in science education by developing core knowledge and ideas through hands-on activities. These activities help prepare students for a broader understanding of deeper levels of investigation through science (Achieve, 2014, August 5). NGSS focus on developing critical thinking skills and inquiry. The NGSS is a list of standards, not a curriculum. It is a series of goals and best practices intended to inform teachers' science instruction (Witte, B., 2015). These standards are written as a learning objective, such as, "3-PS2-1 Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object" (NGSS, Motion and Stability Forces and Interactions). They then list science and engineering practices, disciplinary core ideas, and cross cutting concepts. The standards end with connections to the Common Core State Standards (CCSS).

While many educators enjoy the flexibility that the NGSS provide, they feel overwhelmed working to create curricula that fully addresses these standards. These standards outline overarching goals and aligned CCSS but do not provide direction on implementation. While many schools are in the process of purchasing new science curricula, teachers are either using outdated materials or creating their own lessons from scratch.

Purpose and Value

STEM education provides value to students and teachers through various modalities. STEM learning helps students to persevere through challenges as a team, stay open to new ideas and other points of view, and stay flexible (Johnson, G., 2019). It allows students to have hands-on engagement, work collaboratively with others, and to think outside of the box. Focusing on the combination of science, technology, engineering, and math, STEM education gives students hands-on problem solving situations related to work with their peers (Baker, C., Galanti, T., 2017). These activities focus on the incorporation of real-life problems and engineering design process in open ended problem solving. It emphasizes the need for innovation in the classroom to promote innovation and problem solving skills for the students to apply in other areas of their lives (Slykhuis, D. A., Martin-Hansen, L., Thomas, C. D., & Barbato, S., 2015).

21st Century Skills are defined as a broad set of knowledge, skills, work habits, and character traits that are believed to be critically important to success in today's world (21st Century Skills, 2016). These are skills that teachers are working to include in their classrooms to set up their students for success in their post graduate and professional lives. They include critical thinking, problem solving, research skills, creativity, perseverance, public speaking, leadership, collaboration, technology literacy, data analysis, social justice, global awareness, and reasoning (21st Century Skills, 2016). Many of these skills align closely with STEM education. Both STEM education and 21st Century Skills strive to prepare students for success in their pursuit of higher education or careers.

Paul and Elder (2008) define critical thinking as the process of conceptualizing, applying, analyzing, synthesizing, and evaluating information gathered from or generated by observation, experience, reflection, reasoning, or communication. They state that students who think critically are able to gather and assess information before coming to thought out conclusions. They think open-mindedly and recognize that others may have opinions that differ from their own. Instead of shutting down other ways of thinking, they listen thoughtfully to other's thoughts before forming an opinion. Critical thinkers are able to look at a situation from many points of view and fully consider all opinions before making a decision.

According to Plank (2017), perseverance is the skill which allows students to push through obstacles and try again when activities do not go as expected the first few times. It allows students to push forward with a difficult challenge until they are successful. People with perseverance are able to take a step back, approach the problem from a different angle, and work to solve it in a new way. It is a leveling force (Johnson, A., 2017). Students who are presented with the opportunity to fail in a safe and supportive environment, are more likely to gain the skill of perseverance. When the fear is taken away from failure, students are able to take on risks they otherwise might not have had the courage to explore (Plank, 2017).

Teamwork is an essential part of success inside and outside of the classroom (Johnson, A., 2017). It requires working collaboratively with others in order to reach a common goal. Developing this skill at a young age allows students to become effective communicators, actively listen to and participate in conversations with their peers, work with others to come to an agreement, and accountability. When working with a team it is crucial that all members work collaboratively and hold each other accountable. This allows projects to run smoothly and helps everyone to achieve their goals. Instilling the importance of teamwork and personal accountability at a young age allows students to be more successful through the rest of their education and careers.

Global Awareness is an understanding of how environmental, social, cultural, economic and political factors impact the world. This can be demonstrated through a deeper understanding of other people's cultural values, their beliefs and perceptions which might differ from yours. Students are connected to other parts of the world through technology in which past generations were not capable. This added communication makes students feel connected to the situations of others in different parts of the world (Fresno Pacific Staff, 2018). The empathy gained from learning about other's situations encourages students to look at the world around them in a different way. It presents them with the unique opportunity of looking at an experience through another person's perspective. Students can gain a greater sense of global awareness through literature, foreign language skills, travel, openness, and knowledge in comparative fields (Fresno Pacific Staff, 2018).

When discussing STEM education, it is important to note the areas of inequality. The lack of opportunity to have a STEM curriculum can lead to gaps in race, gender, and socioeconomic status. Many schools in lower income areas do not have the time in the school day or funding to pursue STEM education unless it is funded through an outside source. Over half of 12th grade students of high socioeconomic classes are enrolled in higher math classes, compared to less than a quarter of seniors of low socioeconomic class (Tu, 2017). Many of these lower socioeconomic schools do not have the same opportunities and classes offered as their higher socioeconomic counterparts. When looking at data from the 2015-2016 Civil Rights Data Collection, there is a large discrepancy in the classes offered at high schools with a majority white population and schools with a primarily Black or Latino student population. Advanced mathematics are offered 10% less, Calculus is offered 12% less, and Physics is offered 9% less at primarily Black or Latino high schools (2015–16 Civil Rights Data Collection STEM Course Taking, 2018). Since fewer majority Black and Latino population high schools offer these classes, they are being put at a disadvantage in comparison to their majority white high school counterparts. This disconnect leads into lower standardized test scores for Black and Latino students in STEM related classes. When looking at data from the National Assessment of Educational Progress science test, 33% of white students were deemed proficient or above, but only 6% of black students and 11% of Latino students scored in the same range (Tu, 2017).

There is a large disconnect between the enrollment of men and women in STEM education classes as well as in STEM related career fields. In higher education, only 35% of all students enrolled in STEM-related fields are female and only 28% of all of the world's researchers are women (UNESCO, 2017). The study continued by stating that there tends to be a large drop off in STEM interest between early and late adolescence. By the time many of these women are enrolled in high school they choose to pursue other classes and activities. Schools play a key part in determining girls' interest in STEM subjects and in providing equal opportunities to access and benefit from quality STEM education (UNESCO, 2017). Girls are feeling the historic effects of sexism from a young age. 57% of middle school girls reported feeling that if they went into a STEM career, it would be harder for them to be taken seriously than it would be for a male counterpart (Modi, et al., 2012). STEM careers are considered to be the jobs of the future; it is crucial to ensure women have equal access to STEM education and STEM careers.

There are large inequalities in educational attainment when looking at socioeconomic status (Rozek, C., Ramirez, G., Fine, R., & Beilock, S., 2019). Children from lower income backgrounds receive lower grades, test scores, and rate of college attendance in comparison to their higher income peers (Rozek, C., Ramirez, G., Fine, R., & Beilock, S., 2019). In comparison to racial gaps, socioeconomic gaps can be over twice as large. This gap leads to a continued strain in academic success which reduces career opportunities and can lead to the continuation of intergenerational poverty (Rozek, C., Ramirez, G., Fine, R., & Beilock, S., 2019). STEM fields are being looked at as a way to bridge this gap, which is why it is crucial that disadvantaged groups are given the same opportunities as their peers. As of the end of 2019, there were 2.4 million unfilled STEM jobs because there was a lack of qualified candidates

(Ryan, 2019). In order to reduce the gap, there is urgency to help students develop the skills and receive an education that would allow them to fulfill these careers.

There is a shift happening across the country where many large corporations are seeing this need and intervening at the high school level to help students begin to bridge the gap. These programs are primarily focused on high schools in lower income areas. Companies and individual business owners are partnering with schools creating the ability for these students to explore possible career opportunities, build relationships with professionals, and receive support and an advantage that they would not otherwise be able to attain without this assistance or these programs (Bryan, S.M. & Associated Press, 2019, Friedman, S., 2019, and Chapman, J., 2018). This partnership benefits the students as well as these companies. While the students are receiving the opportunity to interact with these companies the supporting companies are in turn receiving new ideas, a different approach to problem solving, and potential new employees to grow with their companies.

Models of Success and Failure

While STEM education is currently on an uphill trajectory, there have been several setbacks. STEM education is not one size fits all. What works in one school site or state will not always work in another (Sakar, L., 2018). There are many important things to consider when looking at STEM implementation, and several setbacks that have arisen along the way. There is a lack of teacher training opportunities, limited easily accessible or affordable curricula, and not enough time to meet all of the standards that are already in place (Sakar, L., 2018, and Diallo, A., 2018).

Training

The University of Nebraska-Lincoln looked at math, science, engineering, technology, and STEM specific classes in colleges across the United States and Canada (2018). This study looked at 550 teachers from 25 colleges. Participants were observed teaching twice throughout the semester and filled out a questionnaire outlining their teaching choices, thoughts on STEM education, and obstacles they faced throughout the semester. All participants in the study were voluntary. The researchers found that 55% of STEM education in college classrooms are solely lecture based, 27% feature a combination of lecture and hands on activities, and 18% are student centered focusing on group work and discussions (University of Nebraska-Lincoln, 2018). These researchers discovered that the additional work from the teacher's side in creating group work lead to more engaging class sessions and discussions with their students. When speaking with these collegiate educators, several shared that they chose lecture based classes over other types of instruction because their overall class sizes and classroom layouts were more conducive to lectures.

