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Early Introduction of STEM: A Qualitative Study

Michael Toussaint Crosby
Walden University

Walden University

College of Education and Human Sciences

This is to certify that the doctoral study by

Michael Crosby, Sr

has been found to be complete and satisfactory in all respects,
and that any and all revisions required by
the review committee have been made.

Review Committee
Dr. Christopher Cale, Committee Chairperson, Education Faculty
Dr. Sunddip Aguilar, Committee Member, Education Faculty

Chief Academic Officer and Provost
Sue Subocz, Ph.D.

Walden University
2024

Abstract

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by

Michael Crosby, Sr

MBA, Strayer University, 2010

BSB, Southern Wesleyan University, 2005

Project Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Education

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Abstract

To improve student literacy in science, technology, engineering, and math (STEM) education, a STEM program was established in an elementary school in a southeastern state. The problem addressed in this study was that it was unknown how teachers were implementing the STEM framework within their classrooms within a school district in South Carolina. The purpose of this study was to explore the perceptions of teachers and administrators of this school regarding the implementation of STEM frameworks in classrooms. The conceptual framework for this study was comprised of the STEM model developed by Krahenbuhl and the theories of Bruner. The research questions explored the perceptions of teachers and administrators on implementing the STEM curriculum. Data were collected through interviews with four elementary educators (three teachers and one administrator) with five or more years of experience in the school. Open coding of the data led to two emerging themes: the authentic implementation of STEM creates the best learning environment, and administrators' focus on deliberate actions becomes habits for changing the learning environment. The findings of this study led to a 3-day professional development project developed to benefit the implementation of a STEM curriculum. This study may lead to positive social change with schools and community stakeholders using the information about curriculum implementation and program content to improve their curriculum and processes resulting in potential educational growth and understanding of STEM, a set of skills that help 21st-century learners excel in school and beyond.

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Dedication

I am dedicating this study to my wife who supported me in my endeavors.

Acknowledgments

I am taking this opportunity to thank faculty members, family members, and friends who helped me reach this point in my academic career.

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Section 1: The Problem

The problem addressed in this study was that it was unknown how teachers in a Southeastern United States school district were implementing the STEM framework within their classroom instruction. As part of the federal strategy to improve students' literacy for all in science, technology, engineering, and math (STEM) education across the United States, the U.S. Department of Education implemented the STEM Education Strategic Plan in December 2018. Under the STEM Education Strategic Plan, students in the United States are encouraged to enroll in STEM courses (Randazzo, 2017). This way, it is possible to increase the future supply of workers for STEM-related jobs.

A STEM program was established in SSD (a pseudonym), an elementary school in a southeastern state because students were failing to make adequate yearly progress (AYP) on state-required academic testing in science. STEM curricula are more prevalent in secondary school settings than in elementary school settings (Hammack & Ivey,2019). According to Isabelle (2017), awareness of being proactive about STEM falls on elementary teachers and administrators to ensure their students are equipped with skills to be successful which supports the lack of information about how to successfully implement STEM curricula in elementary settings.

Funk and Parker (2018) revealed STEM education in the United States is not better compared to other developed countries worldwide. To retain its position as the leader in advanced technology, the U.S. government is challenged to work with educational institutions to encourage more students to participate in STEM education (Herman, 2018). According to Benson (2020), one of the problems involving STEM is the absence of diversity in the sense that more men are enrolled in STEM-related courses compared to women. Estrada et al. (2016) revealed that minority students are underrepresented in STEM courses. STEM education in the United States is criticized for having no universal standard for each grade level (Successful STEM Education, 2021).

Rationale

In this section, I present the rationale or justification of the problem choice with both local evidence and evidence from the literature that substantiates this problem exists, and justification for exploring this problem.

Local Evidence

Several pieces of local evidence support the existence of this problem and justification for its exploration. The principal at the study site was extremely concerned about the performance of her students and was looking for solutions, preferably a STEM Curriculum (Principal, Faculty Meeting, 2018). The superintendent’s multiple walk-throughs with the principal inspired her to research STEM implementation in elementary schools (Superintendent, Personal Communication, 2019). The superintendent of the SSD was familiar with the STEM structure but did not implement STEM district-wide (Superintendent, Personal Communication, 2019). According to a local educator, very little to no conversations are taking place about STEM implementation in classrooms because of a lack of information (District Plan, 2022).

Evidence from the Literature

Research shows that when the STEM framework is effectively implemented into classroom instruction, the likelihood of student academic outcomes is increased (Molina et al., 2016); however, it is unknown how the teachers implement the STEM framework into their classroom instruction. Loyalka et al. (2019) stated that training needed to be precise and accurate to be effective, which was not happening with the educators. According to Falloon et al. (2020), effective collaboration creates positive outcomes for the learning environment, which is not known to be happening with the educators here. For the students to gain the most from the STEM framework, both Widya et al. (2019) and Kurup et al. (2019) argued that training is important. The purpose of this qualitative study was to explore the perceptions of teachers and administrators at this study site concerning how STEM frameworks are being implemented in classrooms.

Definitions of Terms

Academic performance: Students' academic achievements and ability to reach educational goals (An et al., 2019).

Emotional development: Ability to control emotions when dealing with challenging tasks (Thompson, 2015).

Professional development: Additional training to further knowledge of strategies that could be used to improve delivery (Aldemir & Kermani, 2017).

Social development: Attitudes and behaviors or social skills when dealing with others (van der Aalsvoort, 2010).

STEM education: An approach to learning that focuses on STEM (U.S. Department of Education, 2021).

Annual Yearly Progress (AYP): Rating of categories (academic achievement, preparing for success, English learners' progress, student progress, and state goals) that each school is evaluated on.

Significance of the Study

This study was important to educational leaders at this study site because it affords them an understanding of STEM instructional implementation in their elementary school. Little information is available to guide processes to increase elementary STEM implementation. Educators at the study site may be able to better understand the type of professional development and training needed to ensure a plan or process to assist elementary educators in effectively teaching STEM in their classrooms.

Aldemir and Kermani (2017) discovered with professional development, elementary teachers were able to expose students to content knowledge of STEM. Capraro et al. (2016) stated that sustained professional development has a positive effect on student achievement whereas it creates more opportunities for student engagement. Hassan et al. (2018) stated that STEM would have more advancement when the educators gained more content knowledge to deliver to the students. Li et al. (2019) explained that educators must have the training to specifically and systematically design content that focuses on thinking in place for students in certain areas. The results of this study could benefit elementary students at this study site by providing valuable data to develop a curriculum and training for elementary educators at this study site to effectively implement STEM in their classroom instruction.

Research Questions

The purpose of this qualitative study was to explore the perceptions of teachers and administrators at this study site concerning how STEM frameworks are being implemented in classrooms. Using online interviews, the investigator used the following research questions:

RQ1: What are teachers' perceptions about how they are implementing the STEM framework at SSD Elementary School?

RQ 2: What are administrators' perceptions regarding how teachers implement the STEM framework at SSD Elementary School?

Review of the Literature

The review of literature is comprised of two main sections: the conceptual framework and the review of the broader problem. In the conceptual framework section, a review of the STEM and constructivism frameworks is provided. I then provide an analysis of the recent empirical literature that was related to the problem that was explored in this study.

In the following section, I discuss concepts that ground this study. Information is provided to show connections between key elements of the STEM and constructivism framework. I also provide a review of the literature regarding how the constructivism framework relates to the study approach through questions, instrument development, and data analysis.

Conceptual Framework

The conceptual framework for this study was the STEM model by Krahenbuhl (2016) and elements of the theory of Bruner's constructivism which provided the theoretical grounding for the study. Bruner (1973) expressed constructivism as an active process where the learner builds new ideas based on present and past learning. Krahenbuhl (2016) stated learners take part in their learning by constructing meaning. Developing problem-solving skills in STEM affords students a solid framework from which problem-solving and critical thinking skills may arise (Priemer et al., 2019). Inquiry-based learning in STEM is both authentic and meaningful according to McDonald (2016). The STEM model and constructivism share components that involve building on prior knowledge for deeper understanding.

Elements of the theory of constructivists were utilized during this study to provide the conceptual grounding and rationale for the STEM model. Krahenbuhl (2016) stated learners take part in their learning. Constructivism encourages independent learning to build critical thinking (Amineh & Asl, 2015). Kosnik et al. (2018) noted constructivism is based on how the learner constructs knowledge that is gained.

The study was grounded in elements of the constructivist theory. With constructivism, learners construct their meaning, social interaction is key because collaboration on teams has become more important at work, authentic learning is crucial because it must be able to apply to the real world, and learning is based on existing understanding (Krahenbuhl, 2016). Clements and Battista (1990) noted information being learned is actively created or invented by those who are doing the learning which means they are taking part in their learning or constructing meaning. New information is created by reflecting on actions during the learning process, and individual interpretations are what create various viewpoints in the world through experiences and social interactions (Clements & Battista, 1990). Learning is also a social process where people grow and develop into a specific way of thinking, and finally, their beliefs and views change as time passes (Clements & Batista, 1990). STEM framework is later explained in more detail to establish a solid foundation of understanding.

STEM

A STEM curriculum involving various projects is needed in fields that have communication, collaboration, critical thinking, and problem-solving (Bochno, 2009). Reflection, management of agency, and collaboration are all actions of learning of a student according to Bochno (2009), which support the STEM framework. Wells (2016) stated that minds-on and hands-on learning create a stronger foundation of knowledge as opposed to just talking and not having that active learning. Krahenbuhl (2016) noted social interaction is important, authentic learning is relevant to real-world application, and knowledge is based on existing understanding, all of which follow the same tenets of STEM.

Constructivism

Bruner (1961) shared insights on actions within constructivism that increase learning: reflection, learner-centered instruction, collaborative learning, posing relevant problems and problem-solving, cohort groups, extensive field placements, authentic assessment, professional portfolios, and action research. Social interactions, full participation, thinking, developing practice and theory, and supportive environments are effects of constructivism (Bruner, 1996). According to Bruner (1974), social interaction is also important to the growth of education. Based on years of research Bruner, Dager, and Yadav (2016) were able to determine seven goals for a constructivist learning environment: provide learning experiences within the knowledge process, appreciation for multiple perspectives, embed learning in realistic and relevant contexts, encourage ownership and voice in the learning process, embed education in social experience, encourage the use of multiple modes of representation, and encourage self-awareness of the knowledge construction process. Clements and Sarama (2021) also utilized Bruner in their STEM research as well. Akpan and Kennedy (2020) incorporated some of Bruner's constructivist thoughts and ideas in some of their educational positions.

The study framework is related to and supports the RQs, data analysis, and project development, which will be explained later in the study. The interview questions were guided by the framework of this study. The questions were built on the premise that STEM could be built upon from wherever it was if there was something there the begin with, to using the data collected to create something new. Another reason for this type of question was that it allowed the educators to take part in what they were doing. The final thought was having the ability to solve a problem. This framework guided the analysis of the data in this study to identify the perceptions of the educators. This study was not designed to compare numbers, but perceptions that cannot be quantified. According to Erdogan and Cittci (2017), proper implementation through preservice training is extremely important since the study is about implementation. Through the use of this framework, the PDs were able to be developed with proper instruction on the implementation of STEM for a better opportunity for success in the future. According to Wells (2016), implementation changes as new ways are discovered, so research helps discover that.

Review of the Broader Problem

I used the following databases to locate research relating to the problem: Walden University Library, ProQuest, ERIC, SAGE Journals, and Google Scholar. I used the following search terms: *STEM in elementary, integrating STEM in elementary, elementary teachers and STEM*, *assessments,* and *curriculum integration of STEM*. All sources were published between 2019 and 2023. In the following literature review on the broader problem, the following topics addressed are teacher struggles with implementation, teacher successes with implementation, implementation of stem, assessment data, classroom engagement, and academic growth.

Teacher Struggles with STEM Implementation

Problems with implementation are particularly prevalent at the elementary level, given differences in approach to curriculum that occur at elementary schools as compared to intermediate, middle, and high schools. Some of the struggles have been observed involving self-responsibility, materials, and training according to Dong et al.(2020). Elementary education is highly generalized and focused on ensuring that students have the basic foundational information necessary to understand specialized content to which they will be introduced at later ages and grade levels as stated by Aydin (2020). Margot and Kettler (2019) expressed that older female educators show less passion for STEM which provides less performance. STEM-based instructional strategies provide students with a foundation of problem-solving, critical thinking, and creative skills, which can be translated to other areas. However, even with these considerations in mind, this still leaves the question of how to implement STEM at the elementary level given disparities in approaches to education across states and from district to district.

Teachers have a responsibility to themselves as well as to their students. Han et al. (2015) stated that just because teachers understand STEM, it does not guarantee quality implementation. Content knowledge is detrimental to the success of implementation, but if not enough information is available to learn from creates a problem (Farwati et al., 2021). Teachers must not only understand the STEM-based instructional content to which they are being introduced but must also become familiar enough with that content that implementation becomes second nature (Han et al., 2015). Bolger (2017) expressed lack of confidence and anxiety could have a significant effect on student learning. Hammack and Ivey (2019) also stated the extreme importance of content and pedagogical content knowledge. The lack of content knowledge was an issue of challenge listed in the research according to Aydin (2020). The less familiar the teacher is with content, the less confidence they will have in the adoption of STEM-based instructional strategies, and therefore the less responsive students will be to the application of those particular approaches. Laksmiwati et al. (2020) expressed that teachers needed STEM training and learning materials for true implementation. Teachers must be confident with their approaches and must show any anxiety concerning the results of lessons to increase student willingness to engage, lest they transfer their fears to the students they teach

(Bolger, 2017; Kim & Bolger, 2017). This is due in large part to a lack of knowledge regarding what STEM-based instruction entails in addition to standard concerns regarding change to learning for the students, particularly within classroom environments in which the highest level of accountability in the form of observations is placed on teachers for delivery of content, even though educational environments should be the responsibility of teachers and students (Margot & Kettler, 2019). Ismail et al. (2019) stated teachers have to be more aware of self-development to increase student participation.

Han et al. (2015) concluded that teacher-driven PDs need to be designed after more unannounced observations. Debes (2018) stated that a location struggled with training because it was not specific and directly related to the STEM curriculum. Training was also a challenge for elementary educators according to the research of Sukiyani (2023). Lamberg and Trzynadlowski (2015) stated teachers need more up-to-date technology to have success with the implementation of STEM curriculum. Afriana et al. (2016) stated time management for teachers is an issue for success because within the curriculum many projects and problems take up time that have to be managed. Graves et al. (2016) stated instructional support staff (coaches and instructional leaders) must participate in professional development alongside teachers because they too must understand the STEM curriculum when they have future instruction sessions. Ong et al. (2016) established specific training and guidance are needed for teachers to increase their confidence and effect successful change for their elementary students. Educators are also in need of training on recognizing the socioeconomic struggles of implementing STEM according to Seage and Turegun (2020).

