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Elementary teachers' self-efficacy and its role in STEM implementation

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ABSTRACT To equip students with 21st-century skills, teachers must have both deep STEM content knowledge and the confidence to implement and teach appropriate STEM content. Many elementary teachers have inadequate STEM background knowledge, low confidence, and STEM self-efficacy for implementing STEM in the classroom; as a result, teachers' classroom practices are affected. The study examined how elementary teachers perceive their ability to implement STEM in the classroom. The STEM Efficacy Survey was sent to a randomized pool of 100 elementary educators, and 18 of them agreed to participate in the study. This instrument was designed to elicit responses related to the teachers' previous background in STEM, their beliefs about their ability to implement STEM, and their actual STEM implementation in the elementary classroom. The results revealed that participants were confident in their understanding of the engineering design process and problem-based learning. However, teachers were unwilling to apply the engineering design process in the classroom. From this research, the researchers concluded that higher levels of training in STEM education may influence how teachers perceive their ability to implement STEM in the classroom. Further research should focus on exploring how STEM training affects teachers' self-efficacy in STEM implementation.

Keywords: *Elementary STEM Education, STEM, Teacher Education, Teacher Self-Efficacy*

Öğretmen öz-yeterliliği ve STEM uygulamalarındaki rolü

ÖZ Öğrencilere 21. Yüzyıl becerileriyle donatmak için öğretmenlerin hem derin STEM alan bilgisine hem de STEM içeriğini etkili bir şekilde uygulama ve öğretme konusunda bir özgüvene sahip olması gerekir. Birçok ilkokul öğretmeni, STEM eğitimini sınıfta uygulamak için yetersiz STEM alan bilgisine ve deneyimine, düşük özgüvene ve STEM eğitimini sınıflarında uygulamayla ilgili düşük özyeterliğe sahip olması, öğretmenlerin sınıf uygulamalarını etkileyebilmektedir. Bu çalışmanın amacı, ilkokul öğretmenlerinin STEM eğitiminin öğretimine yönelik öz-yeterlik algılarını incelemektir. STEM Yeterlik Anketi 100 ilkokul öğretmeninden rastgele oluşturulmuş bir örnekleme gönderilmiştir ve 18 öğretmen çalışmaya katılmayı kabul etmiştir. Bu anket öğretmenlerin STEM konusundaki geçmiş deneyimlerini, STEM'i sınıflarında uygulamaya ilişkin inançlarını ve ilkokul sınıflarında STEM uygulamalarını belirlemek amacıyla geliştirilmiştir. Bulgular, katılımcıların mühendislik tasarım süreci ve probleme dayalı öğrenmeyle ilgili öğrenmelerinde kendilerine güvendiklerini ortaya koymuştur. Ancak öğretmenler mühendislik tasarım sürecini sınıflarında uygulama konusunda isteksizdirler. Bu araştırma sonucunda, araştırmacılar STEM eğitimiyle ilgili alınan eğitimlerin öğretmenlerin STEM özyeterlik algılarına ve sınıflarında daha fazla STEM uygulamaları yapmalarına olumlu etki edebileceği sonucuna ulaşmıştır. İleride yapılacak çalışmalar STEM öğretmen eğitimlerinin öğretmenlerin STEM uygulama konusundaki özyeterliklerini nasıl etkilediğini incelenmesine odaklanmalıdır.

Anahtar Sözcükler: *İlkokulda STEM eğitimi, Öğretmen eğitimi, Öğretmen özyeterliği, STEM*

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INTRODUCTION

STEM education initiatives integrating science, technology, engineering, and mathematics subject matter are increasingly prevalent in elementary schools. Although there is broad debate on the definition of STEM education, many researchers claim that teaching STEM subjects by connecting and asking students to solve authentic social problems helps students connect STEM subjects to daily life (Honey et al., 2014). Integrated STEM learning typically encompasses more than just these four disciplines, as its hands-on nature allows students to develop various 21st -century skills (Daugherty et al., 2022). Cultivating students` 21st-century skills requires adequate implementation of integrated STEM education in school curricula (Lamb et al., 2015). To implement STEM education during elementary school, teachers must possess proficient STEM content and pedagogical content knowledge to incorporate the project-based teaching pedagogy. However, due to the predominant generalist nature of elementary teacher preparation, many elementary teachers possess limited knowledge of the STEM disciplines and the supporting STEM pedagogies, which can result in low teacher self-efficacy related to STEM (Rittmayer & Beier, 2008). Many studies have highlighted a linear connection between teachers' self-efficacy and students` success in STEM subjects (Katzenmeyer & Lawrenz, 2006; Smith et al., 2009). Therefore, it is crucial to determine teachers' self-efficacy toward STEM instruction so that proper interventions can be made.