The research also showed that smaller class sizes and open classroom layouts lead to student centered learning. The teachers working with smaller classes or in classrooms more conducive to small group activities made up for the vast majority of student centered teachers (University of Nebraska-Lincoln, 2018). Teachers in larger lecture halls or amphitheaters shared that their choice to teach in a primarily lecture style came from their large class sizes and layout of the classrooms. Of the teachers who participated, many further shared that they were opposed to implementing STEM education in their classrooms because they felt they were not given the proper training to successfully implement other teaching methods (University of Nebraska-Lincoln, 2018).

In Florida, Larry Plank, director for K-12 STEM education for the Hillsborough County Public Schools, spent three years of their professional development time solely on STEM education (2017). The focus on teacher education equipped teachers with the skills to create high-quality, standards-based, integrated STEM lessons to help teachers develop their STEM content knowledge and teaching skills. Their professional development moved away from the standard sit and listen format into hands on experiences that they hoped the teachers would model in their own classroom. By allowing teachers to actively participate, they had a much higher rate of engagement and teacher buy in. He broke their implementation of STEM education into four categories: "1. Teach the teachers first. 2.Create an active place for STEM learning. 3. Build 21st century skills and make real world connections. 4. Go wireless" (Plank, L., 2017). With these changes they noticed an 80% rise in 7th-11th grade students interested in pursuing a STEM career. He felt that they saw an increase in student's engagement and interest as a result of how they taught. In their district they gave teachers access to training which helped shift their outlook towards STEM education. Across their district of 250 schools (with roughly 203,000 students) student performance was at or above grade level across the board in math and science (Plank, L., 2017).

BioEYES created and implemented a similar three year program for K-12 students (Shuda, J., Butler, V., Vary, R., Noushad, N., & Farber, S., 2019). BioEYES developed "self-sustaining teachers", their term for educators who become self-sufficient STEM experts, as a replication strategy to address high demand for STEM programs while promoting long-term school partnerships. During this three year program, teachers learned about the BioEYES hands on science content through professional development workshops, classroom co-teaching experiences, and refresher trainings to assist in teacher autonomy (Shuda, J., Butler, V., Vary, R., Noushad, N., & Farber, S., 2019). In the first year teachers attended university based professional development where the teacher is trained on the program, they observe the program being taught by a mentor teacher in their classroom, and are given pointers from the mentor teachers who come in to observe their teaching. The program then comes in to help with teacher implementation five days a week. Three days a week the mentor teacher does all of the teaching while the other two days the homeroom teacher runs the program with the mentor teacher observing. This gives the teacher the ability to watch someone else implement the program and allows them to receive feedback on their own implementation.

In the second year the teacher co-teaches, they attend another training session, and teach three days a week with the assistance of a BioEYES teacher and two days a week alone. In the third year the teacher becomes a "model teacher" where they receive training practicing technical tasks and they implement the program independently. They discovered that this program had similar effectiveness across the implementation of elementary, middle, and high school students as well as a positive attitude for the students in science (Shuda, J., Butler, V., Vary, R., Noushad, N., & Farber, S., 2019).

The examples above highlight that STEM is not a one size fit for all situations. These examples all highlight the improvement in learning and interest that comes from STEM for students. There are also similarities such as training teachers is critical to the success of STEM education, that making assignments that are reflective of the students' real life experiences enhance the learning opportunities, and creating content applicable to the students through real world connections to their daily lives. Each study briefly summarized above also shines a light on the need to adequately train and prepare teachers for STEM.

The following two sections give a closer look at the current research and first person narratives of middle school and K-6 level.

Micah Stohlmann, Tamara Moore, and Gillian Roehrig laid out their foundation for STEM Education implementation at the middle school level (2012). These researchers formed a year-long partnership with four teachers from a midwestern middle school to conduct their research. Of the teachers included, there were two math teachers, a science teacher, and a technology teacher who were all curious about but inexperienced with STEM education (Stohlmann, M., Moore, T., and Roehrig, G., 2012). The researchers believe STEM education is a way to improve overall achievement in mathematics and science, create an increased awareness of engineering, understanding and being able to do engineering design, and increased technological literacy. They used Project Lead the Way's Gateway to Technology curriculum (PLTW) as their medium of STEM implementation.

The researchers noticed the largest challenge educators have with the implementation of STEM Education is a lack of tools and resources to set them up for success. Supporting teachers, teaching practices around STEM integration, teacher efficacy, and materials needed are the four areas of need the researchers honed in on. The researchers shared that throughout the year there were points where all of the teachers studied felt doubtful of their ability to implement the program to the fullest potential (Stohlmann, M., Moore, T., and Roehrig, G., 2012). They also noted that there was a divide between the teachers that wanted to continue PLTW and the other 75% of the teachers who did not. The teachers shared that their workload for implementing STEM education was overwhelming and they did not feel that it was attainable to keep up the year after working with the researchers (Stohlmann, M., Moore, T., and Roehrig, G., 2012).

Baker and Galanti (2017) created a school-university professional development collaboration on the integration of STEM education in K-6 classrooms. In the study, they worked with eight teachers from the same district who worked across five school sites. All of the participants were volunteers and had received prior STEM education. This study was conducted to create approachable STEM projects for integration in K-6 classrooms. They were given hands-on real world problem solving situations to work through with their students that focused on the combination of math and logic. These Model-Eliciting Activities (MEAs) focused on the incorporation of real life problems and engineering design process in open ended problem solving. The researchers believed that there would be more student and teacher buy-in if they gave the students situations relevant to their lives and personal experiences. They focused on ways to meet the grade level math standards through these activities.

Professional development was created for the elementary grade teachers with three main goals. They wanted to grow participants' experiences on a STEM curriculum integration, create a version of STEM integration through open ended math problems with real life contexts, and a focus on making math content approachable (Baker, C., Galanti, T., 2017). University researchers met with the teachers monthly for STEM professional development to model example lessons. The participants would then recreate these activities in their classrooms with their students. When the teachers were interviewed at the conclusion of the project, they shared that without prior STEM knowledge and one on one training that they would not have been as successful. They also noted that without the support of the researchers that the project would not have been a success. Six of the eight teachers said that they would continue to implement the STEM lessons into their teaching. Baker and Galanti's (2017) work with the K-6 educators allowed a partnership which opened their eyes to the school applications of their research. This collaboration provided the teachers with a deeper understanding of the ways in which STEM curricula can be implemented through their grade level math standards.

School Programs

The state of New Mexico is taking on STEM in a new way. They have created a statewide challenge asking students "How will you use science and technology to help with national security" (Bryan, S., & Associated Press, 2019). This was proposed as a statewide academic challenge as a result of the need for new employees at the Los Alamos National Laboratory. The lab is partnering with interested teachers and businesses to give students time to use what they have learned in class to come up with their own solutions to what the state feels is a large problem. This program began as a way to incorporate the new state science standards which focus on real world problem solving. The state hopes they can continue growing this program to ensure that their students have the skills to be successful in high tech jobs. Their goal is to encourage students to utilize this STEM way of thinking and promised jobs in New Mexico out of high school and college to students they deem worthy candidates (Bryan, S., & Associated Press, 2019).

The state noticed a need of skilled employees and chose to begin putting time, energy, and resources into their students to set them up for success in this career field. High school students will work in teams of ten on a semester long project to come up with their own solutions to this problem. At the end of the year, businesses will come in and look at the solutions students have come up with. They are encouraging students to think out of the box and state that there is no "right" answer. The groups will be judged on the quality of the work and the degree to which the answers use skills required by the businesses. This is giving students the unique opportunity to pair up with their peers and potential employers bridging the connection between high school classes and career opportunities.

High School Case Studies

At the time of writing this thesis the following high school studies were being undertaken.

On a smaller scale to the New Mexico discussion above, Friedman (2019) documents how the students from Brooklyn South high schools have been given a similar opportunity. They have been working with local businesses to learn about the connection between technology and various industries through project based learning. Students were selected as a part of this initiative to take on problems in a collaborative group setting with the assistance of seasoned professionals. Not all students from the high schools will participate, as it is both voluntary and students who volunteer must also be selected to participate. Student participants are then selected by their specific high school. Not all students from the high schools will participate, as it is both voluntary and the students who volunteer must also be selected by the high schools to participate. Selected students receive mentorship and guidance from members of the New Lab team along with professionals at companies including Farmshelf, 10xBeta, Blank Technologies, Terreform ONE, Voltaic and Shared Studios (Friedman, S., 2019). All of these companies specialize in different areas but are looking for forward thinking future employees. The program helps connect high school seniors by identifying potential job opportunities at these companies after graduation.

The New York initiative involves a smaller sample size and is focused on creating equal opportunities for all by focusing on “unstructured problems that lack rules-based solutions” through the lens of access and equity issues (Friedman, S., 2019, p. 2). The students will be creating solutions by combining a human centered focus with design properties. They will be working in conjunction with professionals from New Lab member companies. A key component of this initiative is that students will be actively working with the professionals throughout their entire process, which different from how the program in New Mexico is structured. The New York program infuses the entire process with more collaboration between the students and professionals instead of the New Mexico approach which has professional interaction and involvement only at the beginning and then again at the end.