Teacher Successes with STEM Implementation

Teacher success is looked at from two perspectives which are teacher training and student engagement. STEM programs only develop strong teachers through well-organized and thought-out relevant training (University of Nebraska at Omaha et al., 2018). The teachers have to be in a good position with content knowledge and strong collaboration skills to help the curriculum do well. Based on research from Kimberly et al. (2019), training and consistent communication are essential to success. Smyrnova-Trybulska et al. (2016) stated that using kits (hands-on) in the workshops was vital to success. Chiu et al. (2015) also stated that success happened when the teachers understood and made the transition from a transmitter to a facilitator. Successes with teachers in STEM was from true support with the professional development of the teacher to gain a strong foundation which gave them the confidence to teach according to Gillies and Nichols (2015). According to research from Jaipal-Jamani and Angeli (2017), when self-efficacy increased for teachers, they had a greater effect on implementing STEM. According to the research from Yildirim (2016), teacher success through pre/in-service training that is directed to problem-solving builds a stronger foundation. The research of Sari et al. (2020) stated that pre-service training for teachers has given teachers more confidence to create more classroom activities that are more engaging. Training is paramount but proper engagement shows growth.

There is evidence to indicate that the greater the engagement with the lessons, on the part of students and teachers alike, the greater the impact of the lessons themselves. Evidence for this assertion comes from a variety of sources concerning the implementation of STEM lessons within the classroom environment. Anwari et al. (2015) noted that teachers had a greater engagement with their students as a result of the implementation of STEM practices within the classroom environment based on a lesson in which students were tasked with rebuilding and testing a DC motor, while students had a greater engagement with the lesson because of the structure of the lesson. Collaboration in lesson delivery likewise works to facilitate engagement, as shown by Chiu et al. (2015) in their study of STEM implementation. Chiu et al. (2015) further noted that the greater the collaboration, the greater the engagement, which in turn leads to improvements in teamwork and team-building skills. Farwati et al. (2021) also stated in their research that there were improvements in socialization skills. Student engagement also leads to improved ownership of learning in students (Slavit et al., 2016) and a greater ability to scaffold knowledge (Kim et al., 2017). Student engagement with the material likewise has translated into increased student knowledge gains in standardized testing and improvements to both critical thinking and creative thinking (Douglas et al., 2016; Hacioglu & Gulhan, 2021; Sari et al., 2020; Siregar et al., 2019; Ugras, 2018). This engagement, in turn, translates to a desire for additional knowledge acquisition on the part of students, further boosting support for the implementation of STEM within the classroom environment (Roma & Greca, 2018).

Even though it is secondary to implementation and training, consistency in the implementation of the STEM curriculum is paramount (Guzey et al., 2014). Guzey et al. (2014) discovered that when teachers received proper training on the implementation of engineering within the classroom environment, students performed well throughout the year. In 2015, Han et al. reported that well-organized and ongoing professional development was beneficial to the growth of the STEM program. Christian et al. (2021) also stated in their research that professional development was essential to the success of the implementation. These findings were confirmed by Zhou et al. (2015) who determined that the overall performance and knowledge of the teachers increased with the professional development programs.

According to Capraro et al. (2016), it is true consistency in training that becomes the foundation for making significant gains. Monthly training was established for elementary teachers to grow their skills in implementing STEM within the classroom in studies conducted by both Baker and Galanti (2017) and Gardner et al. (2019) documenting similar findings. Gardner et al. (2019) stated that STEM could increase the achievement level of students if implemented within the classroom through the purposeful training of teachers. Sarwi et al. (2021) also made known through their research that training was most important to the achievement of success as well. However, for such programs to be successful, those responsible for the creation of professional development programs need to maintain a better understanding of teacher needs (Shernoff et al., 2017). As long as the teachers receive the appropriate training in the knowledge, skills, and abilities necessary to implement STEM lessons within the classroom environment, such lessons can be implemented as early as preschool (Aldemir & Kermani, 2017). Thus, the common thread between teachers and principals achieving, and therefore student success, and engagement in the presentation of STEM lessons within the classroom environment becomes professional development, highlighting the need to make administrators and teachers partners in the achievement of these goals.

Implementation of STEM

The way STEM curricula are implemented has a tremendous effect on the development of the students. STEM has been at the forefront of developing skills in both teachers and students, though the impact is greater for students due to their ability to develop the skills of lifelong learning (Holter, 2017). In the early years of STEM exposure, Sumida (2015) noted that professional development is key to gaining true value from the teachers for the best day-by-day results. The greater the exposure to STEM-based instructional practices, the greater the comfort and familiarity teachers will have with this material, which will increase its likelihood of implementation within the classroom environment (Sumida, 2015). Keleman et al. (2021) established with their research that students can increase their critical thinking skills with the proper implementation of training for educators. Yet much of the STEM professional development that is available varies from state to state and, in many states, like Tennessee and Texas, teachers can pick and choose the professional development seminars that they would like to attend, only being required to fill a certain number of hours of professional development each year.

With so few teachers having a firm understanding of what STEM is, the likelihood of selection of STEM-based professional development sessions decreases. As a result, for STEM implementation to occur, more professional development is needed, professional development needs to identify how STEM can be implemented within the classroom and increase teacher comfort with the implementation of those approaches. Before such actions can occur, however, there is a need to ensure that teachers are aware not only of what STEM-based curricula are but their potential applications across subject matter and the approaches to problem-solving that such implementation affords (Bolger, 2017; Han et al., 2015). Akhmad et al. (2020) realized that through the research during the training if they created more real-world relevance the information would be retained better. Demystifying the content is essential to increasing educator exposure and, subsequently, exposure to STEM within the classroom environment.

The sooner the material is entered into the classroom environment the better, as younger students have displayed a higher grasp of STEM subject material due to the lack of a need to unlearn previous content to which the student has been exposed (Milford & Tippet, 2017). By providing STEM content as early as possible, students are provided with the skills to be able to identify multiple problem-solving approaches, as opposed to rote learning of a single approach to be applied within a single target environment. According to Fenton and Essler-Petty creating opportunities for collaboration is very important as well. Milford and Tippet (2017) also expressed the importance of involving Pre-K within the STEM world, though the researchers noted that more data is necessary on how to best implement these lessons uniformly. Such implementation is crucial, particularly at younger ages, due to the rapidity at which younger students can grasp STEM concepts (Milford & Tippet, 2017). This creates a Catch-22 situation, leaving a large gap within the literature because we need more research to understand the best course for implementation, but because of the lack of understanding, not much research exists in this area of investigation.

Assessment Data

There is much debate about the effectiveness of standardized testing when it comes to assessing student knowledge versus student ability to take tests (Buckley et al., 2018); however, despite that debate, research shows that, whether the conclusion regarding assessment data ends up being, introduction and continued exposure to STEM curricula leads to improved results in assessment data (Kelley & Knowles, 2016; Seage & Turegun, 2020). Introduction and exposure to STEM improve student capability as defined through math content assessments (Kelly & Knowles, 2016). Still, further, students also appear to display higher levels of motivation when it comes to completing math content assessments (Kelly & Knowles, 2016). According to Seage and Turegun (2020), students receiving STEM lessons scored significantly higher than those students who received their instruction within a traditional classroom curriculum that did not include STEM content, reinforcing previous findings documenting strong and significant growth in student capabilities when fully immersed within a STEM curriculum (Erdogan et al., 2016). It was established by Toran et al. (2020) that STEM was essential for the readiness of elementary students.

The most likely reason for these improvements in assessment data comes as a result of what the STEM curriculum affords to students, a way of scaffolding knowledge and information in such a way as to hone both critical thinking and creative thinking skills, leading to both greater knowledge gains and greater insight into how to apply these knowledge, skills, and abilities in other contexts (Douglas et al., 2016; Hacioglu & Gulhan, 2021; Sari et al., 2020; Siregar et al., 2019; Ugras, 2018). As a result of student learning through a STEM curriculum, the cognitive and social skills of students develop and improve the more they continue to learn (Tran, 2018). Through the integration of STEM lessons, students are not only able to connect their past knowledge to future knowledge, but they are also able to translate the lessons they learn into different environments, making greater linkages to content applications socially, in other courses within the school environment, and the home (Tran, 2018). By applying the knowledge, skills, and abilities taught through STEM lessons, STEM learners can develop themselves into visual, inductive, and active learners (Kyere, 2017). The benefits of STEM are tied to how early STEM is taught and how confident the teachers are with the content (Kyre, 2017), thereby stressing the importance of identifying a unified approach to the teaching of STEM within the classroom environment. Without the knowledge, skills, and abilities to successfully teach STEM concepts to students, students will be unable to receive the targeted benefits that STEM learning affords throughout the life of the learner (Cinar et al., 2016).

Classroom Engagement

As previously indicated, the greater the level of student engagement with the material in the classroom environment, the greater the translation of that engagement into improved student knowledge gains in standardized testing and improvements to both critical thinking and creative thinking (Douglas et al., 2016; Hacioglu & Gulhan, 2021; Roberson, 2015; Sari et al., 2020; Siregar et al., 2019; Ugras, 2018). The mere presentation of information within the classroom environment is insufficient to result in student learning; if students are not engaged with the material, they will not retain the material (Osborne et al., 2019). Just teaching content in a class is not enough for knowledge retention to occur; there has to be student engagement (Osborne et al., 2019).

STEM curriculum allows for real-world project-based learning to take place in the classroom (Cetin & Balta, 2017). Real-world learning and project-based learning, particularly in scenarios or problems with multiple possible solutions serve as one method of increasing student engagement while simultaneously allowing students to understand key lessons that can benefit them in other areas of their education and their lives (Thibaut et al., 2018). By presenting STEM-based problems with multiple solutions, students become invested in understanding that there are multiple ways to problem solve, allowing them to identify solutions that they may not otherwise have seen and translating these critical thinking skills to gains in other knowledge areas (Thibaut et al., 2018).

STEM education produces reusable conceptual tools for real-life situations, teaching students the creative problem-solving skills they need to explore all relevant aspects of a problem when confronted and affords students the critical thinking skills necessary to take alternative solutions from past problems to identify novel solutions to current and future problems (Kertil & Gurel, 2016). Additionally, skills in the area of both reasoning and analysis are built upon and improved as a result of increased math literacy (English, 2016). In turn, the acquisition of these additional skills works to increase overall student engagement levels due to their ability to see the practical application of learned content within activities of daily living (English & King, 2015). This relevance to daily life can be capitalized on through the adoption of student-centered learning approaches commonly found in learning approaches taught and utilized in STEM education (Kazempour & Sadler, 2015).

Action-based and hands-on activities give students the chance to become more engaged (Cetin & Balta, 2017). STEM lessons afford students that opportunity and may take on a variety of forms depending on the content of the lesson being taught; for example, there are lessons present in the computer science and engineering sub-areas of STEM that provide students with the opportunity to learn how to create and program their games (English, 2017). While the creation of games and learning how to program are far from the only skills that are addressed by STEM lessons, regardless of the lesson content, STEM has been shown to empower and engage students through a process that continuously nurtures their development and cognitive abilities while facilitating the use of SMART goals as a means of targeted and measurable achievements (Cinar et al., 2016). Ching et al. (2019) discovered that engagement increased because with knowledge attitudes became more positive. When teachers make the transition from lecturers to planners, facilitators, and guides in the mutual discovery of knowledge instead of being the only source of information, both student engagement and student retention are increased (Kertil & Gurel, 2016). These benefits have not been shown to have any adverse side effects either, suggesting that the more STEM-associated learning within the classroom, the better students will do in terms of their engagement, their assessment data, and their overall knowledge acquisition, but such benefits require changes to the approach used within the classroom environment (Kertil & Gurel, 2016). DeLoof et al. (2021) stated from their research that when the teachers began to release control the students began to engage in more in-class activities, Such changes not only have the potential to facilitate engagement with the material but have also been shown to result in overarching changes in student attitudes, increasing the overall positivity students have toward learning (Toma & Greca, 2017).

Academic Growth

Gains occurring as a result of STEM lessons translate beyond the initial subject matter being studied, improving student cognition, leading to targeted and measurable gains in knowledge as shown through assessment data, and increasing student engagement (Douglas et al., 2016; Hacioglu & Gulhan, 2021; Roberson, 2015; Sari et al., 2020; Siregar et al., 2019; Ugras, 2018). These gains translate into other areas of academic growth as well, given that the skills learned through the completion of STEM lessons facilitate improvements in the thinking process, which can be applied in all other subjects the student is responsible for learning (Akturk & Demiran, 2017; El-Deghaidy & Mansour, 2015). According to El-Deghaidy and Mansour (2015), STEM changes the student's understanding of school culture by translating the lessons beyond the school environment, thereby instilling within the student a desire to engage in lifelong learning and instilling the student's openness to learning. Along with that openness, STEM has stimulated the growth of the skill of logical analysis and the organization of data (Chiazzese et al., 2019). Akturk and Demiran (2017) determined that this process occurs because STEM builds the required knowledge for interacting with the world, making it unsurprising that the student then applies those knowledge, skills, and abilities to the world around them. These skills benefit the STEM student in their future role in the workforce, while at the same time translating to gains in the student’s academic achievement (Akturk & Demiran, 2017).

Such gains are possible for all students, regardless of their initial ability level when first engaging with the STEM curriculum; Cetin and Balta (2017) stated that a group of low-performing students benefited from project-based learning more than higher-performing students due to the ability of the lessons to present skills acquisition in a new way. Kertil and Gurel (2016) also agreed that project-based learning has contributed to academic achievement in low-performing students. According to Kertil and Gurel, children benefit academically from authentic knowledge, and because STEM lessons are both authentic and hands-on mind-on, students can rapidly grasp both the skills necessary to explore the lesson content but can easily scaffold that information for future use in a variety of situations. Dilek et al. (2020) stated that students grow through activities in measurements. It is because of the targeted approach to the presentation of STEM-based content that children can develop critical thinking and problem-solving skills that can be used just as fluidly within the STEM classroom as in the literature classroom, within the home, or even, later in the student's life, in the 21st-century workplace (Asunda & Mativo, 2016).

Other areas of academic growth are addressed through STEM-based learning as well. With inquiry-based learning and problem-solving, students demonstrate the ability to learn effectively, regardless of the subject being learned (McDonald, 2016). Zeng et al. (2018) showed that STEM education was instrumental in improving students' academic levels across all subject matters as well. For this true growth to occur, however, there needs to be a strong pipeline put in place with a targeted framework for implementation to maintain continuity across knowledge acquisition (Bojic & Arratia, 2015). An example of how this can be implemented, in addition to teacher professional development and the implementation of a learning framework within the school environment, would be for high school students to work with middle school students and middle school students to work with elementary students. Growth in subject matter and application of skills can be lost as children transition from one school environment to the next, particularly if those school environments do not place the same weight on STEM-based activities (Capobianco et al., 2015). The integration of activities designed to minimize those transitionary effects will serve as a means through which academic growth can not only be maintained but can be capitalized upon as well. Success is tied to the students using computers to develop problem-solving abilities (Leonard et al., 2016), however, it is equally important for students to continue to utilize and maintain those skills beyond the computational environment. Li et al. (2019) also discussed the growth of computational thinking. Finally, students, as well as teachers, experience academic growth from STEM due to confidence achieved as a result of knowledge gains and academic growth (Akturk & Demiran, 2017).

Implications

This study in the Southeastern School District provided an understanding of STEM implementation in elementary education settings. Through this research, the educators and administrators had an opportunity to determine if the implementation of STEM could affect second-grade students academically as well as socially, and emotionally. More changes to the implementation of STEM could lead to academic growth after students' comfort level and familiarity with the content and approaches to learning within STEM delivery increase, particularly as more research is discovered. A multiyear professional development training curriculum has been developed to strengthen the knowledge of present and future elementary educators to improve second-grade students' academic performance academically. According to Estapa and Tank (2017), it is likely elementary teachers have less difficulty implementing STEM as they receive more assistance in terms of specific professional development and training. The findings of the current study may show that elementary educators still have difficulties with implementation during the school year training. Research findings may show administrators at this school and district acceptable and unacceptable ways to transition to a STEM curriculum. Future STEM training based on this research could prove to be more efficient than training that was previously provided.