Theoretical Framework

STEM-based learning in elementary school focuses on providing students with hands-on, problem-based learning objectives that develop various skills and expand upon critical content. This learning method fosters engagement in the 4 C's of 21st Century skills: critical thinking, collaboration, creativity, and communication (Claymier, 2014). While applying the engineering design process, students are encouraged to integrate subjects and develop creative solutions to problems and challenges (Havice, 2015). As mentioned, STEM-based learning often expands beyond the four subjects identified in the acronym. It provides students with opportunities in the classroom to gain real-life skills such as leadership, acceptance of failure, problem-solving, productivity, innovation, and flexibility (Autenrieth et al., 2017; Stohlmann et al., 2012).

With the seemingly unstoppable expansion of technology into all facets of society, the job market needs individuals with degrees in STEM-related fields (Havice, 2015). The Smithsonian Science Education Center reported that the demand for non-STEM jobs was three times less than for STEM jobs between 2000 and 2010 (Smithsonian Science Education Center, 2016). Furthermore, the National Academies of Sciences, Engineering, and Medicine (2017) estimates that there will be 3.4 million unfilled skilled technical jobs by 2022. Along with these unfilled jobs, the gender gap is evident in the STEM fields. Women make up only 28% of the STEM workforce, with many girls losing confidence in mathematics by third grade and electing to avoid such career areas (Lubienski et al., 2013). Dejarnette (2012) noted that students exposed to STEM education programs during elementary and secondary school are more likely to pursue degrees and careers focusing on STEM. This finding would indicate that increasing STEM interventions at younger ages could increase students` STEM career intentions.

Additionally, schools began integrating STEM education curricula as it became apparent that the instruction could aid students in making connections from one content area to another (Berry et al., 2004). Consequently, reform initiatives began experimenting with integrating engineering and technology into math and science classrooms (Margot & Kettler, 2019). However, to effectively incorporate STEM education in a way that reaps these benefits, researchers soon discovered that teacher knowledge and confidence are critical components of such integrations (Christian et al., 2021; Hackman et al., 2021; Rifandi & Rahmi, 2019). Nevertheless, many elementary educators remain prepared as generalists and sometimes lack the in-depth preparation that will likely enable them to feel confident in educators` ability to develop or teach the STEM curriculum.

STEM Curriculum

STEM curriculum refers to a discipline that focuses on integrating four content areas of STEM. For decades, STEM professionals have struggled to provide elementary school teachers with the ideas and resources necessary to enact STEM lessons and activities in schools (Brusic & Shearer, 2014). However, with the rise of technology in society and the growing STEM job market, schools must find programs that allow for STEM to be integrated into the core curriculum.

Interdisciplinary STEM is the approach where students make a connection between four content areas of STEM while focusing on an engineering design-based learning approach (Daugherty & Carter, 2017). STEM education can serve as a tool to advance students' 21st-century skills while providing an understanding of STEM content knowledge. This approach involves heightening skills such as problem-solving, critical thinking, communication, collaboration, and creativity (Brusic & Shearer, 2014; Claymier, 2014). The hands-on nature of integrated STEM naturally involves the development of these skills, and the STEM curriculum can provide students with connections between experiences in formal and informal learning environments (Archer et al., 2013). This approach also allows educators to integrate other disciplines, including social studies and art (Havice, 2015). This inquiry-based approach to STEM education introduces problem-based learning and engineering design to create solutions by applying content knowledge. Accordingly, this approach increases students` intention to STEM pathways and careers (Margot & Kettler, 2019).