In Philadelphia, Diallo (2018) documents how one high school is taking yet another or a third approach. In their district they have identified that in 2018 over half of the third graders were reading below grade level and by the 12th Grade only two thirds of high school students were graduating. In order to combat this the district chose to take action in a new way. The District chose an alternative approach toward providing education. Instead of continuing the traditional learning approach, the District felt that STEM education is the way of the future and have created STEM specific high schools designed around project based learning as an alternative for their students. The district believes that this extreme approach will raise engagement and give students the skills to be successful adults after graduation. The District has faced pushback as they struggle to uniformly assess knowledge gained through Project Based Learning (PBL) and STEM. Diallo notes how the standardized tests do not measure the depth and scope of their knowledge. "There's no [statewide] assessment for being able to look people in the eye and speak clearly." (Diablo 2018). The District has struggled with the concept of improving test scores as a priority or that of preparing students to be successful adults.

Philadelphia was chosen by the state of Pennsylvania to use as a pilot program because their district consistently fell behind on statewide assessments and they wanted a way to help bridge the gap for their students. The goal of implementing PBL is to give students the necessary skills for success in college or as they pursue specific career options after high school. One aspect of this approach focused on exposing students to the people in careers around them. Diallo details how freshmen attend field trips to local businesses each week to give them a better idea of where they would like to intern as sophomores. These aren't your typical ride the bus somewhere, get off and walk around looking at thing, then ride the bus back to school. Students actually engage with business owners and hear specifically from them what it takes to be successful.

One example described as a trip to a local restaurant, the owner discussed the challenges of owning a business like his. This owner emphasized the importance of teamwork, accountability, and looking at problems that may arise from a different point of view. He shared that playing the blame game doesn't help anyone, it just puts everyone further behind. First hand exposure provided to students allows them to select internships that will be beneficial. These experiences also give students exposure to first hand real world learning from actual business owners and they bring this new knowledge back to implement the projects they are working on at school. On these field trips students get exposed to many different career options which helps them as they select where they would like to work in the future. The school's goals and STEM assignments are tailored to students and their career choices in tandem with the local business owners and teachers at the school. Through this program students are presented with the opportunity to assess their own strengths and weaknesses while laying the foundation for their future employment and career readiness.

Middle School Case Studies

When looking at STEM education at the middle school level there are less wide spread programs in place. One study looked at a group of twenty-five seventh grade students and their opinions on STEM education (Ugras, M., 2018). They found that there was a significant difference between STEM attitudes, scientific creativity, and motivation beliefs of the students. This study questioned if student attitudes towards STEM directly correlates to their success. It noted that there is not a lot of previous research on the topic that includes the participation of students. Several studies from which they gathered background information only looked at quantitative data but these researchers choose to look at a combination of quantitative and qualitative material. They focused on STEM learning as a holistic approach to teaching students 21st century skills (Ugras, M., 2018). There was a significant difference between the pretest and posttest scores eight weeks later. They found that the STEM activities helped improve the student's view on STEM. When the class had a connection to the project at hand, they became more attentive and engaged in the subject matter. Their discovery was aligned with the reading and research that had been previously done in other studies. The students journaled each week and, at the end of the study, the researchers read over their journals. Although several students shared that they did not find science interesting initially, almost all of the students said that they had fun working on these challenging assignments. When the students were engaged in the hands-on learning, they were more invested in the assignments and embraced the challenges presented head on (Ugras, M., 2018).

This study shows a direct correlation between interest and achievement. The study looked at the class as a whole to find a way to look at their growth, change in opinion, and viewpoints without sitting down and interviewing all of the students one on one each week. The student's journals gave a weekly look at the student's views and opinions regarding STEM. This was easily trackable and gave the researchers valuable insight to thoughts the students might not have otherwise shared.

Similarly, Stohlmann, Moore, Roehrig which utilized Project Lead the Way (2012) to conduct a project on a larger scale. While this study did not go into as much detail on the students as it did with the teachers, there are still some important takeaways. Both studies utilized groups of middle school students, had teachers who received direct training from college educators, and gave educators specific lessons to teach the students (Stohlmann, M., Moore, T., & Roehrig, G., 2012 and Ugras, M., 2018). The study conducted by Ugras, was more student based. It monitored student's opinions, beliefs on STEM education, and read their weekly journal entries which showed the evolution in their thoughts in relation to the STEM education they were receiving. By focusing on the students, the researcher was able to more clearly see the connection between STEM implementation and student agency. The study utilizing PLTW, gave the researchers rich data, but it was focused solely on their perspective as educators. Their data outlined the challenges and triumphs the teachers felt, but neglected to comment on the student experience. This is common among many of the current published studies on STEM education across the board.

Elementary School Gaps

When looking at STEM education in the elementary school classroom, there were not any published studies examining elementary STEM education. There was a first person account from a fifth grade teacher in North Carolina. Mr. Johnson used a combination of the Defined STEM program and his district curricula. He focused on placing his students in real world settings where his class worked on projects and research using teamwork (Johnson, A., 2017).

He began the year by giving his students a PASSPORT (Preparing All Students for Success by Participating in Ongoing Real-world simulation using Technology), simulating the challenges of adulthood, and allowing students to experience real-world situations to gain insight on global affairs (Johnson, A., 2017). He views his room as less of a classroom and more of an interactive city named Johnsonville "where all projects intertwine to create an ecosystem of businesses and homes" (Johnson, A., 2017). At the start of the year students are given Johnsonville cash, buy or rent a home, run for jobs to earn an income, and use their math skills to create a budget. He thinks this method is successful because students in his community see their parents facing the same problems. Johnson feels it is successful because relevant content makes his lessons relatable, it encourages collaboration through PBL projects, flexible seating, and an emphasis on critical thinking. Although his methods may be unconventional, his students consistently score higher in science than other schools in the district. On average, student in the other fifth grade classrooms at his school site score in the 58th percentile in math and science while his students score in the 85th (Johnson, A., 2017).

There is a disparity in the research on STEM education across the grade levels. There are an abundance of schools and programs focused on STEM education at the high school level, but there is a significant drop off in research at the middle and elementary school levels. There is also a disproportionate amount of money focused solely on high school students. Of the $3.1 billion dollars Obama's administration invested in federal programs promoting STEM education, 97% went to high schools, with the remaining 3% devoted to middle schools (Hom, E., 2014). While the need for STEM education is occurring across all age groups, the vast majority of funding is focused on high school programs. If money was reallocated or additional money was available across the grade levels, students would have more of an opportunity to begin bridging the STEM achievement gap and developing a passion for science, technology, engineering, and math at a younger age.

The research shows that there is not one specific model or set of standards for STEM education, but instead there are a group of core values and ideas associated with STEM. STEM learning focuses on teaching students to be critical thinkers, use perseverance, teamwork, and develop global awareness. When looking at STEM guidelines many educators refer to the frameworks created with Next Generation Science Standards (NGSS), International Society for Technology in Education (ISTE), the Common Core Standards for Mathematical Practice (CCSS), and the Standards for Technological Literacy through the International Technology and Engineering Educators Association (ITEEA) (Slykhuis, D., Martin-Hansen, L., Thomas, C., & Barbato, S., 2015). They stressed the importance of STEM integration in a meaningful way, create time and a space for all students to engage in STEM activities throughout the school day (instead of in after school clubs or specialized classes), and further training for teachers. There were many similarities between all of these frameworks but each added their own ideas to what appear to be the fundamentally agreed upon models. They all mentioned the importance of communication, analyzing and interpreting data, and critical thinking. All of the frameworks connected with making sense of problems and persevering through them, construct viable arguments/explanations/solutions, using creativity and innovation, and obtaining, evaluating and communicating information.

Conclusion

As this literature review illuminates, there is a shocking disparity in the levels of STEM education offered at the elementary school level compared to middle and high school. The research highlights and identifies that the earlier students are introduced and engaged in the

STEM fields, the more likely these students are to foster a passion for the science, technology, engineering, and math fields (Sanders, M., 2009). This thesis is being conducted as a way to share the advantages of STEM education, sources for implementation, and how to overcome some obstacles that may arise for teachers along the way. This research project will shed light on how elementary school teachers feel about STEM education, the ability they have to implement it, the curricula they are able to access, and the challenges that arise with implementation. Teachers have been selected from various backgrounds to illuminate light on the many different ideas and styles of implementation. It also allows teachers to discuss the ways in which they are trained, the funding and curricula they have access to, and the pricey challenges that can arise. Research will be conducted through dual modalities in an effort to hear from teachers of all backgrounds and experience levels. Obtaining data from a variety of educators will shed light on a deeper understanding of the ways in which other teachers incorporate STEM learning, the challenges that they have faced, and how they have worked to overcome these obstacles.

The challenges include a lack of funding, minimal or lacking training opportunities, limited curricula options for schools, the cost of one time and reusable resources, an unwillingness of teachers and administrators, and a lack of time to implement any additional curricula. The teachers comment about the lack of funding set aside for STEM education. Many schools are struggling to afford the new curricula with implementation of Common Core State Standards and the Next Generation Science Standards (Freidman, 2019). Schools and districts are stretched to their limit budget wise (Plank, L., 2017). There is a lack of curricula offered for elementary school STEM (Shuda, J. R., Butler, V. G., Vary, R., Noushad, N. F., & Farber, S. A. 2019.) Most teachers who implement STEM in their elementary school classrooms are creating all of their own curricula (Johnson, A., 2017), reaching out to other educators online for assistance, and spending their own money on the addition of STEM into their curricula.