Summary

Education in STEM is extremely important, but for many years, students have been introduced to STEM in the later academic years instead of the early years. In this chapter, relevant research was discussed in terms of the research questions, STEM curriculum, teacher successes and struggles in the classroom with STEM, and academic growth of students. This study showed the importance of STEM and its successes and struggles in schools across the country. This qualitative study involves training teachers to implement an entire STEM curriculum for their elementary students. The methodology used in this study is presented in Section 2, which includes the research design and approach, participant descriptions, data collection, data analysis, and (e) limitations.

Section 2: The Methodology

The purpose of this qualitative study in this Southeastern School District was to explore the perceptions of elementary teachers and administrators from this study site about how STEM is being implemented in second-grade classrooms. Section 2 includes an explanation of the methodology of this project. I addressed the design and approach as well as participant selection later in the chapter. During the data collection, any process as well as tools are explained. Finally, data usage, procedures, and limitations are addressed.

Qualitative Research Design and Approach

A qualitative methodology and a basic qualitative design were utilized to complete the study. According to Merriam and Tisdell (2016), researchers seek to discover and understand a phenomenon, process, or perspectives and worldviews of people who are involved in an experience. In this section, I will describe how the research design derives logically from the problem and research questions, provide a description of the qualitative tradition that will be used, and justify the choice of research design with explanations of why other choices would be less effective.

How the Research Design Derive Logically from the Problem Questions

I focused on a specific group of educators in a situation, the approach I used in this basic qualitative study was inductive which means I used a self-analysis method as a way to create a new theory (Clark et al., 2019; Maxwell, 2005). The method used in data gathering was a semistructured interview guide whereas the research strategy is also known as a case study (Merriam, 2009). While using the interview questions (Appendix

A) as data it was collected and grouped by themes to assist in determining the thoughts of the interviewed educators. These interview questions led to the discovery of information to address the research questions which assisted in understanding the problem.

Description of the Qualitative Tradition Used

Using a semistructured interview guide assisted me in staying on track while answering the research questions as outlined by Richards and Morse (2007). To address the research questions for this study, the open-ended questions asked during the actual online interviews focused on determining what elementary teachers think about the way they implemented STEM in the school curriculum and about how STEM implementation may have affected the student's academic, social, and emotional development. The semistructured interview guide was created to collect participant perspectives (See Appendix A). The interview was set at a specific place and time with the approval of the participants.

Choice of Research Design

The purpose of this qualitative study was to explore the perceptions of teachers and administrators at this study site concerning how STEM frameworks are being implemented in classrooms. While conducting online one-on-one interviews with second-grade elementary teachers and school leaders, an in-depth understanding of the performance of second-grade students was able to be established with this study. This approach was appropriate because it allowed me the opportunity to communicate and relate with the participants.

Other designs were considered for this study, but ultimately not chosen. The first of those was a case study, which focuses on a chronological narration of stories and experiences using multiple data points, (Creswell & Creswell, 2018) which was not appropriate for this study because the only data source was in-depth interviews with participants. Ethnography was not selected because that method uses a large group or population with values to track over some time (Creswell & Creswell, 2018). The next method was phenomenology, where the understanding comes from a universal happening (Creswell & Creswell, 2018). The last method considered was quantitative which relies on numerical data which was not appropriate because this study was designed to collect specific perceptions from participants (Creswell & Creswell, 2018). Using an open-ended semistructured interview guide with questions was utilized to gather meaningful data regarding this subject matter.

Participants

Criteria For Selecting Participants

Criteria to participate in this study included being employed as a 2nd grade, elementary school teacher, or administrative staff for five years or more at the study site. Using these criteria ensured that participants were highly knowledgeable about the potential impact of implementing STEM in the elementary curriculum. Because the problem involved the early introduction of STEM, second-grade teachers would have a good perspective on this implementation. According to Creswell (1998), an adequate sample size for research interviews is between 10 and 12 participants. Therefore, 12 participants were invited as part of the sample population (seven teachers and five administrative leaders). The two most common sampling paths are probability sampling which is a random selection and nonprobability sampling which is more biased and subjective.

Justification for Participant Number

Merriam (2009) stated that purposive sampling involves relying on a set of predetermined criteria for highly qualified participants. In this case, the best informants were second-grade teachers and at this site, there were only three. That is why purposive sampling was used for this study they offered a special insight, also in this sampling, the size is driven by the information needed which was stated by Merriam (2009). Creswell (2018) also stated groups as small as one to three were also adequate-sized groups for research. Four educators (three teachers and one administrator) responded to continue with the interviews. Those four educators were again utilized because of their specific situation of being information rich a term used by Markus (2021).

Procedures for Gaining Access to Participants

To gain access to the correct participants for this study, I contacted the school district and spoke to the Superintendent about the curriculum. I provided written documentation stating who I was and what I was doing and most of all that I was either in school or affiliated with a school. Once I wrote the letter, I waited about two months before I received the approval from the district. Eligible elementary schools in the district were then located as possible sites. Permission from the SSD was obtained to proceed with the research of elementary STEM implementation. I chose the school and made contact by phone with the administrator with approval from the district. Once I contacted the building administrator, and I gained his approval we discussed all consent and procedural information and then I began communication for this study. Through email and telephone, I began seeking permission or getting consent from research participants is necessary before making a record of research interview data. Before scheduling participant interviews, all participants were required to provide their signed informed consent detailing their awareness of the purpose of the study, what the data collected was to be utilized for, and the confidentiality afforded to the participants, along with outlining their ability to leave the study at any time without penalty. In addition to providing their informed consent to participate in the study, participants were also asked to give their informed consent to an audio recording of the interview.

Methods of Establishing a Researcher-Participant Working Relationship

Developing strong working relationships with participants in research studies is crucial. That was why establishing a strong and trustworthy relationship during this study was paramount. Collecting data is time-consuming, which means participants will be spending a great deal of time with the researcher according to DeJonckheere and Vaughn, (2019). While using professional emails to communicate letting them know they could use their email if that made them more comfortable. Also continuously making sure participants knew that this was voluntary, and they could stop at any time. Through their research, DeJonckheere and Vaughn, (2019) stated that a plan should be put in place for interviewing for each specific situation, establishing the proper questions about the research, being timely, and being concise when possible. I assured the participants that there was only a set number of questions for the interview. I reassured them that there would not be any impromptu questions added during the interview either. During the interviews, I only asked participants to elaborate or expand on the pre-determined questions. Gray et al. (2020) suggested that proper equipment be used for comfort by the researcher and the participant. The participants got to set the interview wherever they wanted, they were briefed ahead of time and built a rapport with them so they could feel comfortable.

Measures Taken for the Protection of Participant Rights

As part of research ethics, seeking the information or assuring that information is kept private is necessary before making a record of research interview data according to Alshenqeeti (2014). Before scheduling participant interviews, an email was sent out to all volunteers, all participants were required to provide their signed informed consent detailing their awareness of the purpose of the study. The consent forms were emailed out to participants for their signatures. The form contained information about the study, how it was voluntary, and if signed you can leave if you choose to, and its confidentiality. Volunteers signed and returned the forms via email. It also explained what the data collected was utilized for, which was detailing the confidentiality afforded to the participants while outlining their ability to leave the study at any time without penalty. In addition to providing their informed consent to participate in the study, participants were also reminded that the interview was conducted on Zoom and the audio was transcribed.

I identified participants by a letter and a number code to protect their identity. The letter “E” was used for educator and then a number was added in chronological order. For example, E1 would be the first participant. None of the participants’ identity was released in any of the findings. Alphanumeric codes will be used instead of names in the study. I am the only person who knows the identity of the participants.

All forms of information about this study are maintained by me. All the information was stored on my computer. Anything that was not digital was secured in a locking file drawer in a file cabinet at my home. All the information for this study will be secured and stored according to the protocol established by Walden University which is 5 years. After that time has passed (5 years) the information will be deleted from the device permanently and any hard copies will be shredded.

Data Collection

When conducting research within the education field, a variety of data collection methods have been used to benefit the advancement of educational approaches and evidence-based practices within the education field. It is this history of data collection that was utilized as a means of identifying the best approach to data collection for use within the context of the current study. The following approaches outlined for the data collection process have been specifically targeted for their beneficence in the collection of the same type of data that the proposed study will utilize in the collection of data necessary to resolve the identified research problem.

In this qualitative study, only interviews were used as the data collection method. The interview process was done through virtual means to limit the amount of personal contact involved between myself and the participant. That was considered an ethical consideration for the conduction of research involving human participants during the current coronavirus pandemic (Quenneville & Schwartz-Mette, 2020). The interview questions were self-designed to gather the perceptions of teachers and administrators on the implementation of STEM, and these interview questions were sufficient to answer the research questions. Procedures for tracking data and getting access to participants are described in the following paragraphs. Finally, the researcher's role will be addressed.

Instruments

Salmons (2012) defined online interviews as "interviews conducted with information and communications technologies (ICTs)" (p. xviii). Because of the ongoing coronavirus pandemic, I decided to conduct online video or voice conferencing using social media platforms such as Skype, Zoom, and Google Meets. Therefore, interviewing a small group of education professionals with a list of pre-defined interview questions (see Appendix C) is necessary when it comes to gathering data that will allow the researcher to address the research study questions.

Aside from the need to observe and respect research participants' autonomy and confidentiality, researchers also must protect the research participants from harm (i.e., as stated under the ethical principles of beneficence) (Barnard & Wang, 2021). Through online interviews, I was able to avoid the risks of having close personal contact which may foster coronavirus transmission from researcher to research participants or vice versa.

To obtain qualitative data, open-ended interview questions are commonly used in face-to-face or online research interviews. When creating an interview guide, Roulston (2010) explained that researchers could choose between "structured", "unstructured", or "semi structured" interview guides (p. 16). The structured interview guide allows the researcher to define a limited set of interview questions while allowing flexibility in asking additional follow-up questions to enable participants to clarify or elaborate on the initial responses they provide (Cramb & Purcell, 2001; Walsh, 2001). The unstructured interview guide may lead the researcher to difficulties in analyzing qualitative data and may cause the researcher to go off track, being led by the participant instead of the other way around and translating to the potential inability to resolve the stated research questions (Cramb & Purcell, 2001; Walsh, 2001). For this reason, the best tool for gathering qualitative interview data is to use the semistructured interview guide (Richards & Morse, 2007; Hendricks, 2006).

A semistructured interview guide was utilized during the process to assist in staying on track while answering the research questions (Richards & Morse, 2007). The semi structured interview guide was created to collect participant perspectives (See Appendix C).

Field notes were utilized as a means of documenting steps that occurred throughout the research process as well as providing a location through which it was possible to reflect on the research process as it occurred. According to Neimark (2012), field notes should be detailed, comprehensive, and well-organized. This is important because they are used during the writing which is away from the research site (Neimark, 2012). The notes can be written at any time of the process at the end of the day, as the event occurs, and or at another specified time. There is no right or wrong way to accomplish this because researchers will determine what is best for them individually according to Mulhall (2003), although each researcher has their preferred approach; for example, according to Phillipi and Lauderdale (2018), research notes should be recorded immediately. As a result, the field notes are a researcher-created instrument.

Data Collection Processes

As part of research ethics, seeking permission or getting consent from research participants is necessary before making a record of research interview data (Rapley, 2007). Before scheduling participant interviews, all participants were required to provide their signed informed consent detailing their awareness of the purpose of the study, what the data collected was utilized for, and the confidentiality afforded to the participants, along with outlining their ability to leave the study at any time without penalty. In addition to providing their informed consent to participate in the study, participants were also asked to give their informed consent to an audio recording of the interview.

I created processes to collect, secure, track, and store the data. On the specified date the interviews took place for all of the participants. Interviews had a block of time set (2 hours) for each interview although they averaged forty-five minutes. This process took three days to conclude, cumulatively. All of the data collected through the interviews were collected at the time of the interview and then secured with a lock and key system in a file cabinet when it was not being utilized.

Role of the Researcher

I have more than fifteen years of educating children in several capacities. I had no past or current professional relationships to declare that have a bearing on the current study. I am affiliated with a different district in which the intervention will be implemented. I will serve as the role of the interviewer to the participants, as an observer only. No other roles or relationships are present and as such, should not have any bearing on the project or lead to any potential biases arising in the completion of the proposed study. I kept a research journal throughout this study. Utilizing constant reflection on journal entries allowed me to avoid biases during the study (Orange, 2016). Documenting the research process throughout the field journal helped me to recognize the potential bias due to passion for the subject as it may seem to be an extremely important topic for the United States and a large population because many have taught STEM classes at the middle and high school level and realize the importance.

Data Analysis

Following the completion of the interviews, I transcribed the data using MS Word. I was also responsible for reviewing the transcripts to confirm the accuracy of the transcripts, ensuring that the content written in the transcripts precisely matched the vocalizations of the participants during the interviews. Before analyzing the transcripts, I had the participants engage in transcript checking, the process through which they review the transcripts to ensure that their words match their intention in responding to the questions and that they said what they meant to say (DeCino & Waalkes, 2019).

Using the interview transcripts, I was able to analyze the interview results using manual coding and thematic analysis techniques, as suggested by Saldana (2013) and Guest et al. (2012), respectively. The data were coded using a priori coding and deductive analysis. A priori codes identified at this time include STEM comprehension, student engagement, student knowledge, student social skills, student emotional skills, and implementation, which were established well in advance and assisted following the completion of field validating utilizing the semistructured interview protocol. During this time, the *a priori codes* may not change. All the data from the field test along with all information for this study will be secured and stored according to the protocol established by Walden University which is 5 years. After that time has passed (5 years) the information will be deleted from the device permanently and any hard copies will be shredded. Elliot (2018) stated that the *a priori* approach to coding is a process of analyzing data by dissecting it apart to see what is there and then putting it back together with meaning. The codes were established to begin grouping the quality of education to verify the delivery of STEM, academic growth to validate where the growth occurred, and critical thinking to establish how problem-solving was approached.

A Priori Coding Cycle

The first pass of coding involved searching all the transcripts for evidence of the a priori codes: STEM comprehension, student engagement, student knowledge, student social skills, student emotional skills, and implementation. During a priori coding, I found multiple instances of each a priori code within the data set. Table 1 contains the number of instances by a priori code.

Table 1

Number of A Priori Codes

Code Name	*n*	Excerpt
Stem Comprehension	4	The understanding of STEM
Student Engagement	3	Attracting and keeping the attention of students
Student Knowledge	5	The academic gain of the students
Student Social Skills	1	Skill dealing with society
Student Emotional Skills	2	Handling emotions
Implementation	1	Implementing

Open Coding Pass

During the second coding pass, I examined all the data that were not coded as a priori. This resulted in 17 more codes added to the code book. These codes are explained in Table 2.