According to Daugherty and Carter (2017), the engineering design process (EDP) is considered the cornerstone of STEM education. The EDP involves clearly defining a problem, generating potential ideas, selecting a plan, building it, testing it, and then communicating the results (Cunningham et al., 2018). Problem-based learning (PBL) is fundamental when establishing an environment where students use the EDP. PBL also allows educators to challenge students with real-life problems (El Sayary et al., 2015). Since STEM education, by its nature, requires the use of ill-defined complex problems, PBL allows students to use information and synthesize it while solving real-life problems (Daugherty & Carter, 2017; El Sayary et al., 2015). According to Savery (2006), problem-based learning classrooms have specific characteristics. Learning is covered by ill-structured learning challenges where more than one outcome is likely. During the learning process, the educator is a facilitator while the learners self-direct and self-regulate their learning as they formulate solutions to given problems. This learning process requires students to engage in cooperative learning as they collaborate with other students or an engineering design team to solve problems through questioning, research, and experimentation. This type of learning can help invigorate a learner's desire to engage in the classroom and make sense of the world surrounding them (Daugherty & Carter, 2017; Guzey et al., 2020). Therefore, teachers should strongly understand the application of EDP while applying PBL in the classroom (Hammack et al., 2020).

Another concern of STEM is the link between educators' STEM content knowledge and how this approach is applied in the classroom (Daugherty & Carter, 2017). According to Stohlmann et al. (2012), the four major components of an integrated STEM approach are collaboration and professional development opportunities, instruction that is focused on integrated lesson planning, efficacy and commitment to STEM education, and access to necessary STEM sources. As STEM integration is relatively new, especially at the elementary level, it is vital to understand how these components are enacted while successfully implementing STEM in the elementary classroom.

Successful Implementation of STEM in the Elementary Classroom

When implementing STEM in the classroom, the main factor is integrating scientific and engineering practices while emphasizing core concepts and student engagement (Capobianco & Rupp, 2014). Rogan and Grayson (2003) suggest that three major components ensure implementation. They include the profile of implementation, capability to innovate, and outside support. The profile of implementation refers to the classroom environment. This profile comprises the types of student-teacher interactions, content-rich and practical work, and assessment practices. The capability to innovate refers to the physical resources such as materials, space, and equipment, as well as student and teacher factors such as knowledge, confidence, commitment, and previous experiences. Finally, outside support refers to the actions of organizations outside the school to influence the implementation. These factors all play a critical role and impact the implementation of a STEM program and should be considered when developing an integrated STEM curriculum.

Early interventions are vital to maximizing the effects of STEM education. Therefore, previous findings from these interventions should also be used while developing integrated STEM learning. The effects of early intervention serve as evidence as to why elementary educators need to become well-versed in the pedagogy. Studies have shown that by third grade, many girls lose confidence in their abilities for mathematics and science content knowledge (Lubienski et al., 2013). Furthermore, other studies note that by age 10-14, students have formed their confidence, or lack thereof, and attitude towards STEM subject areas (Daugherty & Carter, 2017). Regrettably, many STEM education programs are not introduced until secondary or high school, past the point where students have formed their opinions toward STEM subject areas. For example, 20 percent of students have lost interest in science by 4th grade. This number jumps to almost 50 percent of students losing interest or deeming the content irrelevant by 8th grade (Daugherty & Carter, 2017). This finding may provide evidence as to why it is so important to have early interventions and integration of STEM education programs to provide students with relevancy and meaningful experiences early.

The challenge with this may impugn the very nature of traditional elementary education training. The curriculum is often generic and covers all subject matters in a shallow fashion in traditional elementary teacher education (Brusic & Shearer, 2014). These programs often result in educators feeling apprehensive about implementing an integrated STEM education program or other programs that include more profound levels of mathematics, engineering, or science (Catalano et al., 2019; Daugherty & Carter, 2017; Rittmayer & Beier, 2008). Supporting these assertions, several researchers have noted that elementary educators may need interventions to help increase self-efficacy towards implementing these programs, which may increase student self-efficacy in STEM classes. Additionally, due to the hands-on nature of STEM, students' self-efficacy will increase their skill sets beyond the walls of the STEM classroom (Havice, 2015; Margot & Kettler, 2019).

Why is STEM Often Not Taught?

Though research has shown that STEM education programs in the elementary classroom are beneficial and can positively influence the long-term aptitudes and attitudes of students, many schools have yet to implement such programs and curricula. There are multiple factors contributing to this perceived deficiency. First, STEM education is a relatively new curricular grouping for elementary schools. School leaders and teachers often struggle, as they are, to meet state and local performance standards, which may lead them to overlook the development and implementation of STEM education programs (An & Cardona-Maguigad, 2019; Johnson, 2020). Additionally, many teachers exhibit discomfort and lack confidence in developing and teaching STEM education programs (Akaygün & Aslan-Tutak, 2016; Katzenmeyer & Lawrenz, 2006; Smith et al., 2009). As these programs are relatively new, many experienced teachers may not have had formal STEM education training, nor did they focus on STEM education while engaged in teacher preparation programs at the university (Brusic & Shearer, 2014). Additional research studies have shown that this transition to delivering STEM in the elementary classroom is often difficult for teachers (Daugherty & Carter, 2017). These challenges and other factors may suggest why STEM education is underutilized in elementary schools in the United States.