As detailed in Shuda, J. R., Butler, V. G., Vary, R., Noushad, N. F., & Farber, S. A. (2019), another large challenge arises with the lack of training options available for teachers. There are many math or science specific trainings available to teachers, but very few specifically created for the benefit of STEM educators. Even when potential trainings arise, many teachers noted that their schools' sites would not fund attending these trainings. They feel that their employees should be more focused on receiving training in language arts and math (Plank, L., 2017). These schools are concerned with test scores in these areas and place a higher value on them. Most teachers implementing STEM education are creating their own curriculum, purchasing from other educators from sites like Teachers Pay Teachers, or working with other interested teachers at their school site, or collaborating with online groups such as Facebook.

STEM curriculum also comes with a large price tag. In addition to purchasing curricula teachers also need to pay for the cost of resources, many of which cannot be used more than once. In many cases these teachers are using their own money to supplement their classroom budgets. The materials that can be used for multiple projects and activities can be very costly. Materials like tape, paper, and aluminum foil tend to only be used once. While the initial cost of these items are relatively low, consistently purchasing additional resources begins to add up. For lower income schools, these seemingly minor costs to some teachers are a defining factor in why other teachers are unable to implement STEM education (Lewis, C. W., Capraro, R. M., & Capraro, M. M., 2013). Another large setback for others is the cost of the technology component that comes along with STEM. This is easier for schools who already have access to laptops, tablets, 3D printers, laser cutters, and coding software for their students. Projects and activities that may appear to be simplistic are not always cost efficient. Schools are also facing pushback from some teachers and administrators who do not feel that STEM education is worth the time, cost, and curricula that it entails. Without the support from the staff and administration STEM implementation is more challenging to begin. Across the board, teachers have voiced their concerns meeting their minutes for all of the other subject areas (Plank, L., 2017), Johnson, A., 2017, and Stohlmann, Micah; Moore, Tamara J.; and Roehrig, Gillian H., 2012). The days seem to fly by and there never appears to be enough time in the day to get through what is required, let alone teach what they would like additionally. Teachers are feeling challenged to accomplish teaching all of the standards as is (Johnson, A., 2017 and Shuda, J. R., Butler, V. G., Vary, R., Noushad, N. F., & Farber, S. A., 2019).

There is a large gap in the knowledge when looking at STEM education at the elementary school level. The research notes that students are more likely to become engaged in science, technology, engineering, and math when they are exposed to in a hands-on way. The earlier students experience these subjects, the more likely they are to foster an affinity for the pursuit of them. Although research notes on the importance of early exposure, they do not have concrete examples of STEM curricula incorporation on a wide scale in elementary schools. The research shows the need to start at a younger age, but money is not being placed into elementary education for STEM learning (Sanders, M., 2009).

The goal of this research is to illuminate the ways in which teachers are teaching STEM education to students, the curricula they are using, the challenges that they have faced, and how they have worked to overcome them. By compiling this research and sharing it, other educators who are interested in implementing STEM education or who are looking at ways to add to their knowledge will develop an understanding of how other people have successfully implemented

STEM education into their classrooms. In an area with limited resources, budget, and time, the goal of this research is to create an easy to implement model for teachers looking to teach STEM. The goal is to create more tools for teachers looking to begin their own STEM journeys in their classrooms. STEM can appear to be a daunting undertaking for many educators. Hours of planning, many resources, and a lot of money goes into creating and teaching STEM education. It is not an easy undertaking. There are many things to consider when beginning to create a STEM curriculum. Each teacher must decide when and how to implement it, how it aligns with the curricula in their school, how frequently to implement it, and the amount of changes that they would like to improve upon. This thesis will take a deeper look into STEM implementation in the elementary school classroom, interview teachers who use STEM curricula, and survey teachers across the United States on their experiences.

Chapter 3: Methods

The purpose of this study is to gain a deeper understanding of the role STEM education plays in the elementary school classroom. When looking at STEM education as a whole, there is a large disparity in the implementation across grade levels. STEM learning teaches students to ask questions, think outside of the box, plan carefully, create new things, revisit their ideas and improve upon them, perseverance through challenges, stay open to new ideas and other points of view, and flexibility (Johnson, G., 2019 & Shaffer, L., 2018).

Research Questions

This research was conducted through a holistic approach as a qualitative study focused on a combination of survey responses and individual interviews. The survey and interview questions were based on the following essential questions:

How does STEM education impact student behavior and agency in science, technology, engineering, and math?

What challenges do teachers face when implementing STEM education into elementary school classrooms?

Description and Rationale of Research Approach

To research STEM education in elementary school classrooms, I conducted qualitative research using two modalities to gain a broader understanding of teacher's views and opinions regarding STEM education. Qualitative researchers ask open-ended questions to validate the accuracy of their findings, evaluate data, and strive to create educational reform (Creswell, 2008). This approach involves collecting and evaluating data gathered through surveys, interviews, and observing participants. The research was conducted through the lens of constructivism. This lens was selected to examine STEM education through social and historical lenses of development, diving into theory generation, looking at collaboration, and inspiring others to create a change (Creswell, 2008). The researcher worked to understand the different perspectives and obstacles that may be preventing STEM education from occurring on a wider scale in elementary school classrooms.

The researcher utilized a mixed methods phenomenological research approach (Maxwell, 2013, p.102). The phenomenological approach dove into the diverse perspectives and worldviews of the participants in this study (Creswell, 2008). This focused on the distinct importance of acknowledging the lived experience of all of the teachers interviewed and acknowledged the specific biases and worldviews of these educators.

A cross-sectional survey asked teachers questions related to math and science implementation at their school site, the level of choice educators have in the curricula they use to instruct their students, and their thoughts and experiences regarding STEM education. The survey explored a more complete picture of student and teacher attitudes towards STEM education across the United States, with particular interest in identifying inequities. The survey allowed for a deeper understanding of the topic from a greater number of differing points of view and lived experiences (Creswell, 2008). The different perspectives of elementary school educators provided the researcher with the opportunity to discover unexpected insights, such as first-person narratives, different strategies used for implementation, and a deeper understanding of the challenges that have arisen for these educators while implementing STEM education in their classrooms.

This research further implemented a phenomenological approach by interviewing four educators with differing STEM experience (Creswell, 2008). The researcher held two, thirty-minute interviews with each of the interview participants. The first interview discussed their introduction to STEM, experiences implementing STEM curricula, observations of their students during STEM, and the challenges they have faced through the addition of STEM curricula to their classes. The second interview discussed a STEM project they worked on with their students. The researcher asked questions about the strengths and struggles of the project, the successes their students achieved, the obstacles their students faced and how they overcame them, and the changes they would make if they were to redo the STEM project. This study discusses the inequities of age access, gender, race, and funding in STEM education. Research has shown that some educators who have shown interest in STEM do not feel they have the proper training for successful implementation in their classrooms (Shaffer, L., 2018). Other teachers worry about the financial cost that comes along with STEM (Shaffer, L., 2018).

Research Design

Research Sites and Entry into the Field

The survey participants were invited through an elementary STEM education Facebook page. This group is made up of elementary teachers from the United States who are all implementing STEM education to some degree in their classrooms. These teachers have a wide variety of STEM training, implementation styles, and views on STEM education as a whole. This Facebook group is used by teachers to share projects they are working on in their classrooms, to ask for ideas and suggestions from other educators, and to share insight and provide support with other educators interested in STEM.

The interview participants all worked at a private K-8 school in the bay area. This school has roughly 280 students and an average of 14:1 student to teacher ratio. It is an Apple Distinguished School that implements Stanford's Challenge Success Program. The student population is made up of 70% white students, 10% of students with two or more races, 9%

Hispanic students, 6% Asian students, 4% African American students, less than 1% American Indian, and less than 1% Pacific Islander students. 56% of the student body are female and 44% are male. The students at the school consistently rank in the top 10% nationally in STAR Testing of Basic Language Arts and Mathematics.

Participants

All participants either previously had or were currently teaching STEM in elementary school classrooms at the time of this thesis. All of the participants were teachers currently working at elementary or K-8 school sites.

Survey Participants. Fifty elementary teachers participated in the Facebook posted Google survey as a part of this study. All names have been removed and teachers are referenced with a letter instead of a name. The researcher did not have any prior relationship with the survey participants. The teachers surveyed teach across the United States of America in kindergarten through fifth grade elementary school classrooms. These teachers have a variety of educational backgrounds, differing school environments, socioeconomic status, and various levels of administrative funding and support. The use of this survey allowed the researcher to access a broad group of educators and allowed for the researcher to hear about the differing triumphs and tribulations that these respondents provided at varying school sites.

Teacher Interview Participants. The four teacher participants interviewed in this study are of mixed ages and levels of teaching experience. This sample of teachers include all native English speakers who have taught across four states and have over fifty combined years of experience. These teachers were solicited through the researcher, who has previously worked with all four educators. The study relied on a population of experienced STEM educators with diverse teaching backgrounds. For this specific study, the selected population was desirable because each teacher came to the table with different types of STEM education, implementation, and experience levels across the desired grade levels. This purposeful selection allowed for differing perspectives and a broader look into STEM education and implementation as a whole (Creswell).

Sampling Procedure

Survey Participants were invited from a STEM Facebook group and self-selected by clicking on a link to the Google survey that was posted to the group page. The survey began with a consent form outlining the researcher's thesis project, the procedures, potential risks and/or discomforts, and benefits of participation. Before beginning the survey, teachers selected to confirm they agreed to allow for their data to be included in the thesis findings. Surveys took the teachers roughly fifteen minutes to complete.