Table 2

Number of Open Codes

Code Name	*N*	Excerpt
Culture	5	The educational environment
Professional Development	1	Training
STEM Curriculum	3	STEM standards of teaching
Lesson Plan	4	Plans for each lesson
Subject Matter	5	Knowledge of subject
STEM Implementation	8	Begin utilizing STEM
Training	1	Learning
Classroom Engagement	4	Classroom Attention
Classroom Environment	0	Classroom Culture
Student Learning	5	Individual Learning
Lifelong Learner	2	Continued Search for Knowledge
Social Learning	1	Developing the External Learning
Emotional Learning	1	Developing Internal Learning Skills
Real World	4	Able to Apply to Life
Project Based Learning	3	Projects to Teach Lessons
Student Centered	4	Learning Specific to Students
Hands On	6	More Interaction and Attention from Students

Thematic Analysis

After all the data were coded, both a priori and open, I had a total of 23 codes. These codes were then carefully organized into categories. Table 3 shows the Categories and the codes nested in those categories.

Table 3

Codes in Each Category

Category Name	Codes in Each Category
Quality Education	Cul, PD, SC, SI, LP, and SM
Academic Growth	T, CE, SE, Cen, SL, LL, SOC, and EL
Critical Thinking	RW, PBL, STC, and HO
Quality Education	Cul, PD, SC, SI, LP, and SM
Academic Growth	T, CE, SE, Cen, SL, LL, SOC, and EL
Critical Thinking	RW, PBL, STC, and HO

Note: Key to code abbreviations are in the Appendix B

After identifying the frequency within the categories from the responses, the categories were examined to create themes Each theme was discovered through the majority of frequencies seen throughout the collected data. Two core themes were uncovered. All like data were collected and put into categories addressing coding consisting of Quality Education, Academic Growth, and Critical Thinking which had applications, tasks, or practices with codes (see Table 3). Finally, two themes were determined from the data. First, teachers perceived authentic implementation as creating the best environment. Administrators realized that teachers had to emphasize that the actions were to become second nature.

Table 4

Themes Addressing the Research Questions

Research Question	Theme
What are teachers' perceptions about how they are implementing the STEM framework at SSD Elementary School?	The authentic implementation of STEM creates the best learning environment.
What are administrators' perceptions regarding how teachers implement the STEM framework at SSD Elementary School?	Administrators' focus on deliberate actions become habits for changing the learning environment.

Data Analysis Results

The purpose of this qualitative study was to explore the perceptions of teachers and administrators at this study site concerning how STEM frameworks are being implemented in classrooms. While interviews lasted no more than forty-five minutes in length, I informed participants that this was only for educational use for this study. I began asking questions from the interview sheet (Appendix C) to each of the participants during their specific interview time. After all the information had been documented an expressed appreciation was extended to all the participants for taking time out of their extremely busy schedules as educators. It was also stated that they would get information on the findings when possible. After the interviews were completed it would be time to begin the analysis. The data were collected and analyzed to answer the following research questions:

RQ1: What are teachers' perceptions about how they are implementing the STEM framework at SSD Elementary School?

RQ 2: What are administrators' perceptions regarding how teachers implement the STEM framework at SSD Elementary School?

I developed two themes from the four categories synthesized from all the interview data.

Theme 1: The Authentic Implementation of STEM Creates the Best Learning Environment

The first research question about teacher perceptions of STEM implementation is answered by Theme 1. The impact of STEM has created several positive implications for the development of students. At various points throughout the data, all participants revealed that linking learning to individual students to make it personal was important. Comfort and security are elements needed in learning which are strengthened through STEM. Students can showcase their work in their way. STEM gives them the chance for students to develop their critical thinking skills. The STEM framework allows learners to take part in their learning which has a stronger impact. That statement was echoed when E3 stated, "The students learn more when they take a key part in their learning." One of the participants (E1) also confirmed this in an answer about them having to figure things out on their own. Authenticity is also created when the learners feel that what they learned is more than just books, it can be life-related which was stated by E4. Participants also linked the framework to collaboration as well. Positive learning environments are created when all of the skills and actions listed above are nurtured in classrooms.

Quality education and life-long learning skills come together to impact the whole child. Quality education and life-long learning are constructed through the STEM curriculum. Through quality education, students can observe and analyze, draw conclusions, make mistakes, and grow. In STEM there are steps and or processes in place to follow to position you to be able to do certain things. Once the quality of implementation is increased then the quality of the education itself is then raised. It was also discussed that life-long learning skills needed to be developed. E3 said, “that students will become better adults because understanding the quality of education will encourage them to learn more.” Thinking and addressing problems and or projects individually or in a collaborative effort increase those learning skills for the present, but just as important it prepares them to learn in the future which was addressed by E2. Learning is a skill that needs to be practiced because it doesn’t stop at the end of school but increases as the person enters the workforce. E1 stated, “When they (the students) see us (educators) still wanting to and still learning things makes a big difference.”

Initial and focused training contributed to a strong understanding of the subject delivered to the students. Engagement on sides, (teachers and students) was strengthened with the increase in confidence in the subject matter. Teachers were to work with other teachers to assist each other with content growth. Seeking outside experts with real-world experience are also key to the growth of content matter. Half of the participants addressed student and classroom engagement for participating in academic growth. E4 discussed that academic growth is very important and there should be at least 3 – 5% by the end of the year”. If a student is not engaged, he or she will not grow academically. This was tied to E3 explaining that if the lesson is not taught well when the teacher is unsure of what to teach”. E1 said, “We have to keep training and learning to make sure we are on top of our game to teach the best way we can”.

Critical thinking is a key growth factor within the STEM curriculum. Just answering lower-level questions is not able to create rigor. It is more than just acquiring those critical thinking skills; the students have to apply them to multiple concepts. Now that the students are more engaged in class with more hands-on learning, critical thinking skills are continuously being polished. Having the problem or project right in front of them allowed them to have a better view. E2 stated, “When the students have their hands in their mind tend to work harder”. E2 also stated, “When their hands are in the mud (meaning the problem) they are thinking”. E1 stated earlier that training was important to educator comfort, but when an educator knows and can ask those specific questions to make the students look at a problem is also important to expand the critical thinking skills of our students. E4 showed concern about this when it was stated: “that hands-on must be utilized by all with consistency and comfort.”

Theme 2: Administrators’ Focus on Deliberate Actions Becomes Habits for Changing the Learning Environment

To answer Research Question 2 about how administrators perceive teachers’ implementation of STEM, Theme 2 emerged from the data. All participants expressed through data in several instances that the learning needs to happen without being told, it is an understanding of what you do. Administrators want the same thing for the students as the teachers though they view them through a different pair of lenses. They see all of the various skills, processes, and systems and they want to use them to affect the masses. Learning in the classroom needs to become the culture of the entire school. The mindset and thinking must be altered by the students to assist in the cultural change that was discussed by E3. Administrators look at this as the entire building and not just inside the classroom as teachers do. According to E4 learning must be on the macro level so they can apply concepts in and out of school, which was also agreed upon by E1.

The administrator's mindset is to have everyone in the building know that learning is what you are expected to do and not an option. The mindset in the building is learning processes are key. Administrators are moving to shift the culture of the thought process and learning process to be normal from every teacher to the youngest student in the building. E4 stated, “Using the STEM curriculum teaches a process that gives the students a plan on how to solve or attempt to solve a problem.” To be able to do this, they need to be able to focus on what they get from this curriculum according to E2. The ultimate goal is to create growth in all students by developing a culture that displays that everyone in the building is always learning. E1 also stated, “We all have to be on the same page when it comes to teaching our students.”

Education is education, so the only thing that can and needs to change is how we as educators present it to the students. Creating excitement through STEM with projects, problems, and experiments is needed to impact learning through student engagement. For this to happen we have to capture the students' attention, which had to be grabbed and maintained. E1 stated, “We have to get engagement, if we don’t, we have lost them and in some cases for the rest of their academic career.”

Having information and being able to use it at any time is important and effective. This is accomplished by being able to relate what was learned in class to something outside of the school. Every student in every class sits in that room and drifts about the topic not having any part of their present and future life. E2 explained, that students sometimes don't care or even think about anything unless they see the value or see how it can be used." When they realize that, E3 said, "You get to see the excitement of discovery when they understand and can apply it to what they know." From that one thing, you see how that student goes from being lost to becoming a leader and establishing himself or herself as a truly engaged student with a purpose. E4 said, "ultimately we want everything we taught our students to be reflected on when that time comes for them to use that particular skill."

Credibility and Trustworthiness

During this study, there has been constant openness between myself and the participants to see and or review any part of information about the study and the interview. I established reliability by having participants review any documents that were created as a result of their interview for accuracy of thoughts and meanings. According to Gall et al. (2003), the use of triangulation provided another form of reliability. Any other issues were worked out until solved.

Transferability

This study has the possibility of transferability because the participants interviewed were all like-minded educators who understand the needs of the children. Since this study was done at a school that already had diversity transferability is possible. Even though it was a low-income elementary school this same study could be done at an elementary school, so according to Pretre, (2020) the results can be transferred to other locations. The study is based on the younger scholars being introduced to the early implementation of STEM. So, any elementary setting would be fine. Based on Tong and Dew, (2016) these concepts and theories can be relevant in other settings.

Dependability

The validity of the study was established through triangulation of interviewing the different participants and the validation of the data collected. Dependability is viewed as reliability according to Tong and Dew, (2016) in that accuracy must be coherent with the entire research process. The reflective journal/notes also assisted in that it contained various information throughout the study from the participants. Also, the validity and dependability of this research were determined due to eliminating any confusion about this study, according to Hafeez-Baig, Gururajan, and Chakraborty, (2016).

Summary

The purpose of this basic qualitative study was to explore the perceptions of elementary teachers and administrators about how STEM is being implemented in classrooms. Through this study, a better understanding of best practices was learned. The research findings showed acceptable and unacceptable ways to transition to a STEM curriculum. The findings showed that educators could have difficulties with the implementation during the school year training and implementation. Future STEM training based on this research could prove to be more efficient than the training previously provided. Educators may better understand the type of professional development and training needed to ensure a plan or process for elementary educators to teach STEM. This study was utilized to gather qualitative data about teachers' perceptions of how the implementation of STEM education will affect local students.

Conclusion

The purpose of this qualitative project study was to explore the perceptions of teachers and administrators about how STEM is being implemented in classrooms. The data was collected from semistructured interviews of educators at the SSD. All of the audio/video interviews were conducted through Zoom and transcribed and shared with participants for accuracy and validity. The participants were all elementary educators from the SSD. All of the data collected were used to create the Professional Development/Training (PD). This PD would be a 3-day training with additional training days throughout the school year to assist grade-level faculty with STEM implementation. Section 3 describes the project, goals, rationale, review of literature, and search strategy. Specific training material would be provided to all to reach the specific outcomes of achievement and growth looked for in the new implementation. This project will help teachers work on various strategies, develop a growth mindset, and develop collaborative skills.

Section 3: The Project

This section includes a description of the 3-day PD project. Data from the elementary school reveals students and teachers would benefit from this project. Responses and data indicate PD is needed to support student growth and content knowledge. Findings include information that teachers, principals, and district administrators can use to create an effective STEM program for various schools within the district. Information on this research project is addressed and discussed as well as descriptions and goals, project goals, rationale, review of literature, project description, evaluation plan, and implications.

The study revealed that with initial and consistent STEM training, teachers and students would be more likely to experience growth in terms of academic, social, and emotional learning. It is also more likely that teachers will perceive the implemented STEM framework as successful. Teachers attended a 3-day training session during the summer. Once the school year began, they received 3 additional days of training, which are 1-day sessions in October, January, and April. This time frame was chosen to allow teachers the opportunity to learn and implement new procedures and techniques.

Description and Goals

The purpose of this qualitative project study was to explore the perceptions of teachers and administrators about how STEM is being implemented in classrooms. Additional information is needed for administrators to understand the impact of proper implementation. Data from this study was collected from individual interviews as well as state assessments. This study addressed the following research questions:

RQ1: What are teachers' perceptions about how they are implementing the STEM framework at the SSD elementary school?

RQ2: What are administrators' perceptions about how teachers implement the STEM framework at the SSD elementary school?

Project Goal

This study is important to local educational leaders to understand STEM instructional implementation in elementary schools because there is insufficient information to guide established processes to improve elementary implementation. Local educators may be able to better understand the type of PD and training needed to ensure a plan or process for elementary educators to teach STEM. This could benefit elementary students by providing valuable data and results to develop a curriculum for elementary educators to successfully implement STEM in their classrooms. This study may give teachers skills to properly implement STEM curriculum in elementary schools to improve student learning in STEM classes.

Rationale

The purpose of this project was the development of the best ways to implement STEM to improve early education. There would be unlikely any success by just giving curriculum to teachers and just saying go teach without some sort of guidance. After analyzing data, my objective was to evaluate ways STEM education was implemented with proper support to affect the learning of elementary-aged students positively. Teachers and administrators provided data on training and PD through interviews. Educators are truly in favor of well-organized PDs that give them many tools to utilize in their classrooms. For example, Popova et al. (2022) used the In-Service Teacher Training Survey Instrument as an assessment tool to identify the gap between evidence and practice in teacher professional development. A STEM instructional implementation strategy was developed from the research program. Several days of training PDs were created to assist the second-grade teachers with implementing the STEM curriculum. The schedule is structured for some sessions to occur during summer months and some on teacher workdays. Along with receiving information teachers have an opportunity to ask many questions as well. Results from this study included recommendations on training for the school and district about STEM.

Review of the Literature

This PD project involved providing teachers with knowledge and understanding about how elementary students are affected academically, socially, and emotionally by the early introduction of STEM and equipping them with knowledge and skills for promoting elementary student achievement in STEM. Theoretical and empirical data support the development of the 3-day PD project. This literature review focuses on core concepts related to PD. I discuss the search strategy and define PD, best practices for effective PD, and methods of instructional delivery for PD.

Search Strategy

A literature search was conducted using Google Scholar and ERIC databases. The two search terms used were: *professional development* and *teacher professional development*. The search was limited to articles published between 2019 and 2023. All sources were published in the English language and relevant to the project.

Defining PD

PD is a term that can be applied across any discipline. People from any profession can engage in and benefit from PD programs. PD involves helping workers gain the skills and knowledge they need for better performance.

Islami et al. (2022) defined PD as “activities that develop an individual’s skills, knowledge, expertise and other characteristics as a teacher” (p. 2). PD programs are designed to focus on specific intended learning outcomes. PD programs can also target improved analytical competence (Plöger et al., 2019), enhanced skills and ability for self-regulated learning (Xu & Ko, 2019), as well as improved teacher motivation (Dirk et al., 2019). This PD program involves enhancing teachers’ understanding of how early delivery of STEM education affects students academically, socially, and emotionally in terms of improved science teaching skills, specific STEM subjects, comprehension of content and performance standards for STEM subjects at the elementary level, student assessment practices for STEM, and student counseling as related to STEM subjects.

Empirical Evidence for PD in STEM Education

STEM education combines rigorous academic concepts with real-world lessons to deliver STEM literacy to recipients (Stevens, 2020). STEM literacy refers to familiarity with the critical aspects of the STEM area (Margot & Kettler, 2019). Furthermore, effective STEM education requires a well-prepared STEM teaching force (Stevens, 2020). STEM education is predicated on adequate teacher preparation for STEM teaching and curriculum delivery at all levels. Recent studies, however, reveal that over 50% of new teachers do not feel ready to teach elementary science, while two-thirds of new teachers do not feel prepared to teach science (Stevens, 2020). This situation is even more dire in rural schools as recruiting highly qualified and experienced teachers to work there is more difficult.