Teacher Self-Efficacy

Bandura (1997) defined self-efficacy as one individual belief about his ability to complete a task successfully. These beliefs affect teachers in the classroom (Bandura, 1997). Teachers who possess a high sense of self-efficacy can motivate students and improve students' cognitive development

(Bandura, 1997). Self-efficacy is affected by the teacher's effort and persistence, professional commitment, openness to new methods, and positive strategies to deal with student problems (Mojavezi & Tamiz, 2012). Supporting these assertions, Ashton and Webb (1986) note that teachers with high self-efficacy plan and organize their classes more than others, have more developed questioning and instructional skills, and provide better student feedback. These implications indicate why it is vital for teachers to have a high sense of self-efficacy in their subject areas—It directly affects their students.

According to Rittmayer and Beier (2008), an individual's self-efficacy is affected by four primary sources: mastery experiences, vicarious experiences, social persuasion, and physiological reactions. Successful outcomes typically increase self-efficacy, while failures lower it. Vicarious experiences refer to learning through observing others performing a task, while social persuasion is the effects of others' judgments, feedback, and support on self-efficacy. These experiences are compelling when the source of social persuasion comes from influential figures and is accompanied by a mastery experience. For example, positive feedback from a teacher or parent boosts self-efficacy, especially when it is aligned with past performance and actual ability. Finally, physiological reactions refer to the emotional and physical states, like 'butterflies in the stomach,' that determine self-efficacy beliefs. Knowing the four sources that can affect self-efficacy is essential to increasing teacher self-efficacy in STEM fields and when preparing elementary teachers to deliver integrated STEM in the primary grades. Furthermore, teachers who lack experience in implementing STEM integration in the classroom reported low self-efficacy and often avoided STEM lessons (Gerde et al., 2018; Hammock et al., 2017; Kelley et al., 2020; Martínez-Borreguero et al., 2022; Nadelson et al., 2013). Professional development opportunities are often designated as a potential solution to improved elementary STEM instruction (Honey et al., 2014; Rich et al., 2017; Radloff & Guzey, 2017; Rinke et al., 2016; Zhou et al., 2023). However, there is little agreement on effective integrated STEM professional development characteristics.

Importance of Teacher Self-Efficacy

Many factors impact the use of STEM education in elementary schools. Elementary teachers are less confident in teaching STEM subjects in-depth and are concerned about their ability to teach STEM subject matter for various reasons, such as limited experience in developing STEM lessons and limited STEM content knowledge (Love et al., 2023). Integrating subject areas outside teachers` expertise may pose new challenges for teachers (Boice et al., 2021). These challenges cause teachers to feel less comfortable teaching outside of their area of expertise, and, as a result, teachers` self-efficacy and confidence in teaching integrated STEM may decrease (Geng et al., 2019, Stohlmann et al., 2012). Teachers` self-efficacy affects teachers` choice of pedagogical approaches, class preparation, teaching strategies, and students` success in that subject (Catalano et al., 2019; Katzenmeyer & Lawrenz, 2006; Klassen et al., 2010; Kelley et al., 2020; Smith et al., 2009). Nadelson et al. (2013) found a connection between willingness to teach integrated STEM, their motivation, and the learning outcome. Through studying STEM self-efficacy, researchers have found that teachers` efficacy is a critical component that may influence instructional quality in STEM education, teachers` intention to use STEM education in the classroom, and teachers` success in delivering appropriate learning experiences (Dong et al., 2019; Holzberger et al., 2013; Kelley et al., 2020; Love et al., 2023; Martinez-Borreguero et al., 2022). Therefore, enhancing teachers` efficacy towards STEM subjects may increase teachers` confidence and ultimately result in more integration of STEM instruction in elementary classrooms (Love et al., 2023).