The individual teacher interviews were conducted in the teacher's classroom during times of their choice. Before the first session with each teacher, the researcher went over the consent form and had the participant sign allowing for their participation in the study.

Teachers were presented with the interview questions ahead of time allowing them to know exactly what was going to be asked of them before signing the consent forms. The interview questions were designed by the researcher to gather information on the participant's experiences with STEM education, their observations of their students during STEM activities, and the challenges they have faced. Sample interview questions from Appendix C (#1, #3, and #6)

> When did you begin using STEM projects in your classroom? Has your school been supportive of your choice to implement STEM education?
>
> What do you notice about your students when they work on STEM assignments?

> Teachers who do not currently use STEM Education in their classrooms tend to comment on three major issues they see. They feel that there is a lack of curricula, a lot of expenses that go into completing STEM projects while using materials that can not be used again, and a lack of funding and support from the school. Did any of these problems arise for you, and if so, how did you work to overcome them?

These questions allowed the researcher to look at STEM education through the perspectives of these four teachers who have varied levels of training, resources, and experiences. The researcher also let each teacher know that follow-up questions might be asked during the first or second interview to gain deeper insight into the observation and experiences of the participants. All of the participants felt at ease reading over the questions ahead of time. This pre-interview preparation allowed the researcher to utilize the entire time for each interview and ensured that participants were not caught off guard by any of the questions asked. This led to thoughtful responses from the participants and allowed for more meaningful dialogues between the participants and the researcher.

All of the interviews were recorded through the researcher's cell phone using the Voice Memo application. During each interview, the researcher also took notes in a binder detailing the participant's body language, inflection and tone of voice, connections to the researcher's own experiences and the experiences of other participants, new findings shared, and key insights into their experiences with STEM education implementation. The combination of an audio recording and notes from the interviews allowed the researcher to reflect upon each interview and draw upon the similarities and differences expressed between the participants in the dialogue, expression, and insights into the STEM education.

Data Analysis

Data from the survey was collected and automatically stored via Google Forms before coding and triangulating (Creswell, 2008). Survey data was analyzed aggregately and individually toward a holistic assessment. Interview data was categorized and coded with concept mapping and open coding focused through the lens of constructivism (Creswell, 2008).

Survey Analysis

Responses were concept coded before the assignment of initial codes. When completing concept coding themes of student engagement and collaboration, self-taught STEM teachers, and 21st Century Skills emerged. Next, the data was open coded to determine the underlying themes not gathered during the initial concept coding. The researcher went through all of the data a second time, looking for any connections or anomalies missed upon the first analysis. During open coding themes of inequality, cost, and teacher innovation presented themselves. The researcher placed the codes in groups to create a concept map which was utilized to determine the themes. This led to the comparative analysis which presented further connections between STEM education and the implementation of 21st Century Skills. A clear connection emerged between the lack of curricula and the inequity between opportunities presented across sites limiting teacher opportunities for STEM exposure.

Interview Analysis

Both interviews with each teacher were audio recorded for analysis and notes taken during these interviews were transcribed and stored electronically. Teacher interviews were initially looked at through concept coding. Concept coding focused on looking at the initial themes that emerge from the interviews. The interviews brought up themes of out of pocket expenses, increased conflict resolution skills, and teachers who were self-taught out of a lack of opportunities provided. The researcher then went through the transcriptions a second time open coding looking for any missed topics and concepts not coded through the initial analysis. Upon further analysis the themes of peer relationships, single use product waste, and limited curricula arose. The researcher took the coded information to create a concept map allowing for comparison analysis between all of the interviews.

Holistic Analysis

The researcher gathered all of the data from the survey responses and interviews to look at the information through a holistic approach. This approach was selected in order to view elementary STEM education through multiple perspectives. When looking at the themes presented through coding the surveys and interviews, many different points of view arose. Selecting this research approach allowed for the varying experiences and views to be explored and discussed. The researcher took the concept maps created from the survey analysis and interview analysis to create a combined concept map focused on the key findings of the data. Holistic analysis allowed the researcher to take the insights and opinions of participants and give them a voice in the research. The lived experiences of the participants led to themes focused on the teachers implementing STEM, their personal takeaways, and the challenges they have faced.

Validity and Reliability

The triangulation of data between the survey data and both sets of interviews increased the validity of the study through procedures for qualitative reliability. The researcher checked for accuracy of the findings by employing specific procedures (Creswell, 2008, p.199). These procedures included conducting all interviews in quiet locations, using the same questions in each interview, recording each interview, and transcribing all of the interviews verbatim to ensure that information was recorded and coded correctly. The researcher worked with all of the interviewed teachers previously. These working relationships allowed the researcher to utilize her prior knowledge of the interviewee's teaching styles and classroom environment to gather a deeper understanding of the thought process between their projects and overall teaching style. Respondent validation was used by soliciting feedback and data from the teachers interviewed (Maxwell, 2013, p.126). This helped ensure that data was not misinterpreted and the participant's points of view were represented accurately. The researcher also relied on discrepant evidence and negative cases. This involved rigorously assessing the supportive and negating data to determine if it retained or modified the conclusion without allowing it to be impacted by personal bias (Maxwell, 2013, p. 127).

The researcher has prior experience implementing STEM education and working with the teachers interviewed. She taught math and science for 1st-4th grade students at a K-8 elementary school. The researcher was first introduced to STEM education while student teaching with her mentor teacher. Creswell states that the most meaningful research often arises from relationships that involve trust and prolonged working time leads to more accurate findings. The mentor teacher took a group of resistant learners and captivated them with the innovative STEM projects incorporated into their curricula. Students were enthralled during these lessons and the researcher was inspired by the overall engagement and excitement in the classroom. The researcher took her prior experiences and observations with STEM education into account while conducting the research. Instead of inserting her own experiences, the researcher focused this thesis on the experiences and voices of other STEM educators.

Chapter 4: Findings

This thesis sought to discover whether there is a connection between student behavior and agency in science, technology, engineering, and math when students receive STEM education. This study also sought to find the challenges that arise during the implementation and teaching of STEM education, as well as the ways in which teachers have overcome them. The results of the research confirmed my hypothesis.

After reviewing the teacher survey responses and concluding this study, the findings show that while all teachers see the benefits of incorporating STEM education into elementary school classrooms, and approximately half identified they are struggling to maintain STEM programs. These teachers acknowledged the positive benefits STEM adds to their classroom environments, but these educators are also bogged down by other school requirements. Many cite a lack of time in the school day, the cost of single use materials, and a lack of access to relevant grade level materials. STEM curricula quickly becomes expensive and these costs are not included in most classroom budgets. Teachers are finding that in order to purchase the materials and curricula for STEM, they are losing out on budget money for other key areas in their classrooms. Although the curriculum is a one-time purchase, teachers need to keep buying single use materials to complete most of these projects. Teachers are faced with the decision to reallocate money from other parts of their school budget or pay for the supplemental materials out of pocket in order to add STEM education to their classrooms.

Teachers also say that since many of their schools have recently purchased new curricula in alignment with the Common Core State Standard and the Next Generation Science Standards that their schools cannot justify spending money on STEM specific curricula. Most of the teachers interviewed stated that they pay for their STEM curricula out of pocket from websites like Teachers Pay Teachers. This allows them to pick and choose the specific activities that align with their in place curricula as an add on instead of trying to purchase curricula for the entire school year. Over half of the teachers interviewed stated that they complete one STEM project per month and only a quarter of the teachers interviewed use STEM multiple times per month.

Several overarching themes emerged when closely examining the survey data and teacher interviews. First, teachers feel that there is value not only academically, but also in regards to social emotional learning when incorporating STEM education into their classrooms. As a result of the findings of this research these emerging interpersonal problem solving skills are defined as increased conflict-resolution skills. Second, while all surveyed teachers see the value in STEM education, many do not feel they have the skills and tools for sustainable STEM integration. This leads to the second theme of teachers who are educating themselves on STEM education in place of formal trainings which are unavailable to them and defined herein as teachers who are self-taught out of a lack of opportunities provided to them. Lastly, while all teachers interviewed see the value STEM education adds to their classrooms, many of the challenges with funding, a lack of time to implement STEM, and the challenges of finding relevant affordable curricula prevent them from implementing STEM education into the classroom on a regular basis. This theme refers to the out of pocket expenses STEM can add to elementary school classrooms. In summary, these findings will focus on increased conflict-resolution skills developed by students who participated in STEM, teachers who are self-taught out of a lack of opportunity for formal training, and out of pocket expenses that are incurred in order to provide STEM training. .

Increased Conflict-Resolution Skills

Fifty teachers were interviewed in the STEM survey, and all fifty participants unanimously agreed that a higher percentage of students are more engaged in integrated STEM learning than they are in single subject assignments focused on science, technology, engineering, and math. The teachers have varied levels of choice in the science, technology, engineering, and math curricula taught in their classrooms, the ways in which they implement STEM education, and the frequency of STEM learning in their classrooms; but they all agree that STEM adds value to their classrooms.

Interdisciplinary Empowerment and Fun

STEM learning gives students a way to access their current curricula through interdisciplinary connections, and students who struggle in one subject area are able to pull their knowledge from the other areas which to allow for building connections and a deeper understanding across the curriculum. For example, one survey respondent offered that:

> Students feel connected to STEM learning because it requires creative thinking and does not have one 'right' answer. There are seemingly endless possibilities that allow for students to use the knowledge that they already have to solve problems in a new light.