At the systems level, shifts in modern education from traditional to constructivist approaches, particularly, in science education, affect how teachers shape their practice. Based on this premise, Alt (2018) led a study to explore science teachers’ conceptions regarding teaching and learning, Information and Communication Technology (ICT) efficacy, ICT-related professional development, and ICT practices in the classrooms. The study assessed four precursors to ICT practices in classrooms, namely, the teachers' understanding of traditional versus constructivist teaching, ICT efficacy, sense of efficacy, and ICT-related professional development, among a sample of 303 science teachers. Alt found that constructivist conceptions had a moderate effect on teachers' sense of efficacy and this in turn increased ICT efficacy. The results also revealed that teachers' ICT professional development positively mediated ICT efficacy and ICT use for constructivist teaching activities in the science classroom.

Based on the premise that policymakers, leaders, and school administrators need to understand and address the barriers that prevent teachers from successfully developing STEM talent in schools, Margot and Kettler (2019) conducted a literature review to explore teachers’ perceptions regarding STEM integration and education. The review focused on primary studies using pre-K-12 teachers as a sample. The researchers found teacher-reported barriers to STEM teaching to include a lack of teacher support, pedagogical challenges, structural challenges, curriculum challenges, concerns about students, and concerns about assessments. Teachers identified four factors that would improve their efforts in STEM education collaboration with peers, increased district support, quality curriculum, experience, and effective professional development. The teachers believed that frequently available and well-organized professional learning opportunities would increase their ability to integrate STEM content into the curriculum and facilitate success in STEM initiatives. Effective professional development in STEM or continuing education in STEM would increase teachers' content knowledge and exposure to STEM experiences. The researchers concluded that quality in-service training on STEM pedagogy and best practices would support success in STEM education initiatives and their outcomes.

Research evidence shows that to be effective in teaching STEM programs, teachers require teaching self-efficacy, STEM-related pedagogical design self-efficacy, and collegial support (Dong et al., 2019). Evidence from earlier stated research shows that professional development can help address these needs and deliver the skills and competencies necessary for building an effective STEM teaching workforce. For example, Stevens (2020) conducted a mixed-methods study to examine the relationship between pedagogical content knowledge in elementary science and science teaching practices. The sample for the study consisted of early-career elementary teachers. The study developed a significant and positive correlation between the pedagogical content knowledge taught to students and the best practices used by early career teachers. This finding, therefore, suggests that professional development can be beneficial for teaching outcomes. Teachers' knowledge of STEM pedagogical content can be improved through professional development programs. Supporting this finding, Margot and Kettler (2019) also posited that the literature reveals that teachers at various career stages have also reported significant increases in knowledge, confidence, and efficacy regarding teaching STEM courses after attending professional development programs.

Competence and confidence are required attributes in STEM teachers. Research on teacher attitudes shows that teachers, who are intimidated by STEM topics may pass such fears to students (Harris, 2019). For example, Skinner (2020) investigated pre-service teachers' attitudes toward science and math teaching after participating in science coursework. The study found a significant change in the attitude of the teachers toward teaching science and mathematics after the coursework. The researcher concluded that experiential and active learning with modeling can improve teachers' confidence and attitudes toward science and math teaching. Such research findings have implications for the current professional development project, as the objective is to improve teachers' skills, attitudes, and competencies to deliver an early STEM program.

Theoretical Framing for Teacher PD

While a range of stakeholders are involved in the efforts to implement STEM in schools from the government to authorities at the school level, teachers remain the single most important group in the process. Teachers have to deliver STEM information and knowledge using the right approaches. For instance, teachers have to be competent at developing project-based curricula that stimulate critical thinking while building student understanding of curricula content. Teachers must be competent at using questioning strategies that provide rigor for thinking deeply about concepts and solutions to STEM problems using higher cognitive processes (Margot & Kettler, 2019). The task in professional development for teachers is to deliver such needed competencies for STEM teaching. Professional development, like every other educational practice, is underpinned by both educational philosophy and learning theories. Such learning theories provide a framework for understanding how knowledge and skills are gained in professional development and how changes in attitudes, behavior, and performance are derived (Mukhalalati & Taylor, 2019).

Andragogy

Andragogy is an educational theory in which adults are the target of educational practice (Mukhalalati & Taylor, 2019). Andragogy is based on the premise that adults already have a wealth of experience and have different learning orientations and motivations compared to children (Hartikainen et al., 2019). Educational programs that target adults must take adult experiences and motivations into consideration to be successful (Elmetaher, 2021). For example, adult learners are motivated by functional learning, which is how relevant the information they learn is to the problems they encounter in real life. Educational programs for adults must provide practical information and tools that adults can apply immediately to their lives and work situations (Margunayasa et al., 2019). Adult learners have already amassed experience and significant pools of knowledge and even expertise in their work areas. Continuity must be created in the learning process so adult learners can link the new information they receive to what they already know. Effective professional development builds on adult learners' preexisting knowledge and enhances it (Elmetaher, 2021; Margunayasa et al., 2019).

Andragogy is underpinned by several learning theories, some of which are discussed below.

Instrumental Learning Theories

Instrumental learning theories link behavior and outcomes from behavior (Mukhalalati & Taylor, 2019). Instrumental learning theories are split into experiential learning, behavioral, and cognitivism (Hajian, 2019). Experiential learning is a concept that holds learning and knowledge construction to occur through the learners' interaction with an authentic environment (Elmetaher, 2021; Plöger et al., 2019). Learning occurs through comprehension, reflective observation, conceptualization, and extension of knowledge (Hajian, 2019; Mukhalalati & Taylor, 2019). This professional development project will apply experiential learning as the teachers will interact with the elementary school environment as the basis for developing skills and competencies for early STEM education.

Behavioral theories hold that change in a learner's behavior is generated by a stimulus in the learner's environment. Learning is held to be a change in behavior due to some environmental stimulus. Positive reinforcements strengthen the behavior change, while negative consequences may weaken learning (Hajian, 2019; Mukhalalati & Taylor, 2019). Applying this paradigm to the professional development context, leaders of the educational activity have to organize the learning environment of the professional development project (such as removing distractions, designing effective lessons, and encouraging idea generation) in such a way as to achieve the desired learning outcomes (Akiba et al. 2019; Richter et al., 2019; Kerwin & Thornton, 2021).

Cognitivism focuses on the internal rather than the external environment. It concentrates on the learner's cognitive structures (the mental and psychological processes engaged during the learning process) rather than contextual variables (Margunayasa et al., 2019). Cognitive learning theories, thus, emphasize aspects such as perceptions, metacognition, reflection, insight, information processing, and memory (Elmetaher, 2021; Margunayasa et al., 2019). This professional development project will create new perceptions and understanding regarding early STEM education, promote reflection on student learning and teaching practices used in elementary STEM education, and encourage new insights and information processing. The instructional techniques used in the project will be carefully selected to promote metacognition, reflective thinking, and transformations in attitude and practice.

Social Theories of Learning

Social learning theories identify observation and modeling as the underlying processes for learning and improving task performance. These theories also hold that learning is facilitated by community and social interactions (Hajian, 2019; Koponen et al., 2019). In the professional development context, teacher communities of practice will, therefore, be important facilitators of learning (Hajian, 2019). As members of the same elementary-level community, participants will learn from each other as they explore skills and competencies for early STEM education.

Motivational Learning Theories

For learning to occur, some type of motivational factor must be present. Based on this premise, motivational learning theories associate adult learning with two key concepts—motivation and reflection (Mukhalalati & Taylor, 2019). According to motivational learning theories, motivation may be of the intrinsic or internal type or extrinsic (external). Learners' attitude toward education is influenced by three intrinsic forces: self-evaluation, attitude toward education, and learner goals and expectations (Sivarajah et al., 2019). Thus, teachers' motivation in the professional development project will be influenced by self-evaluation of their skills and competency in STEM teaching, attitude towards STEM education, and their goals and expectations for the professional development project.

Reflective Learning

Also known as transformative learning, reflective learning theories emphasize changes in understanding and embedded assumptions as an outcome of learning (Mukhalalati & Taylor, 2019). Learning takes place when new knowledge acquired has been integrated into existing knowledge, creating a transformation. While learners may maintain their embedded frames of reference, some change occurs in their perspectives and thinking (Mukhalalati & Taylor, 2019). Transformative learning involves a sequence of steps: first, an experience of confusion regarding previous perspectives about an issue; second, critical reevaluation of the issue and self-reflection; and third, taking transformative action based on self-reflection (Mukhalalati & Taylor, 2019). For the professional development project, teachers may identify their attitudes and frames of reference regarding STEM education through self-reflection and take transformative action that tutors motivation and effectiveness in teaching science to students in elementary school.

Best Practices for Effective PD

The qualities needed for effective professional development programs have been widely examined in the research literature. Through these studies, the best practices for professional development have been largely identified. For example, Popova et al. (2022) used the In-Service Teacher Training Survey Instrument as an assessment tool to identify the gap between evidence and practice in teacher professional development. The researchers evaluated 33 professional development programs across the world. The study found professional development programs that yielded higher student learning gains to have four characteristics: they were linked to career incentives, they involved initial physical (face-to-face) training, they were designed around a specific subject, and they addressed practice through role plays and lesson enactment.

Similarly, Smith et al. (2020) conducted a study to evaluate a model of teacher professional development based on the Team Teaching and Learning (TTL) framework which is comprised of five characteristics of effective teacher professional learning: (a) content knowledge, which refers to areas such as teaching and management methods, pedagogical knowledge, and subject-area knowledge (how students learn content in an area of focus); (b) coherence, which means that the content of the professional development must build on prior teacher learning as well as align with teaching standards; (c) active learning, which refers to methods of active learning such as discussions, collaborative learning, review of students' work, and peer observations; (d) collective teacher participation, which involves organizing professional development in such a way that participants share similarities such as same grade, same subject, or same school, allowing the program to address teaching communities with similar characteristics and focus; and (e) duration of the professional development activity (a minimum contact time of 20 hours has been suggested for effective professional development interventions). The study found teacher professional development that involved all five elements to be highly effective with positive effects on teachers' knowledge, skills, and competency in the classroom.

It is important to note, however, that not all studies show positive impacts from professional development activities. Some studies on professional development have shown negligible impacts on areas such as teaching practices and student learning outcomes (Loyalka et al., 2019). However, this review of the literature supports the view that professional development is more effective when it focuses on a specific subject (content knowledge), addresses a practice-related issue (active learning and coherence), and has teachers' buy-in (collective teacher participation; Popova et al., 2022; Sims & Fletcher-Wood, 2021; Smith et al., 2020).

Methods of Instruction Delivery in PD

Several techniques are used in the delivery of content in professional development interventions. The methods are discussed individually in this review of the literature for conceptual clarity. However, in practice, a mix or combination of methods is used depending on the content of the professional development. Some methods also overlap in their theoretical framing, practical implementation, and learning outcomes. Facilitators in such programs identify the best mix of methods to enable them to deliver the content effectively and achieve the desired learning outcomes.

Lectures

Lectures are the primary method of instruction used in educational settings; the teacher imparts knowledge to the students by talking to them, and students listen to what is being taught (Popova et al., 2022). Lectures are simple, cost-effective, and efficient for dispensing information to small and large groups. Teachers ensure that lectures will be effective by preparing the content to be delivered and using an appropriate manner of delivery so that students can understand the information being provided to them (Patel, 2020). In the professional development setting, for example, lectures can be used to deliver information regarding core theoretical concepts related to STEM education. A good understanding of educational theories and concepts is essential before students can apply such concepts to real-life situations and problem-solving. Thus, lectures remain a fundamental strategy for information and learning transfers.

Demonstration

In the demonstration method of instruction, oral explanations are combined with action or enactment of the concept being taught. Such practical illustration of the information being taught enhances learning and helps students connect theoretical learning and actual practice. Practical demonstrations may include the handling of materials and equipment (Patel, 2020). Demonstrations stimulate thinking and offer opportunities for nuanced discussion, thereby further reinforcing students' learning (Maulina & Rusli, 2019). Demonstrations are a very effective method of instruction for teaching skills to students (Maulina & Rusli, 2019; Patel, 2020). A professional development project, for example, may include demonstrations on instructional strategies for early STEM education, such as how to use interactive technologies to deliver science content to young children.

Group Discussion

This instructional method involves placing participants in groups to discuss a given subject or topic. Group discussions may be guided by a selected leader or by the teacher/facilitator. This method is effective for deepening cognitive learning, where the members of the group have already acquired sufficient knowledge of the subject matter to enable useful and meaningful discussion (Patel, 2020). For example, group discussions around the needs of students in early STEM education would require some basic understanding of STEM education and the challenges that students face in learning the various STEM subjects.

Group-Based Learning

Group-based learning involves placing participants in groups to learn together. Such groups may be informal or formal. In professional development, formal groups are usually created and assigned some learning tasks such as discussion, creation of a plan, problem-solving, and so on. The groups can range in size from small groups, such as dyads that involve two persons, to larger groups (Patel, 2020; Popova et al., 2022).

Action Learning

Action learning methods involve participation in the construction of knowledge (Sivarajah et al., 2019). Rather than a passive transmission of information from teachers to students, action learning methods allow students to engage in creative thinking, analysis of information, and idea generation (Hartikainen et al., 2019). Some examples of action-learning instructional methods are assignments, discussions, and small group learning (Sivarajah et al., 2019).

Role-Playing

Role-plays involve the practical enactment of some aspects of the professional development content. Role-plays are very effective for learning practical skills, building experience, and enhancing the confidence of professional development participants (Patel, 2020). Role-plays are, therefore, a form or technique under action as participants apply what they have learned to real-life situations. For example, participants in the teacher professional development may engage in role-plays on areas such as instructional techniques in STEM and counseling students who are enrolled in an early STEM program.

Brainstorming

Brainstorming is a commonly used technique in professional development to promote creativity in groups (Patel, 2020). Brainstorming allows participants to present their perspectives and ideas regarding an issue. Brainstorming is not related to knowledge construction but rather supports reflection, idea generation, and active participation of each participant in the professional development program (Patel, 2020). These processes, in turn, deepen the learning process as they help the participants authentically engage with the subject of interest.

Problem-Based Learning

Problem-based learning involves tailoring the learning content to address real problems encountered in the workplace. The participants learn how to solve specific problems as against just receiving general information in a subject area. Problem-based learning enables students to develop skills or solutions that can be transferred immediately to an existing problem (Patel, 2020). For example, a professional development workshop for teachers who teach in an early STEM program may explore how teachers can facilitate the psychological arrangement of students with STEM content and make STEM classes exciting for elementary students to improve achievement in the area.

Question-Answer Activity

Questions are very effective tools to promote students' learning. Questions can be used strategically to engage students' attention, promote critical thinking, help students link new information to previous knowledge, or engender participation in the learning process. Questions also help students to practice oral communication or oral presentation of information (Patel, 2020). There are several types of questions, such as introductory, probing, developing, leading, rhetorical, capitulatory, centering, and redirecting questions (Olatunde-Aiyedun et al., 2021; Patel, 2020). Teachers select the type of question to use based on the learning outcome they wish to elicit. Most instructional delivery methods incorporate question-and-answer sessions or at least some questions to check students' learning.

Aligning PD with the Project Problem

Global economic prosperity depends upon countries having sufficient numbers of professionals in the STEM area. Such professionals are also critical for progress in global issues such as clean energy, biodiversity, and climate change mitigation (Harris, 2019).

Therefore, creating a robust knowledge base in STEM and a STEM-ready workforce is now a priority for countries worldwide (Skinner, 2020). Recent evaluations show that the United States has an estimated 17 million STEM jobs requiring the generation of a massive STEM workforce (Skinner, 2020). At the same time, research evidence reveals that the number of high school students who are interested in the STEM fields is declining, with only 16% of students achieving the necessary proficiency in STEM to be ready for STEM studies at the college level (Harris, 2019; Skinner, 2020). This problem makes STEM instruction a priority area for schools and education leaders in the country (Margot & Kettler, 2019), with research attention being focused on ways of improving students' beliefs, attitudes, and proficiency in STEM areas not only at college levels but also at the K-12 levels. (Skinner, 2020). To address this problem, there is a vital need for competent and effective STEM teachers. Teachers in the STEM area have the essential role of advancing student comprehension and achievement.

Furthermore, in the elementary school system, insufficient time is allotted to science learning. Such insufficiency in instructional attention impacts the levels of science achievement among elementary students creating a situation where students advance into higher levels of education and the post-educational environment that has a stronger base in liberal arts rather than science (Stevens, 2020). Research evidence shows that when children are taught concepts in the early years, it encourages investigation and exploration. Research evidence also shows that children begin to lose interest in science between ages 10–13. Therefore, it is of the essence to create programs that will encourage and stimulate children's interest in STEM in preschool and across the elementary school level (Harris, 2019). Corrective action taken at the elementary level to expose students to STEM knowledge and literacy will help to assure that they can develop the proficiency and confidence required to engage in STEM studies as they advance in their educational careers and ultimately graduate to enter the STEM workforce as competent participants.

Such corrective action again depends on the availability of competent teachers and early STEM programs in the elementary system. However, the lack of teacher exposure to STEM teaching in the K-12 system also impacts teacher self-efficacy negatively and obstructs professional identity development (Stevens, 2020). Teachers cannot effectively advance learning and student achievement at the elementary level, where they do not have the requisite subject matter skills and competency. For this reason, a professional development program to improve teachers' skills and competencies for an early program in STEM education is vital.

There are also broader issues in STEM education beyond the availability of qualified teachers. For example, minority students tend to be concentrated in schools that are located in high-poverty areas. Such schools have fewer resources, such as supplies and facilities, and lower numbers of highly qualified teachers, compared to schools that are located in wealthier neighborhoods (Harris, 2020). Such schools may have teachers who do not have sufficient training to teach STEM topics (Harris, 2019). Gender stereotypes are also an important challenge in STEM education, with girls being restricted and pushed to non-STEM fields; research evidence shows that girls as young as six are affected by gender stereotypes (Carlana, 2019). Addressing this issue requires treating girls as persons with equal capabilities as boys and allowing them to gain proficiency in all areas, including STEM (Harris, 2019). Teacher professional development that targets STEM education may be a cost-effective way to enhance the skills and competencies of science teachers in poorer schools while providing teachers with the knowledge to address gender stereotypes that affect STEM education for girls at the elementary school level, which is crucial.

Effective PD programs must deliver some type of skill, information, and competency (Sims & Fletcher-Wood, 2021). Professional development has already been identified as an effective method for improving the skills and competencies of teachers, allowing them to deliver required goals in the classroom (Ahmad Zaky El Islami et al., 2022; Popova et al., 2022). Furthermore, learning experiences acquired through professional development must align with the policies and goals of the school (Smith et al., 2020). Accordingly, this professional development project will develop teachers' skills and competencies to transfer knowledge to students in an early STEM program. By focusing on teachers who work with elementary students in an early STEM program, the professional development workshop will focus on a community of practice, a group of individuals with similar goals and interests who can learn from each other and support each other (Hajian, 2019). Organizing professional development in a specific way that the participants come from similar groups, such as the same grade, subject, or school, has already been identified in the literature review as one of the best practices in teacher professional development (Smith et al., 2018). A range of instructional techniques identified in the literature review, such as problem-based learning, brainstorming, role-playing, group discussion, action learning, and group learning, will be applied in conducting the professional development program since they are supported in the literature.

Section 4: Reflections and Conclusions

In this section strengths and limitations of this qualitative study were explored. The significance of this entire process is included in this section. My experiences with project development, scholarship, and leadership were also addressed in this section. Finally, the analysis of myself as a project developer and a scholar is noted and discussed in this section as well.

Project Strengths and Limitations

Through established PD, elementary educators would gain several strengths. The first is for elementary educators to become more comfortable with implementing STEM because of repetition during the PD and established training throughout the school year. Guzey et al. (2014) stated daily performance of elementary students shows growth with yearlong training for educators. Educators receive training in planning and designing lessons for STEM activities. They can enhance their skills and capacity in terms of incorporating STEM resources and the Internet for the growth of their students. Finally, this training will serve as a way for elementary educators to collaborate and network for future use.

The one-on-one interviews gave the educators at the SSD an opportunity for a voice in this study. Data collected and analyzed during this qualitative study developed insight that created recommendations for growth at the SSD. A summary of the study will be shared with all necessary stakeholders.

Some limitations were encountered during this study. There was only one school year's worth of data that teachers had access to reference when they participated in the study. This study was conducted for only one school year so the educators could only reference school data to evaluate growth in the class.

An additional limitation was the actual size of the sample. The size was small. This number did not truly represent the larger population of students.

Another limitation of this study was related to technology. The issue resulted from intermittent power loss. The loss created visibility and hearing issues during the interviews at various times that had to be addressed.

Recommendations for Alternative Approaches

This qualitative project study was needed to explore the perceptions of teachers and administrators about how STEM is being implemented in classrooms. The established criteria made it possible for qualified educators to participate. Semistructured interview questions were utilized with consenting educators after the approval of the site principal.

One approach could have been a strictly quantitative approach that focused on various assessments. Items that could have been used were class, school, district, and state assessments to measure the growth of second-grade students before and after the implementation of the STEM curriculum. Issue the same before and after assessment for measurement.

The second approach was to increase the sample size from a larger district and use another qualitative study with some school additional data. To do this, the entire district would need to be included. Using all elementary schools in the district and collecting the data at each school then compiling it for the district to see the larger number.

Finally, a qualitative study using a focus group could have been created to involve only curriculum developers to create a curriculum based on scores and surveys from tests and opinions of schools. Involving a group of educators evaluating test scores and answering questions. Then that data is compiled and turned over to developers to create a new version of the curriculum.

Scholarship, Project Development, and Leadership and Change

Throughout this study, I received much-needed feedback to grow. My writing improved in terms of scholarly writing with a research purpose. The guidance I received from the committee chairman, second chair, URR, and professors along this academic journey was well received. The thought of just how much knowledge I gained from this research has caused me a great deal of pleasure and thankfulness that cannot be repaid. Through this study, from all of the feedback I have developed new research skills as well as sharpened old ones. Positive academic achievement for students increases with PD (Capraro et al., 2016).

Data made it possible to determine the types of training needed to assist in the development of educators in the study site-building. According to Kimberly et al. (2019), consistent communication and training are essential to success. A curriculum for the PD itself for elementary educators at the study site was established. They had to be created so lessons that were engaging for the elementary educators as well as applicable. Feedback was sought by participants to ensure all STEM training that was needed was received and met all goals.

This study required effective leadership throughout to be a success. My skills were developed by managing and communicating with Walden staff, committee members, and participants. As the facilitator, it was my responsibility to ensure inquiry, collaboration, organization, and rigor were established so elementary educators could make their classrooms and students better.

Reflection on the Importance of the Work

This journey has been tough. I have always had discipline, being raised by a military father and then joining the military myself. This is a bit different because it was more than just me as a resource or a moving piece. I had to manage time from library services, student services, faculty, research center, etc. I tremendously grew my skills as a project leader logistically getting things in order and put where they needed to be.

I now look at things with a different set of eyes. Before I started this I would look and think of things at the class and or school level. Now it is different. I catch myself starting with the school to get the kinks out then the district to go state. Ultimately as far as I can get it to go.

This journey has been very difficult for me in terms of writing. Learning how to write all over again is extremely stressful. This was a whole different level of depth that I could not have explained before this experience. This taught me to humble myself more because this was a world that was new to me. I found myself researching how to do various things as well as my research for my manuscript. I ultimately learned and understood the importance of my scholarly voice.

I now find myself analyzing everything that is happening around me and trying to find solutions. It has become a bit challenging to manage work life and home life seeing myself in a different role. As a change agent wanting to make a difference by finding reasonable solutions to the problems at hand becomes time-consuming. At this point, learning to delegate began to make a difference.

Implications, Applications, and Directions for Future Research

Elementary educators want to implement STEM curricula but are unaware of proper implementation. This study has the potential to affect social change in a way that may give teachers the skills to properly implement a STEM curriculum in elementary school to improve student learning in STEM classes locally as well as nationally. One benefit of this study for the local stakeholders as well as those across the U.S was the development of young men and women who are critical thinkers and good collaborators of the future. Another benefit learned was that elementary educators and second-grade students can perform effectively and efficiently when PDs are available.

This basic qualitative study was established to explore the perceptions of elementary teachers and administrators about how the STEM curriculum is being implemented in second-grade classrooms. There was not a great deal of evidence to show success in the implementation of a STEM Curriculum at the SSD. Various mindsets were explored in education within this study site. Through this research, it was anticipated that participants would have opportunities to determine if the implementation of STEM affected second-grade students academically as well as socially and emotionally. This study was and is important to local elementary educational leaders because it affords them an understanding of STEM instructional implementation in elementary schools. This research led to the creation of a 3-day PD session (see Appendix A) for elementary educators in the building. Since this research is STEM-driven, it is imperative that training addresses issues and concerns that were brought forth from interviews. While this study provided educators with much-needed information, future research is recommended to ensure success with the implementation of STEM curricula.

Conclusion

Pursuing this EdD has been a journey, to say the least. I have lost a lot of foundational support that has caused my endurance to be tested and grow stronger. I lost my Grandmother, Uncle, and Father-in-Law who all were extremely influential in my life. I will continue to endure with HIS help (Ps 30:5) on my journey as I improve and be of service to educators and students as a change agent.

Obtaining this degree was not a choice in my initial career path. As I think back, I can remember telling my mom when I finished high school I was done with school. Then I joined the Army and all of that changed, but an Ed.D. I had never thought about it until I started teaching. I began to wonder if I could accomplish that task. It then became a goal. Now I can say the mission is complete.

The results from this basic qualitative research study were positive changes that can happen to the learning environment for students at this school. Changes in the learning environment will ultimately improve academic growth within the school. Along with academic growth, students will also experience a shift in school culture where they begin to experience learning school-wide. Elementary educators experience growth as well because through the training they get more skills in teaching STEM to elementary students. It would be beneficial for more research on types of training.

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Appendix A: Project

Service Agenda

2 Day Pre-Service Agenda

Day 1

Time	Activity
8:00 – 8:30 a.m.	Introduction, Greetings, and Housekeeping
8:30 - 8:45 a.m.	Project Plan
8:45 – 9:00 a.m.	Pre-Service Objectives
9:00 – 10:00 a.m.	Professional Development Process
10:00 – 10:15 a.m.	Break
10:15 – 11:00 a.m.	Teacher Mindset
11:00 a.m. – 12:00 p.m.	STEM Introduction (Framework)
12:00 – 1:00 p.m.	Lunch
1:00 – 2:00 p.m.	Learning Strategies in STEM
2:00 – 3:00 p.m.	Best Practices
3:00 – 3:15 p.m.	Break

3:15 – 4:00 p.m.	Inquiry-Based Learning
4:00 – 5:00 p.m.	Wrap up.

Day 2

Time	**Activity**
8:00 – 8:30 a.m.	Introduction, Greetings, and Housekeeping
8:30 - 8:45 a.m.	Recap of yesterday
8:45 – 9:00 a.m.	Determination of Teacher Needs
9:00 – 10:00 a.m.	Areas of Integration
10:00 – 10:15 a.m.	Break
10:15 – 11:00 a.m.	STEM Exercises
11:00 a.m. – 12:00 p.m.	STEM Exercises
12:00 – 1:00 p.m.	Lunch
1:00 – 2:00 p.m.	Content Structure
2:00 – 3:00 pm	STEM Exercises
3:00 – 3:15 p.m.	Break
3:15 – 4:00 p.m.	STEM Exercises
4:00 – 5:00 p.m.	Wrap up

Professional Development Session Agenda

Day 1

Time	**Activity**
8:00 – 8:30 a.m.	Introduction, Greetings, and Housekeeping
8:30 - 8:45 a.m.	Recap from Summer Training
8:45 – 9:00 a.m.	Discussion of STEM Activities in Class
9:00 – 10:00 a.m.	Topic Address (TBD)
10:00 – 10:15 a.m.	Break
10:15 – 11:00 a.m.	STEM Exercises
11:00 a.m. – 12:00 p.m.	STEM Exercises
12:00 – 1:00 p.m.	Lunch
1:00 – 2:00 p.m.	Class/Lesson Planning
2:00 – 3:00 p.m.	Class/Lesson Planning
3:00 – 3:15 p.m.	Break
3:15 – 4:00 p.m.	Class/Lesson Planning
4:00 – 5:00 p.m.	Wrap up/Next Session Highlights

Day 2

Time	**Activity**
8:00 – 8:30 a.m.	Introduction, Greetings, and House Keeping
8:30 - 8:45 a.m.	Recap of Last Session

8:45 – 9:00 a.m.	Discussion of STEM Activities in Class
9:00 – 10:00 a.m.	Topic Address (TBD)
10:00 – 10:15 a.m.	Break
10:15 – 11:00 a.m.	STEM Exercises
11:00 a.m. – 12:00 p.m.	STEM Exercises
12:00 – 1:00 p.m.	Lunch
1:00 – 2:00 p.m.	Class/Lesson Planning
2:00 – 3:00 p.m.	Class/Lesson Planning
3:00 – 3:15 p.m.	Break
3:15 – 4:00 p.m.	Class/Lesson Planning
4:00 – 5:00 p.m.	Wrap up/Next Session Highlights

Day 3

Time	**Activity**
8:00 – 8:30 a.m.	Introduction, Greetings, and Housekeeping
8:30 - 8:45 a.m.	Recap of Last Session
8:45 – 9:00 a.m.	Discussion of STEM Activities in Class
9:00 – 10:00 a.m.	Topic Address (TBD)

10:00 – 10:15 a.m.	Break
10:15 – 11:00 a.m.	STEM Exercises
11:00 a.m. – 12:00 p.m.	STEM Exercises
12:00 – 1:00 p.m.	Lunch
1:00 – 2:00 p.m.	Class/Lesson Planning
2:00 – 3:00 p.m.	Class/Lesson Planning
3:00 – 3:15 p.m.	Break
3:15 – 4:00 p.m.	Class/Lesson Planning
4:00 – 5:00 p.m.	Wrap up.

The 2-Day STEM Pre-Service
Professional Learning Syllabus

Description

STEM implementation training

Performance Objective

Upon completion of this experience, participants will:

- Implement a STEM framework in their classrooms to increase participation and scholar growth.