The teachers also noticed an overwhelming difference in the attitudes of the students and an increase in their productivity. One respondent drew attention to how the integral quality of STEM learning creates a more fun learning experience: "STEM has this way of hooking even the students that aren't usually engaged with these subjects on their own. Something about the way in which they are brought together makes it more fun." The teachers surveyed noted higher levels of thinking and engagement that arise from working on STEM assignments. STEM learning allows students to work on collaborative hands-on assignments that link their prior knowledge and understanding to new possibilities. One teacher shared:

> I notice higher engagement, enthusiasm, and improving teamwork and communication within my classroom. Since the beginning of the year, students have become more focused, aware of time management, and collaborative. I see the transformation STEM education brings to my classes each year.

This resonated with several of the survey responses. Over 90% of teachers surveyed noticed an increase in overall class engagement during STEM activities. There were many examples of teacher survey responses using the phrases “higher engagement,” “collaboration,” and “teamwork” when describing the positive changes in the classroom. Teachers see their students getting excited about what they are working on and have fostered classroom communities where “students are not afraid to fail…they go back to the proverbial drawing board and try again.”

Communication Skills and Shared Knowledge

Teachers noticed the communication skills of their students growing throughout STEM learning. STEM requires students to work in tandem with other students and requires teachers to teach students problem solving strategies. Survey participant Teacher P noted, “The students quickly learn that the more time they spend arguing, the less time they have to complete the activity.” Students would see their peers working hard and having fun while they were waiting around for the teacher to come solve the interpersonal conflict for them. Instead of relying so heavily on the teacher, students began to implement the strategies modeled in their classrooms. Interviewed teachers shared the many ways they have worked with their students on problem solving strategies including roshambo, taking a vote, and combining parts of all ideas presented. Survey Participant L shared:

> When we first began STEM our students would waste away a significant amount of time bickering amongst themselves. The students complained about not having enough time to finish their projects. Instead of adding more time to STEM we held a class discussion to address why the students felt they needed more time. It came to light that they spent a lot of time in disagreements waiting for me to come settle the problem for them. For the next three projects, one member of each group was responsible for tracking the minutes spent on disagreements. The students quickly realized that they were spending close to ten minutes per activity arguing. This created a shift in the classroom. My students began taking a majority rules vote or alternating on who got to make the final choice during disagreements. This gave my students the time they needed to complete their assignments and showed them that there are more important things in life than always being 'right.'

Interview participant Teacher B also noticed that aligning STEM activities to their in-class curricula helped instill the concepts and shared knowledge among the students. This allowed for the students to retain more of what they were learning about in their math and science curricula and then check for understanding, allow for deeper exploration, and clarify in any places it was needed. She connected it to a unit her class was completing on understanding mining during the Gold Rush. She described how each pair of her students were given a piece of grid paper with different resources printed throughout several areas of the paper. The partners were then given a chocolate chip cookie, marker, and two toothpicks. They were asked to choose a spot on the paper to place their cookie, note the resources it covered, and trace around it with a marker. The teacher set a timer for one minute and the first student had that amount of time to remove as many chocolate chips as possible. When she called time, the students switched positions and the second student took over mining chocolate chips for the last minute. When the teacher called time everyone stopped where they were, and the students took a picture of their entire piece of graph paper. This consisted of the remains of the cookie, the pile of chocolate chips, and the mess made along the paper. Students tallied the amount of chocolate chips mined, the resources that were covered in the cookie or cookie crumbs that had been "destroyed" through the mining process, and then worked with their partners to research the long term effects of what would happen to the land if these resources were impacted through mining.

Teacher B said the students were outraged and she heard comments such as "but you didn't tell us this would happen," "well I want a redo," and "they're destroyed I can just move the cookie." She referred back to the gold rush miners and asked, "Did the miners know what they were going to do to the environment and the lasting impact it would have? Did they get a redo when things didn't go their way? Could they just put the gravel deposits back into hillsides after hydraulic mining?" The teacher wanted students to realize that while we have endless possibilities in STEM, we do not have endless resources. This seemingly simple activity helped connect students to the real world implications of the results of our actions. By Teacher B aligning the class STEM activities to her in-class curricula, she was able to help instill the concepts and shared knowledge among her students. This allowed students to retain more of what they were learning about in their math and science curricula, while allowing Teacher B to check for understanding, allow for deeper exploration, and clarify any concepts as needed.

Safe, Secure and Cooperative

STEM learning allows students a safe and supportive environment to overcome many obstacles. It allows them to remove their fears of failure, overcome disagreements respectfully, and foster a little bit of healthy competition. Incorporating STEM education in elementary schools allows students to take risks without being too hard on themselves if things don't go according to plan the first time around. Teacher C shared that she encourages failure and begins her first STEM assignment of the year with the Thomas Edison quote " I have not failed. I've just found 1,000 ways that won't work." It is important to set students up with the expectation that STEM is not a one and done kind of thing. It requires trial and error, looking at the problem from different perspectives, and learning from your mistakes.

A little over a quarter (thirteen out of fifty, or 26%) of the surveyed teachers noticed a healthy sense of competition in their classrooms during STEM activities. One surveyed teacher shared "My students are extremely competitive. STEM helped them channel their sometimes harmful competition from recess into something positive in the classroom." He, and several other teachers, have seen their students' competitive nature come out in the classroom in healthier ways. He went on to share that in his classroom he spent the first month of school working with the class on positive ways to be competitive in the classroom. This included self-competition by striving to be the best version of oneself, team competition working collaboratively to create the strongest final product, and class competition cheering on their peers to be the best versions of themselves.

Self-Taught out of Lack of Opportunities

Teachers are the driving force behind STEM implementation in elementary school classrooms. All of the teachers interviewed touched on the benefits as well as the challenges that they have faced through their experiences with STEM education. Eighty-two percent (41 of 50) of the teachers surveyed shared that they felt underprepared to teach STEM as a result of the lack or nonexistent training opportunities in their area. Without any STEM trainings, they were reliant on other teachers, the help of teaching blogs and groups on Facebook, along with curricula from websites including Teachers Pay Teachers to begin to educate themselves on STEM.

Interview participant Teacher C worked with her students on creating Rube Goldberg projects. She began the unit by teaching students about Rube Goldberg by showing videos created by other students inspired by his cartoons, and had the students sketch out ideas of their own. The students were divided into groups of four to five and instructed to work together to create a four-step machine utilizing five specific materials (duct tape, paper straws, aluminum foil, popsicle sticks, and a rubber ball). Students spent the first week discussing ideas, writing down the steps, and drawing a blueprint for their machine. During the second week, the students who had completed their blueprints began building and testing their machines. During week three all students worked on building and testing out their machines. At the end of the week each group member wrote up the things they were proud of and the things that needed to be modified. During the last week students made their final changes, set up their machines around the classroom, and took turns demonstrating their machines to the class. Not all of the machines were fully functional. After all of the groups shared, Teacher C had the students independently write down what they would change about their machine if they were able to use all that they had learned from the month long project and start all over again.

On the positive side of the experience, she was surprised by the deep connections her students were able to make while reflecting on their projects. Students noted their need to (1) use their time more effectively, (2) listen to the advice of their peers in other groups having more success than they had, and (3) let themselves take risks. She shared that there were two types of groups on this activity; the students who threw caution to the wind and went all out testing their wildest ideas and the students who were more focused on just having something work therefore not giving themselves the freedom to be as creative as their peers. Ultimately, projects from both groups had some that were successful in meeting their goal and others that were not. By the end of the project her students saw the merit and hindrances of both strategies, realizing that the best STEM projects come from finding that balance somewhere along the middle of both ideas of thought. However, the teacher also shared feeling overwhelmed by the chaos that took over her classroom during the second and third weeks while students were working. "I felt like I couldn't hear myself think, let alone believe that the students were able to get any work done." She took it as a moment to reflect upon her own teaching and establish new rules for the classroom, and noted a variety of challenges she felt unprepared to handle. She shared how students felt they needed to communicate with each other without shouting across the room. They also began hoarding supplies which led to other groups not having what they needed to work on their own projects. She reestablished rules in her room for STEM activities including using inside voices, walking carefully around the classroom, and only taking the materials you needed for the day. When she implemented these new rules and students began to realize how much time they were wasting arguing over the color of duct tape they were given, she noticed a switch in the mindset and productivity of her students.

When reflecting back on the Rube Goldberg unit as a whole, she came to three specific takeaways. First, students are capable of far more than we give them credit for. She asked students to complete at least a four-step machine but all of the groups exceeded this number. Second, the implementation of this project would have gone smoother if she frontloaded her expectations more than once and spent a day running through problem solving strategies. The largest obstacles her students needed to overcome resulted from a lack of setting clear expectations and setting boundaries from the start. Third, she would have given students a specific goal to have their machines achieve, such as getting a ball into a cup or popping a balloon so that there was a clear end goal in place for all of the students.

All of the teacher interviews shared several insights into the thought processes behind their ways of thinking and how they would modify their STEM lessons if they were to teach them again. They agreed that taking a look back and reflecting on their teaching helped them add to their own notes and will be something they look back on next year before teaching the activity to a new group of students. Teacher A shared "In STEM we are always asking our students to look back at what they know in order to shape their next idea. It's only fitting for us to do the same". As teachers, it is hard to not get caught up in the day to day flow and allow time for regular self-reflection. Three of the four teachers interviewed said they do not regularly take time to look back on their teaching but that it's something they want to implement into their personal growth plans going forward.