Learning Objectives

Upon completion of this module, participants will have learned and/or practiced the following:

- Develop an understanding of how to implement STEM education in classes.
- Participate in activities that are part of the STEM frameworks that develop an understanding of how STEM processes increase scholars' academic ability.
- Reflect on activities to create implementation plans.

Audience

Elementary Educators

Timing

8 Hours

Essential Question

How do we implement STEM into our classes?

Timing: Duration and Running Time	**WHAT: HOW**	**Materials**
8 hours total **Day 1**	**Activity**	

30 Minutes

08:00–08:30

1. **Meet and Greet-** getting coffee and snacks, talking with other educators.
2. **Attendance-** make sure you have signed in on the sign-in sheet, create a name card once you have found a seat.
3. **Information-** restrooms are located down the hall on the right, phones on vibrate or off (your choice), and introduction.

"Good morning,

I am ________. Welcome to your STEM Pre-Service Training. I will be facilitating for the next two days and the three PD days during the year. The agenda you see at your seat is a guide for the next two Pre-Service days with breaks

Materials:

Lined notebook paper or blank paper

Notes taken using personal style:

- Cornell
- 2 or 3 Column
- Graphic

	and lunch included for this training.”
15 Minutes	**Project Plan**
08:30–08:45	We are here to introduce you to STEM Education. After our training you should become more comfortable and aware of how it can and will help our scholars. We are here to expose our scholars as early as possible to the opportunities of STEM. In order to do that we must get you ready to deliver the information and make sure you are as comfortable with STEM as you are with your content area. Any questions before we begin?
15 Minutes	**Pre-Service Objectives**
08:45–09:00	After this training you will be able to conduct yourself in an entire new manor when it comes to STEM. Increasing the quality of

	STEM Education through better implementation creates an opportunity to increase your classroom and scholar engagement to show growth. We are striving to make this possible through all of your classes.
60 Minutes	**Professional Development Process**
09:00–10:00	Today our PD process is and should always be with the thought process of we need to ACE-IT…. A- Acknowledge the issue C- Cut the info into pieces E- Explore what we can do I- Identify how we will address it T- Test it and then see what we have Without knowing what the PD should be for wastes the time of everyone. Everything has to be done with a purpose.

	Brief discussion (12 min per topic)
15 Minutes **10:00–10:15**	**Break**
45 Minutes **10:15-11:00**	**Teacher Mindset** Mindsets can and are looked at in various ways. Many people see mindsets in different orders, processes, or importance. For the sake of our training, we will live in the realm of 4 mindsets: • Growth- the mindset of having the ability to do something through hard work • Positive- the mindset of focusing on good things rather than bad things • Entrepreneurial- the mindset of

development of skills needed to adapt and cope with the rapid change and uncertainty around us

- Challenge- the mindset of the ability to rise to the occasion or situation in our case, test-taking

As educators, this is the only community we should live in. We must maintain this in order to direct and guide our scholars on their path. If we do anything less we are doing them a tragic disservice.

60 Minutes	**STEM Exercise**	**Materials**
11:00 – 12:00	Research building a bridge out of sticks	Glue Pop Cycle Sticks String

	Build a bridge that can withstand the max amount of weight over a 6-inch span.	Thumb Tacks
60 Minutes **12:00–01:00**	**Lunch**	
60 Minutes **01:00–02:00**	**Learning Strategies in STEM** These strategies are key STEM because they all boil down to engagement and involvement. These strategies capture the attention and does not let go. • Hands-on • Active Listening • Discussion • Solving issues • Individual and group Brief discussion (10 min per topic)	

60 Minutes **02:00–03:00**	**Best Practices** • Consistency • Communication • Collaboration Brief discussion (20 min per topic)
15 Minutes **03:00–03:15**	**Break**
45 Minutes **03:15–04:00**	**Inquiry-Based Learning** • Structured • Open Ended • Problem/Project-Based • Guided Brief discussion (10 min per topic)
60 Minutes **04:00–05:00**	**Wrap-Up** Today we discussed: • Why we was here • Project Plan

- Our Objectives
- Our PD Process
- Our Framework
- Strategies
- Best Practices
- Inquiry-Based Learning Modes

Now let's check for understanding:

- Are there any questions
- Give me a thumbs-up if you are ok, thumbs-down if you are lost, and a thumbs-sideways if it is cloudy
- Tomorrow we will dig into STEM Exercises to get your hands dirty

Timing: Duration and Running Time	**WHAT: HOW**	**Materials**
8 hours total	**Activity**	

Day 2

30 Minutes

08:00–08:30

1. **Meet and Greet-** getting coffee and snacks, talking with other educators.
2. **Attendance-** make sure you have signed in on the sign-in sheet, create a name card once you have found a seat.
3. **Information-** restrooms are located down the hall on the right, phones on vibrate or off (your choice), and introduction.

"Good morning,

I am ________ again. Welcome to your STEM Pre-Service Training. I will be facilitating for today. The agenda you see at your seat guides us today with session

Materials:

Lined notebook paper or blank paper

Notes taken using personal style:

- Cornell
- 2 or 3 Column
- Graphic

	times, breaks, and lunch for this training.”
15 Minutes	**Recap of Yesterday**
08:30–08:45	Addressing questions from teachers. Are there any questions pertaining to what you have done thus far?
15 Minutes	**Determination of Teacher Needs**
08:45–09:00	A brief discussion of activities that you all have been doing in class. An open discussion for fifteen minutes. With the topic or topics from the teachers based on past experience. I want you to explain what you have noticed thus far with the positives and negatives.
60 Minutes	**Areas of Integration**

09:00–10:00	Where can we integrate STEM	
	Everywhere	
15 Minutes	**Break**	
10:00–10:15		
45 Minutes	**STEM Exercise**	**Materials**
10:15-11:00	Design. Build. Play. Create. Challenge your child to build a house ... or anything really. By inserting half of a pipe cleaner in the end of one straw, bending it, and inserting another straw, you can start to make shapes, sculptures, and whatever your heart desires. **Prep** Cut several pipe cleaners into 2-3-inch-long lengths.	Plastic drinking straws Pipe cleaners Scissors

60 Minutes	**STEM Introduction (Framework)**
11:00 – 12:00	• Participation/Ownership- 1. If scholars have some input and really believe they have contributed to their learning 2. Own what they are working on tends to change the outcome for the good • Problem Solving to develop critical thinking- 1. It is human nature to want to fix things 2. Developing the thought process to grow educationally • Authentic and Meaningful Learning 1. Being original with learning

	Making them feel whatever they learned can be related to them
60 Minutes	**Lunch**
12:00–01:00	
60 Minutes	**Content Structure**
01:00–02:00	Understanding that a structure needs to be build and secure with a foundation. The following is the content structure for STEM: • Questions/Problems • Developing • Developing inquiry skills • Getting data/Analyzing

- Critical Thinking (Looking at everything)
- Constructing
- Engaging
- Evaluate

Brief discussion (Approx.. 7 min per topic)

60 Minutes	**STEM Exercise**	**Materials**
02:00–03:00	Research building a solar oven	Cardboard pizza box
		Aluminum foil
	Build a solar oven	Plastic wrap
		Black construction paper
		Tape
		Glue stick
		Scissors
		Chocolate bar
		Graham crackers Marshmallows

15 Minutes	**Break**	
03:00–03:15		
45 Minutes	**STEM Exercise**	**Materials**
	Research a rubber-band car	
03:15–04:00	Build a Rubber Band-Powered Car	Corrugated cardboard Two drinking straws Two wooden skewers Four CDs Sponge Paper clip Rubber bands Tape Scissors Hot-glue gun (optional)
60 Minutes	**Wrap-Up**	
	Today we discussed:	
04:00–05:00	• Why we was here • Yesterday's activities	

- Integration areas
- Participated in STEM exercises
- Also, content structure

Now let's check for understanding:

- Are there any questions
- Give me a thumbs-up if you are ok, thumbs-down if you are lost, and a thumbs-sideways if it is cloudy

Don't forget to send in your emails with questions and issues for our next PD because they will be complied for our topics

The 3-Day STEM PD
Professional Learning Syllabus

Description

STEM implementation training

Performance Objective

Upon completion of this experience, participants will:

- Implement a STEM framework in their classrooms to increase participation and scholar growth.

Learning Objectives

Upon completion of this module, participants will have learned and/or practiced the following:

- Develop an understanding of how to implement STEM education in classes.
- Participate in activities that are part of the STEM frameworks that develop an understanding of how STEM processes increase scholars' academic ability.
- Reflect on activities to create implementation plans.

Audience

Elementary Educators

Timing

8 Hours

Essential Question

How do we implement STEM into our classes?

Timing: Duration and Running Time	WHAT: HOW	Materials
8 hours total **Day 1**	**Activity**	
30 Minutes **08:00–08:30**	1. **Meet and Greet-** getting coffee and snacks, talking with other educators. 2. **Attendance-** make sure you have signed in on the sign-in sheet, create a name card once you have found a seat. 3. **Information-** restrooms are located down the hall on the right, phones on vibrate or off (your choice), and introduction. "Good morning, I am ________. Welcome to your STEM PD Training. I will be facilitating our training today. The agenda you see at your seat is a guide for today with breaks and lunch included for this training."	**Materials:** Lined notebook paper or blank paper **Notes taken using personal style:** • Cornell • 2 or 3 Column • Graphic

15 Minutes	**Summer Training Recap**
08:30–08:45	"We are here to continue our STEM education journey. Since our last training session have there been any issues. I hope that you all are comfortable with applying STEM in your classrooms."
	Are there any questions pertaining to what you have done thus far?
15 Minutes	**Discussion of STEM Activities in Class**
08:45–09:00	A brief discussion of activities that you all have been doing in class. I want you to explain how it went. The positives and negatives.
15 Minutes	**Topic Hands-On Exercises (Hypothetically)**
09:00–9:15	The topic was determined and established from the information

	collected from the last 2 weeks from all of you.	
15 Minutes	**Break**	
9:15–9:30		
90 Minutes	**STEM Exercise/w a 15-minute break**	**Materials:**
9:30-11:00	Ice Project- The exercise will determine the length of time it will take ice to melt with light at a set temperature. Once the data is collected information can be determined the timeframe in which the ice melted in specific time parameters.	• Water/Ice • Clock • Pencils • Charts • Light • Lightbulb • Extension Cord
60 Minutes	**STEM Exercise**	**Materials:**
11:00 – 12:00	Build a basketball tower to hold a basketball. Students must build a tower out of newspaper that will hold the basketball without falling.	• Basketball • Newspaper

		• Masking Tape
60 Minutes **12:00–01:00**	**Lunch**	
60 Minutes **01:00–02:00**	**STEM Exercise** Creating a roller coaster with marbles	**Materials:** • Construction Paper (Heavy Duty) • Tape • Scissors • Marbles
60 Minutes **02:00–03:00**	**STEM Exercise** Create a paper speaker	**Material:** • Paper speaker template, printed on cardstock • Paper speaker

cones, printed on cardstock

- 1/2 inch by 1/2-inch neodymium magnet
- 28 AWG enameled magnet wire
- 2-position spring wire connector
- 3.5 mm audio cable with bare wire ends
- Fine-grit sandpaper

15 Minutes	**Break**	
03:00–03:15		
45 Minutes	**STEM Exercise**	**Materials:**

03:15–04:00	Connecting mini solar panels. Working panels are connected to generate power the max amount of power as possible.	• Mini Solar Panels • Multi-Meters • Alligator Clamps • Lights • Lightbulbs
60 Minutes **04:00–05:00**	**Wrap-Up** Today we discussed: • Why we were here • Our PD process • Addressed our topic issue Now let’s check for understanding: • Are there any questions • Give me a thumbs-up if you are ok, thumbs-down if you are lost, and a thumbs-sideways if it is cloudy • Don’t forget to send in your emails for our next PD	

Timing: Duration and Running Time	**WHAT: HOW**	**Materials**
8 hours total	**Activity**	
Day 2		
30 Minutes **08:00–08:30**	• **Meet and Greet-** getting coffee and snacks, talking with other educators. • **Attendance-** make sure you have signed in on the sign-in sheet, create a name card once you have found a seat. • **Information-** restrooms are located down the hall on the right, phones on vibrate or off (your choice), and introduction. “Good morning, I am ________. Welcome to your STEM PD Training. I will be facilitating our training today. The agenda you see at your seat is a guide for today with breaks and lunch included for this training.”	**Materials:** Lined notebook paper or blank paper **Notes taken using personal style:** • Cornell • 2 or 3 Column • Graphic

15 Minutes **08:30–08:45**	**Recap of Last Session** Are there any questions pertaining to what you have done thus far?	
15 Minutes **08:45–09:00**	**Discussion of STEM Activities in Class** A brief discussion of activities that you all have been doing in class. I want you to explain how it went. The positives and negatives.	
60 Minutes **09:00–10:00**	**Topic Class/Lesson Planning** We will discuss lesson options and create lesson plans. Teachers will break into groups and decide on a title and standards for a lesson for each subject using the templets provided. This activity has 15 minutes allotted for each subject (Math, Science, Social Studies, and ELA).	**Materials:** • Lesson Plan Template • Subject Text • State Standards
15 Minutes **10:00–10:15**	**Break**	
45 Minutes	**Class/Lesson Planning**	**Materials**

10:15-11:00	We will discuss lesson options and create lesson plans. Teachers will break into their working groups and decide on objectives and hooks for a lesson for each subject using the template provided. No specific time, as many as can be completed.	• Lesson Plan Template • Subject Text
60 Minutes	**Class/Lesson Planning**	
11:00 – 12:00	We will discuss lesson options and create lesson plans. Teachers will break into their same working groups and decide on a presentation and guiding practice for a lesson for each subject using the templets provided. This activity has 15 minutes allotted for each subject (Math, Science, Social Studies, and ELA).	**Materials** • Lesson Plan Template • Subject Text
60 Minutes	**Lunch**	
12:00–01:00		
60 Minutes	**Class/Lesson Planning**	**Materials:**
01:00–02:00	We will discuss lesson options and create lesson plans. Teachers will break into their same working groups and decide on independent practice	• Lesson Plan Template • Subject Text

	(work for students) and closure for a lesson for each subject using the templets provided. This activity has 15 minutes allotted for each subject (Math, Science, Social Studies, and ELA).	
60 Minutes	**Class/Lesson Planning**	**Materials**
02:00–03:00	We will discuss lesson options and create lesson plans. Teachers will break into their working groups and decide on all activities and questions for the students for a lesson for each subject using the templets provided. This activity has 15 minutes allotted for each subject (Math, Science, Social Studies, and ELA).	• Lesson Plan Template • Subject Text • State Materials
15 Minutes	**Break**	
03:00–03:15		
45 Minutes	**Class/Lesson Planning**	**Materials:**
03:15–04:00	We will discuss lesson options and create lesson plans. Teachers will break into their working groups and decide on two assessments for a lesson for each subject using the	• Lesson Plan Template • Subject Text

	template provided. No specific time, as many as can be completed.	
60 Minutes	**Wrap-Up**	
	Today we discussed:	
04:00–05:00	• Why we were here • Our PD process • Addressed our topic issue	
	Now let's check for understanding: • Are there any questions • Give me a thumbs-up if you are ok, thumbs-down if you are lost, and a thumbs-sideways if it is cloudy	
	Don't forget to send in your emails for our next PD	
Timing: Duration and Running Time	**WHAT: HOW**	**Materials**
8 hours total	**Activity**	
Day 3		
30 Minutes	• **Meet and Greet-** getting coffee and snacks, talking with other educators.	**Materials:**

08:00–08:30	• **Attendance-** make sure you have signed in on the sign-in sheet, create a name card once you have found a seat. • **Information-** restrooms are located down the hall on the right, phones on vibrate or off (your choice), and introduction. "Good morning, I am ________. Welcome to your STEM PD Training. I will be facilitating our training today. The agenda you see at your seat is a guide for today with breaks and lunch included for this training."	Lined notebook paper or blank paper **Notes taken using personal style:** • Cornell • 2 or 3 Column • Graphic
15 Minutes **08:30–08:45**	**Recap of Last Session** Are there any questions pertaining to what you have done thus far?	
15 Minutes **08:45–09:00**	**Determination of Teacher Needs** A brief discussion of activities that you all have been doing in class. I want you to explain how it went. The positives and negatives.	