Out of Pocket Expenses

Teachers have hit on three main struggles regarding STEM implementation. There is a lack of funds for STEM specific teacher training, the high cost of STEM materials and curricula, and the waste created by single use materials. There are limited areas that provide teacher training in STEM education at the elementary school level. In the survey one teacher noted that while she was able to find a STEM conference relevant to grade level, her school said that they were unable to pay for it, but managed to find the money for one of her peers to attend a language arts training at the same price. Administrators in many schools would rather put money towards language arts training or math specific training over STEM. Several teachers shared that while their schools are in support of them adding STEM education into their classrooms, many cannot financially contribute. These teachers are looking online in order to find relevant training materials and educate themselves. Eighteen percent (9 of 50) of these teachers shared that they felt unsure of their implementation and were hesitant to continue using STEM education in their classrooms. They cited “a lack of classroom management”, “an inability to answer their student’s questions”, and “self-doubt” as main contributors for not pursuing STEM learning in their classes.

Self-Reliance and STEM Costs

Many of the teachers interviewed are taking training into their own hands and searching for online programs to help fill in the gaps they see when implementing STEM. Several rely on free resources, groups of other teachers through Facebook groups, talking to other teacher friends who have received STEM trainings or have experiences using it in their classrooms, and paying for materials on websites like Teachers Pay Teachers to help supplement their STEM knowledge. These educators have found support from these online communities but others feel they don’t have enough time in the day to accomplish everything they need to in their classes while also pursuing STEM training. These teachers shared that they would be more willing to pursue online training if the school would allow them to utilize some of their staff meeting/professional development time in this way. This makes teaching STEM something that falls almost entirely back on teachers. They are choosing to give their free time to educate themselves in order to provide their students with STEM education.

Another huge challenge for teachers is the cost of STEM. Of all of the surveys completed, there were only two teachers who identified that their schools purchased STEM curricula. This means the other ninety-six percent (48 of 50) of the teachers surveyed are left with the decision to either create all of their own curricula or pay out of pocket for lessons off of websites like Teachers Pay Teachers. Educators are faced with the challenging decision to fund

STEM education out of pocket or by reallocating their classroom funds towards STEM. While the curricula is a one-time purchase, most of the cost of STEM education comes as a result of single use materials. These include things like pipe cleaners, notecards, tape, popsicle sticks, etc. that are never quite the same after their first use. While these items may seem relatively inexpensive initially, the price quickly adds up. Teachers are left to determine if their money should be spent on these single use items or if their money would be better used elsewhere on items that can be utilized more than once.

The price tag on single use materials are not the only issue these items present. Several items for STEM projects are used once and unable to be used again. Many of these single use items are not recyclable and go straight into landfills. Few teachers shared their concerns for the waste that STEM education can create. One teacher shared "at the end of STEM projects students tend to disagree on who should take home the project. I alleviated this problem by having the students keep the projects at school." Many teachers noted a challenge of STEM education is the lack of space to store large STEM projects. Most of these larger STEM projects are not single day activities. They are lessons that take place over multiple days or weeks. Classroom teachers do not have the space to store all of these projects in the classroom past their completion. Most, if not all, of these projects eventually end up being thrown out. Of all of the teachers who completed the survey, only one touched on how he disposes of these projects. He shared "after finishing our builds the students take pictures of what they have created before disassembling their projects and dividing them into recyclable and trash piles." This teaches students to be aware of the materials they are utilizing and allows them to see what things can be recycled and used as something else in the future. It also allowed students to think about the long term impact their STEM projects can have on the environment.

Conclusion

Findings in both the survey responses and teacher interviews highlighted the increased conflict-resolution skills, self-taught teachers out of a lack of training opportunities, and out of pocket expenses; further demonstrating that while STEM education is beneficial for students, implementation can be costly and challenging for classroom teachers. STEM allows students to apply what they have learned throughout the year in an interdisciplinary way while navigating working collaboratively with their peers. Students are able to grow in their academic and social emotional learning through STEM education. All of the teachers surveyed see the positive impact STEM has in their classrooms. Unfortunately, STEM education comes with challenges at most school sites. These challenges presented include funding for relevant curriculum and materials, a lack of teacher training, and the waste created through single use materials. Teachers are relying on themselves to learn more about STEM. These teachers are funding lessons on their own, seeking out their own training opportunities, and relying on other teachers who have experience to help lead the way. Thus, without support from their schools, successful STEM implementation is not guaranteed.

Chapter 5: Discussion

According to the findings of this research STEM education in the elementary school classroom creates increased conflict-resolution skills for students, teachers who are self-taught out of a lack of opportunity, and out of pocket expenses which teachers incur. STEM education brings a myriad of positives to the elementary school classroom but comes with some challenges.

This research found that STEM education, as was the case at higher grade levels, provides students with higher levels of in class engagement, increases student collaboration, and real world applications of in class learning (Johnson, G., 2019). These skills help the students to transition from daily in-class learning to big picture ideas and concepts. During STEM projects students are required to work together in order to reach a communal goal. They are able to reach these goals through teamwork and open communication. Findings from the research show that students also improve their conflict-resolution skills as a direct result of the incorporation of STEM education in the classroom. STEM assignments encourage students to find new ways to work collaboratively and learn how to compromise. Students involved in STEM education are able to take the concepts, ideas, and problems posed in their classroom lessons and apply them to real world situations (Paul and Elder, 2008).

While comparing the literature review to the data collected from the interviews and survey conducted during the research, several similarities emerged as well as the constant issue of inadequate funding. Namely, STEM education contributes to higher levels of student engagement, a deeper understanding of concepts and their real world applications. Currently, there is a huge disproportion in the allocation of STEM Funding. STEM funding on a federal level goes into middle schools and high schools with little funding being specifically allocated for elementary schools (Hom, E., 2014). The findings show an overwhelming majority of teachers working in elementary schools who would benefit from money allocated specifically for their training on STEM, curricula aligned with their grade level Common Core State Standards (CCSS) and Next Generation Science Standards (NGSS), and materials required for their students to participate in STEM learning.

Implications for the Literature

In the research findings, an overwhelming majority of teachers shared that they were unable to find or attend STEM trainings and professional development sessions. While Plank, Shuda, Butler, Vary, Noushad, Farber, Stohlmann, Moore, and Roehrig, had found that some schools and districts have provided instructional training at higher grade levels (middle school and above), the findings from the research found that this was not the case for any of the teachers at the elementary level. Many of the teachers I surveyed and all of the teachers interviewed felt overwhelmed trying to make these changes in their classrooms in a year with limited, if any, support. The research findings show there are limited teacher trainings available focused at the elementary school level. Of the STEM trainings available, several surveyed teachers shared that their schools would not pay for this type of professional development. Schools are opting to have teachers rely on free online trainings or discovering ways to implement STEM curricula on their own. Several teachers surveyed expressed that they do not have enough time to do their preparation and planning as well as having available classroom time to implement fully immersive STEM programs. Teachers are already faced with a limited amount of time in the school day to complete the statewide curricula. The research showed that teachers are finding it challenging to meet all of the school's requirements and assignments while at the same time attempting to implement STEM into their classroom schedules.

The literature notes that there is currently a lack of STEM education curricula at the elementary school level (Johnson, A., 2017). The research conducted aligned with Johnson's findings, but advanced the analysis by revealing that participants purchase specific lessons and activities from Teachers Pay Teachers, create their own curricula, or reach out to peers through STEM education groups on Facebook to ask for assistance and ideas. The teachers interviewed also noted that there was a lack of relevant grade level curricula which aligned with the Common Core State Standards (CCSS) and the Next Generation Science Standards (NGSS). Many of the teachers surveyed and interviewed chose to work with their grade level teams or other STEM educators to create assignments which aligned with their students' interests, academic levels, and the content being covered in their classrooms.

Research findings show that efforts must take place to reallocate or increase funding for teacher training, curriculum development, and the cost of needed materials so more elementary students can be introduced to STEM learning, since all of the research shows that when younger students are exposed to STEM they become more interested in it and are more likely to pursue STEM careers long term.

This research expands upon previous literature to show specific ways that *elementary* students also learn how to work collaboratively, discover strong problem solving strategies, gain a deeper understanding of time management, and grow through social emotional learning in STEM education. More directly, the research shows that students are given different tools and strategies from their teachers and encouraged to work collaboratively to find solutions which may require personal opinion compromises. Students working on STEM assignments also gain a deeper understanding of time management. There are many assignments and projects in class where students can have additional time to complete assignments and assessments, but STEM is not one of them. Findings from the teacher interviews and survey responses shared that students involved in STEM rapidly learn how to prioritize their time, come to quick compromises, and solve their problems independently in order to not waste the limited time they have by debating and disagreeing on the challenge at hand. Students also develop a deeper understanding of social emotional learning by taking the opinions, ideas, and feelings of their peers into consideration when working on these activities. STEM projects aim to ensure that everyone is and feels included and a part of the group.

Research findings show that STEM education presents students with the opportunity to work with the concepts addressed in their classrooms in a hands-on way. This includes but is not limited to projects, models, and digital activities where students share their knowledge in creative ways.