60 Minutes **09:00–10:00**	**Topic Cross-Subject Planning** The topic will be determined and established 2 weeks prior. Science/Social Studies	**Materials:** • Science Text • SS Text
15 Minutes **10:00–10:15**	**Break**	
45 Minutes **10:15-11:00**	**Cross-Subject Planning** **ELA/Science**	**Materials:** • ELA Text • Science Text
60 Minutes **11:00 – 12:00**	**Cross-Subject Planning** Math/Social Studies	**Materials:** • **Math Text** • **SS Text**
60 Minutes **12:00–01:00**	**Lunch**	
60 Minutes **01:00–02:00**	**Cross-Subject Planning** Math/Science	**Materials:** • Math Text • Science Text

60 Minutes **02:00–03:00**	**Cross-Subject Planning** Social Studies/Engineering	**Materials** • SS Text • Engineering Text
15 Minutes **03:00–03:15**	**Break**	
45 Minutes **03:15–04:00**	**Cross-Subject Planning** ELA/Technology	**Materials:** • ELA Text • Technology Text
60 Minutes **04:00–05:00**	**Wrap-Up** Today we discussed: • Why we were here • Our PD process • Addressed our topic issue Now let’s check for understanding: • Are there any questions • Give me a thumbs-up if you are ok, thumbs-down if you are lost, and a thumbs-sideways if it is cloudy	

Don’t forget to send in your emails
for to me or each other for any
assistance

Day 1 Sections

PD Process

Today’s PD process is “ACE-IT”

ACI-IT is a process that I created. This process is based on many professional development experts, but mainly the ADDIE structure. The Center for Educational Technology at Florida State University produced this concept for the United States Army back in 1975. For those not familiar with ADDIE it stands for analyze, design, develop, implement, and evaluate. Now for ACE-IT in the PD process, using this to create a more efficient PD to develop educators to be able to implement STEM.

A- Acknowledge the issue (The first step is to know why the training is being created. What is the problem? When this training is complete our educators will have the tools to be able to address whatever the issue is. To have the proper plan you must know what is happening. You can’t fix a tire by cutting off the lug nuts, well you can, but you create a different and or bigger problem. When the main issue is that the tire is defective, we just need to be able to replace the tire. So, when you learn the steps, removing the tire is much easier.)

C- Cut the info into pieces (Next, once we know what has to be done, we have to begin to break the issue down. Addressing the issue of training in smaller pieces ensures that all details are covered. This goes back to the old saying “How do you eat a whole elephant? One bite or piece at a time.” Another way to look at this is by trying to drink water from a garden hose or a fireman’s hose.)

E- Explore what we can do (Now, you know what the problem is, and you have established what needs to be delivered. With the first two in place, it is time now to begin laying out all the parts and pieces to make the delivery whole.)

I- Identify how we will address it (How will we make this work? We begin putting the pieces together. Through this process we may have to arrange and rearrange to achieve the most effective plan to address the delivery.)

T- Test it and then see what we have (To know the best sequence, we have to test our plan. Once we have tested, we evaluate to see what changes need to be made for our delivery.

(Discuss each for 12 minutes)

Teacher Mindset

Now we will discuss mindsets.

Using the K W L sheet, we will break each down

- A separate sheet will be used for each mindset
- You are going to write what you know, what you want to know, and what you learned from each
- Using the timer, you will have 5 minutes per sheet

Teachers need to be open and ready. Ready with a STEM Mindset, according to Fuesting et al. (2019) needs to be open and positive because it affects fellow teachers as well as their students. Mindsets can and are looked at in various ways. Many people see mindsets in different orders, processes, or importance. For the sake of our training, we will live in the realm of 4 mindsets:

- Growth- the mindset of having the ability to do something through hard work

- Positive- the mindset of focusing on good things rather than bad things
- Entrepreneurial- the mindset of development of skills needed to adapt and cope with the rapid change and uncertainty around us
- Challenge- the mindset of the ability to rise to the occasion or situation in our case, test-taking

As educators, this is the only community we should live in. We must maintain this to direct and guide our scholars on their path. If we do anything less we are doing them a tragic disservice.

K-W-L

(Growth Mindset)

What you **know**	What you **want** to learn	What did you **learn**

Summary

K-W-L

(Positive Mindset)

What you **know**	What you **want** to learn	What did you **learn**

Summary

K-W-L

(Entrepreneurial Mindset)

What you **know**	What you **want** to learn	What did you **learn**

Summary

K-W-L

(Challenge Mindset)

What you **know**	What you **want** to learn	What did you **learn**

Summary

Learning Strategies in STEM

Brief discussion (10 min per topic)

These strategies are key to STEM because they all boil down to engagement and involvement. These strategies capture the attention and do not let go.

- Hands-on

Smyrnova-Trybulska et al. (2016) stated that using kits (hands-on) in the workshops was key to success. Chiu et al. (2015) also stated that success happened when the teachers understood and made the transition from a transmitter to a facilitator. Such implementation is crucial, particularly at younger ages, due to the rapidity at which younger students can grasp STEM concepts (Milford & Tippet, 2017). By providing STEM content as early as possible, students are provided with the skills to be able to identify multiple problem-solving approaches, as opposed to rote learning of a single approach to be applied within a single target environment.

- Active Listening

Through the integration of STEM lessons, students are not only able to connect their past knowledge to future knowledge, but they are also able to translate the lessons they learn into different environments, making greater linkages to content applications socially, in other courses within the school environment, and the home (Tran, 2018). By applying the knowledge, skills, and abilities taught through STEM lessons, STEM learners can develop themselves into visual, inductive, and active learners (Kyere, 2017).

- Discussion

The greater the level of student engagement with the material in the classroom environment, the greater the translation of that engagement into improved student knowledge gains in standardized testing and improvements to both critical thinking and creative thinking (Douglas et al., 2016; Hacioglu & Gulhan, 2021; Roberson, 2015; Sari et al., 2020; Siregar et al., 2019; Ugras, 2018).

- Solving issues

Before such actions can occur, however, there is a need to ensure that teachers are aware not only of what STEM-based curricula are but their potential applications across subject matter and the approaches to problem-solving that such implementation affords (Bolger, 2017; Han et al., 2015).

- Individual and group

Suggesting that the more STEM-associated learning within the classroom, the better students will do in terms of their engagement, assessment data, and overall knowledge acquisition, but such benefits require changes to the approach used within the classroom environment (Kertil & Gurel, 2016). Such changes not only have the potential to facilitate engagement with the material but have also been shown to result in overarching changes in student attitudes, increasing the overall positivity students have toward learning (Toma & Greca, 2017).

Best Practices

We will discuss this topic (20 minutes per topic)

- Consistency

Consistency in the implementation of the STEM curriculum is paramount (Guzey et al., 2014). Guzey et al. (2014) discovered that when teachers received proper training on implementing engineering within the classroom environment, students performed well throughout the year. In 2015, Han et al. reported that well-organized and ongoing professional development was beneficial to the growth of the STEM program. These findings were confirmed by Zhou et al. (2015) who determined that the overall performance and knowledge of the teachers increased with the professional development programs. According to Capraro et al. (2016), true consistency in training becomes the foundation for making significant gains. Monthly training was established for elementary teachers to grow their skills in implementing STEM within the classroom in studies conducted by both Baker and Galanti (2017) and Gardner et al. (2019) documenting similar findings.

- Communication

The teacher must not only understand the STEM-based instructional content to which they are being introduced, but they must also become familiar enough with that content that implementation becomes second nature (Han et al., 2015). The teacher must be confident in the approach and must have a low level of anxiety concerning the results of the lesson to increase student willingness to engage, lest they transfer their fears about the approach to the student population (Bolger, 2017; Kim & Bolger, 2017).

- Collaboration

The teachers have to be in a good position with content knowledge and strong collaboration skills to help the program succeed. Anwari et al. (2015) noted that teachers had a greater engagement with their students as a result of the implementation of STEM practices within the classroom environment based on a lesson in which students were tasked with rebuilding and testing a DC motor, while students had a greater engagement with the lesson because of the structure of the lesson. Collaboration in lesson delivery likewise works to facilitate engagement, as shown by Chiu et al. (2015) in their study of STEM implementation.

Inquiry-Based Learning Models

Brief discussion (10 min per topic)

Inquiry-based learning shares a strong tie to STEM because STEM itself is linked to Constructivism which develops all of the models within this discussion. A great deal of our base comes from the research of Bruner.

- Structured

It is just that structured. The teacher brings about a question, then introduces the topic, and so on… The teacher also decides on assessments, resources, and most of all the activities.

Ex. Building a bridge out of specific materials with the ability to refer to a set number of resources.

- Guided

This is where the teacher introduces a topic and then directs the students to create their questions and then research using the resources that they locate.

Ex. The teacher introduces the production of the best design of wind turbine blades.

- Controlled

The teacher provides the students with a list of questions with the instructions to choose one. A list of resources is also provided by the teacher for the students to do their work.

Ex. Giving the students a list of questions on how to save energy and only allowing them to use specific resources.

- Free

This is just that free. The students are given the latitude to choose a topic and create questions using their resources. The students also have the freedom to create an assessment.

Day 2

Areas of Integration

Where can we integrate STEM?

In this session, we will discuss the areas in which we can integrate STEM.

Can anyone tell me where they think STEM can be integrated?

(Discussion for 20 minutes)

The entry to this solution is exposure through a PD.

Developing a PD to get a cross-curriculum understanding of the possibilities for all subject areas to begin to see how vast the realm is for creating lessons within all subjects. Find out how to relate the classes (Science, Technology, Engineering, Math, History, and Related Arts) together. This can be structured where the classes work together or apart. The better effect is when the classes are together, so each class uses its strength so to speak.

Ex. Math/History- Design a lesson where the teachers work together to link their classes and how their subjects are related. Each class used the other class to research the topic to understand how math was used in history and how history has affected math.

Now that was just that, an example. Many have been created and many more can be created. Now it doesn't have to be us against them anymore. You know what I mean.

The short answer to our session question is Everywhere

STEM Introduction (Framework)

STEM is the integration of science, technology, engineering, and math – fields that are used to develop communication, collaboration, critical thinking, and problem-solving through a student-focused curriculum using various projects (Bochno, 2009).

Research shows that when the STEM framework is effectively implemented into classroom instruction, the likelihood of student academic outcomes is increased (Molina et al., 2016)

The STEM framework allows learners to participate in their learning which has a stronger impact.

- Participation/Ownership-
    1. If scholars have some input and believe they have contributed to their learning
    2. Own what they are working on tends to change the outcome for the good

STEM is based on solving problems through structured, controlled, and guided inquiry. STEM is also used to develop critical thinking skills for educational growth.

- Problem Solving to develop critical thinking-
    1. It is human nature to want to fix things
    2. Developing the thought process to grow educationally

STEM curriculum allows for real-world project-based learning to take place in the classroom (Cetin & Balta, 2017). Real-world learning and project-based learning, particularly in scenarios or problems with multiple possible solutions serve as one method of increasing student engagement while simultaneously allowing students to understand key lessons that can benefit them in other areas of their education and their lives (Thibaut et al., 2018).

- Authentic and Meaningful Learning
    1. Being original with learning
    2. Making them feel whatever they learned can be related to them

Content Structure

Understanding that a structure needs to be built and secure with a foundation. The following is the content structure for STEM:

- Questions/Problems – to truly challenge and take ownership one has to fix or solve an issue.
- Developing- putting ideas together.
- Developing inquiry skills- learning to ask the right questions.
- Getting data/Analyzing – collecting/looking at the info we have.
- Critical Thinking (Looking at everything) - observing to make a judgment objectively.
- Constructing- putting everything in place (as in building).
- Engaging- now let's challenge what we have (put it to the test).
- Evaluate- what worked, what didn't work, what do we add, or what do we take away?

Brief discussion (Approx. 7 min per topic)

Teacher Application Survey

(Taken after the 2-Day Training and the 1st Two of the 3 Training Days)
(45 Days after each)

Answer the following question

1. In which area do you need more training/practice?

A. Hands-On

B. Lesson Planning

C. Project Creation

D. Cross-Subject Planning

Lesson Plan Template

Note: This is a generic lesson plan template. If the section is shaded on the rubric for the lesson plan, do not include that entry on the template. Follow the directions and observe the rubrics for all three lesson plans. The points assigned to the lessons vary according to the requirements for each lesson plan.

Name		
Subject and Grade Level		
Unit Title		
Standard(s)		
Objective(s)		
Instructional Design ***Include what the teacher will be doing AND what the students will be doing in each segment of the instructional design.***		**Pacing**
Hook		

Presentation/ **Demonstration**		
Guided Practice		
Independent Practice		
Closure		
Questions		
Lists to include		
Materials		
Assessments	**Formal** **Informal**	

Appendix B: Code Legend

Code Legend (Teachers and Administrators)

Category (Priori Code)	Definition	Coding Labels
Quality Education	An education that provides all learners with the skills and abilities to be lifelong learners to be economically productive.	Cul- Culture PD – Professional Development SC- STEM Curriculum SI- STEM Implementation LP- Lesson Plan SM-Subject Matter
Academic Growth	A measurement between two points of information at a specific time.	T- Training CE- Classroom Engagement SE- Student Engagement Cen- Classroom Environment SL- Student Learning LL- Lifelong Learner SOC- Social Learning EL- Emotional Learning
Critical Thinking	The ability to form a judgment from analysis and evaluation of a problem or issue.	RW- Real World PBL- Project Based Learning STC- Student Centered HO-Hands On

Appendix C: Questions

Interview Questions (Teachers)

1. Explain your view on quality education for elementary students.
2. What strategies and or practices were utilized to establish academic growth using STEM?
3. Explain your before and after perspective on the implementation of a STEM curriculum.
4. Is using the STEM curriculum essential to developing critical thinking skills in your students? Explain
5. How has student engagement changed in your classroom concerning STEM implementation?

Interview Questions (Administrators)

1. Explain your philosophy on academic growth while using a STEM curriculum.
2. How does student data show or explain the impact that STEM has had on the academic growth of the students if any?
3. When analyzing academic growth, how important is critical thinking and why?
4. How has the quality of education improved in the school? Can it be attributed to the implementation of the STEM curriculum?
5. Where has the STEM curriculum impacted you as a school the most?