Implications for Policy and Practice

When looking at implications for policy and practice, two main ideas emerged. Time should be set aside by administrators for teachers to focus on professional development. There should be dedicated and specific funding set aside for teachers to use in their pursuit of additional professional STEM development. These changes would allow interested elementary school teachers the time and funding to receive training in STEM education.

There should be equity in the division of STEM specific funding among interested elementary schools, middle schools, and high schools. Obama's administration invested $3.1 billion in federal programs promoting STEM education, but all of that money was assigned to STEM focused high schools, to better understand the Next Generation Science Standards (NGSS), and to recruit STEM teachers from current STEM fields (Hom, E., 2014). Based on the findings of this research, this money could have been allocated in a more equitable way to encourage the addition of STEM education to elementary and middle schools instead of placing the focus solely on high school students. Findings of the research showed that the desire for the inclusion of STEM education is there among elementary school teachers; but currently the funding is not. Future funding should be earmarked for interested STEM educators at elementary schools.

Districts should provide their teachers with additional resources, curricula, and funding for STEM related professional development. Over half of the teachers surveyed shared that their school does not have any funding allocated for STEM education. These teachers are left to create their own curricula, research different teaching strategies on their own, and navigate the challenges that can arise through STEM education without the assistance or funding in their districts. These teachers are feeling challenged in attempting to replicate these programs independently without the support or dedicated professional development time from their school sites. In contrast, some of the schools and districts focusing on STEM professional development have dedicated three years to learning about, designing lessons for, and implementing STEM education at their school sites (Shuda, J., Butler, V., Vary, R., Noushad, N., & Farber, S., 2019 and Plank, L., 2017). Going forward this proactive approach should be the norm and not the exception.

Limitations of the Study and Future Research

There are a few main limitations of the study conducted for this thesis project. All individuals surveyed were not asked to describe the type of school they worked at or where their school was located. Increasing the sample size and sampling from public, charter, and private schools would have given a more inclusive look at STEM education on a broader scale. Since the researcher did not focus on one specific state or district, the data was not localized to teachers of a specific area. Participants included educators from the United States who work in all types of elementary, K-8, and K-12 schools.

There is a limited perspective provided in the research because teachers who currently or have previously used STEM education were the only population sampled. Continuing this research could focus to include interviews with teachers who do and do not have STEM education experience. This study is missing research from the perspective of educators who have never implemented STEM education. Interviewing teachers who have not chosen to implement STEM in their elementary school classrooms could give comparisons of student development with and without STEM. It could also provide more insight into the opportunities and resources that need to be made available for the growth and continuation of STEM in additional elementary school classrooms.

The study also did not research or address the diversity of the student populations at each school or the ethnicity of the educators. The research did not include the socioeconomic status of the population of the school interviewed. This piece of data would have provided the researcher with a deeper understanding of the correlation, if one is present, between socioeconomic status of the students at the school and the amount of STEM technology and resources available to them. Examining this piece would have allowed the researcher to focus on the inequalities present in differing schools and allowed for teachers who have found ways to incorporate STEM curricula in their classrooms to share their insights and experiences with other educators.

The findings of this research are specific to teachers already implementing STEM education. The interviews were held with teachers who all currently work at the same school site, but they shared their experiences working at other school locations. By choosing interview participants that the researcher had previously worked with, the researcher was able to include individuals with varied levels of experience and strong STEM backgrounds. Choosing educators from the same school site prevented the researcher from taking a closer look at STEM implementation utilized at other elementary school sites.

The findings of this research were also influenced by the researcher's positive experiences implementing STEM curricula. The researcher used STEM in her prior student teaching experience and as a 1st through 4th grade math and science teacher. The researcher was inspired to conduct the research as a result of the positive benefits she observed her students received from STEM activities. Her prior experience and STEM knowledge allowed her to relate to her interview participants and encouraged a natural flow of conversation with all of the participants.

This research could be continued by surveying a larger sample population, focusing on teachers from schools with diverse student populations, differing levels of funding, and looking at the curricula available for K-5 classrooms aligned with the CCSS and the NGSS. Additional research could focus on the current elementary school STEM education programs available, the in-class application by surveying teachers using the program and students currently in their classes, and by observing the implementation of STEM education in the classroom. Additionally, research could also focus on a group of elementary school students receiving STEM instruction and a control group not receiving STEM instruction over a multi-year period in order to determine if there is a connection between STEM education and long term STEM career interest.

Conclusion

The research outlined in this thesis demonstrates the correlation between STEM education in elementary school and student behavior and agency in science, technology, engineering, and math. This research has outlined the positive ways STEM education adds to elementary school classrooms while addressing the challenges most commonly experienced through implementation for the teachers. This key piece of data uncovered through the research findings is something that has not previously been highlighted. Findings from the 50 teachers who participated in the survey provided insight into the ways in which STEM education is implemented into their elementary school classrooms, the positive changes they observe in their students through the incorporation of STEM education, and the real world connections students are making between these activities and their Common Core State Standards (CCSS) in math and Next Generation Science Standards (NGSS) in science curricula.

STEM education increases elementary students' interest in science, technology, engineering, and math. It provides students with a way to take in class curricula and connect it to real world examples. Through STEM education students learn to work collaboratively, become effective communicators, and create compromises when disagreements arise. The findings of this research show that one area of growth for students occurs in their conflict-resolution skills. The students are discovering skills and strategies through STEM education that allow them to create compromise and problem solve. These life-long interpersonal skills will benefit students throughout the rest of their education, in their careers, and in their personal lives.

STEM education presents students with the ability to demonstrate their knowledge in a creative, hands on way. Students are able to demonstrate their knowledge in a variety of modalities. STEM education integration in earlier grades increases the number of students who are likely to pursue additional studies and ultimately find careers in these fields after graduating from both high school and college. By incorporating STEM education in elementary school, teachers are exposing students to STEM at a much younger age than if they began implementation in high school or college. This creates an earlier opportunity for students to see the ways in which in-class learning connects to real world and future jobs. Students begin to think about the real world connections of their learning.

Additional research needs to be conducted on STEM education in elementary school classrooms. This thesis shows that STEM education is being implemented by numerous elementary school teachers, but a sufficient amount of formal research has not been conducted. By conducting research on school sites and districts with successful STEM implementation, other teachers will have a greater insight to values STEM education adds to the elementary school classroom, the possible obstacles that may arise, and how other educators have overcome them. This continued research would give teachers more insight into the different types of cross curricular lessons, implementation styles, and benefits for their students.

Additionally, funding is needed for teacher education, training, and curriculum development in STEM at the elementary school level. Without funding, teachers are left to create or purchase their own curricula, train themselves, and determine the best way to implement STEM education for their students. Setting aside funding specifically dedicated to STEM education will allow teachers to receive the training, curricula, and materials needed to successfully implement STEM education into their classrooms. The creation of a more universal or standardized curriculum is key to implementing STEM in more, if not all, elementary schools, but cannot occur without additional funding. Currently, there are very few comprehensive STEM curricula programs that align with the Common Core State Standards (CCSS) and Next

Generation Science Standards (NGSS). The creation of this curriculum is essential for teachers in order for the inclusion of STEM education in all elementary school classrooms.

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Appendix A: IRB Approval Letter

DOMINICAN UNIVERSITY of CALIFORNIA

1/16/20

Kendal Carter
50 Acacia Ave.
San Rafael, CA 94901

Dear Kendal,

On behalf of the Dominican University of California Institutional Review Board for the Protection of Human Participants, I am pleased to approve your proposal entitled *STEM and Student Agency* (IRBPHP IRB Application #10846).

In your final report or paper please indicate that your project was approved by the IRBPHP and indicate the identification number.

I wish you well in your very interesting research effort. Sincerely,

[redacted]

Randall Hall, Ph.D.
Chair, IRBPHP
Cc: Matthew E. Davis, Ph.D.

Institutional Review Board for the Protection of Human Participants

Office of Academic Affairs • 50 Acacia Avenue, San Rafael, California 95901-2298 • 415-257-1310 *www.dominican.edu*

Appendix B: Online Survey Questions

1. How are science, technology, engineering, and math taught at your school site?
2. Do you have a choice in the math and science curriculum you implement in your classroom?
3. How do you feel about STEM?
4. Have you implemented STEM curricula in your classroom?
5. If so what have you noticed and how frequently, if so why not?

Appendix C: Interview One Questions

1. When did you begin using STEM projects in your classroom? Has your school been supportive of your choice to implement STEM education?

2. How did you decide to incorporate STEM into your classroom? How frequently do you complete STEM activities?

3. What do you notice about your students when they work on STEM assignments?

4. How do your students feel about science, technology, engineering, and math as independent subjects? Do they feel differently while working on projects that combine these STEM areas of focus?

5. What STEM project are you about to begin with your class? How did you select this project?

6. Have you worked on something similar with your students before?

7. Teachers who do not currently use STEM Education in their classrooms tend to comment on three major issues they see. They feel that there is a lack of curricula, a lot of expenses that go into completing STEM projects while using materials that can not be used again, and a lack of funding and support from the school. Did any of these problems arise for you, and if so, how did you work to overcome them?

Appendix D: Interview Two Questions

1. How did the STEM project go?

2. What were some of the strengths and struggles from completing this project?

3. What did your students feel were their biggest successes?

4. Where did your students struggle?

5. How did they overcome these struggles?

6. If you were to do this project again, would you make any changes? If so, what would you change?

7. What advice do you have for other educators looking to begin the implementation of STEM education?

8. What resources do you feel you are lacking/what additional support do you need?