The Implications of Teacher Self-Efficacy

Self-efficacy is a significant predictor affecting teachers' motivation and task performance. Therefore, the implications of teacher self-efficacy while implementing an integrated STEM program are essential. Individuals with high STEM self-efficacy adopt STEM instruction to the classroom better than others and persistently use it longer in the field than those with low STEM self-efficacy (Rittmayer & Beier, 2008). However, as previously stated, elementary teachers commonly hold lower self-efficacy views towards mathematics and science than secondary teachers (Catalano et al., 2019). Additionally, teachers with higher self-efficacy use more effective teaching strategies, are keener on the profession and are less likely to burn out or leave teaching (Catalano et al., 2019; Muijs & Rejnolds, 2001).

While self-efficacy's effects on the teacher's well-being are important, it is equally essential to note that a teacher's level of self-efficacy also affects students' achievement and motivation (Catalano et al., 2019; Hammock & Ivey, 2017; Klassen & Chiu, 2010; Mojavezi & Tamiz, 2012). The nature of STEM learning differs from traditional science and math instruction. When examining predominant science and math instructional techniques, these teachers rely heavily on textbooks and traditional teaching approaches that are not student-centered and tend to overuse outside experts (Goodnough et al., 2014). Teaching specific content such as mathematics, technology, engineering, and science involves using domain-specific self-efficacy (Gerde et al., 2018). Teachers confident in their mastery of a single subject tend to report greater self-efficacy in their capability to teach that subject (Gerde et al., 2018).

Meanwhile, integrated STEM courses rely heavily upon providing students with enriching hands-on experiences. Due to the generalist nature of elementary educator training in the United States, teachers' self-efficacy may be low in STEM areas, leading to avoidance when implementing integrated STEM initiatives. These programs can result in lower self-efficacy, leading to negative results for students under the direction of teachers with low self-efficacy. However, numerous studies have illustrated that teachers with high self-efficacy manage classrooms and teach students using different approaches that encourage autonomy (Mojavezi & Tamiz, 2012). Developing student independence is vital to PBL and integrated STEM as the educator is a facilitator, and the learners are more self-directed and self-regulated.

Tournaki and Podell (2005) suggest that teachers with high self-efficacy do not make pessimistic predictions about students and are more likely to change their predictions unless students change. Considering that social persuasion, especially from influential figures, is one of the four primary influencers of self-efficacy, educators need to hold these positive predictions about students. As Gardner's motivation theory (1985) states, learners` motivation to learn increases when they sense that educators care about them and their success. Therefore, teachers with high self-efficacy make more positive predictions, which may positively affect their students.

Self-efficacy is goal-directed and, therefore, affects the individual's goals. When setting these goals, individuals with higher self-efficacy adopt a greater commitment to the goals, indicating more effort expended and greater persistence when difficulties arise (Rittmayer & Beier, 2008). Thus, it is essential to gauge and improve teacher self-efficacy related to integrated STEM to result in rigorous goals being set for the curriculum. Furthermore, effective professional development opportunities improve teachers' confidence in teaching STEM subjects and make them change their classroom practices (Goodnough et al., 2014). Research shows that a teacher's efficacious views directly affect their implementation and, therefore, their students' achievement. Thus, it is essential to continue studying the contributing factors to teacher efficacy to make the necessary efforts to improve the effects (Gardner et al., 2019).

Significance of This Study

With these factors in mind, this study was designed to determine how elementary teachers perceive their ability to implement STEM in the classroom. Teachers' self-efficacy affects teaching practices in the classroom and influences students' success and motivation toward STEM subjects (Catalano et al., 2019; Mujis & Rejnolds, 2001; Skaalvik & Skaalvik, 2007; Tournaki & Podell, 2005; Tschannen-Moran & Hoy, 2001). Therefore, determining how elementary teachers perceive their self-efficacy beliefs is helpful in improving STEM integration in schools.

METHODOLOGY

The survey method was used in this study. The survey method can be used to investigate participants' self-efficacy, characteristics, and behaviors about specific issues (Büyüköztürk, 2015). This study aimed to determine teachers perceived self-efficacy levels in teaching integrated STEM education. The following research questions guided the study: How do elementary teachers perceive their ability to implement STEM education in the classroom?

Participants

The core research focused on elementary teachers in the south-central United States. The Ethics Committee approval was provided by the Institutional Review Board in Research Integrity and Compliance at the University of Arkansas (Number: 2101307040, Date: 26.01.2021). After approval from the university institutional review board, the researchers created a pool of participants, making certain to select elementary subject matter teachers and excluding non-classroom teachers (i.e., guidance counselors). To maintain the confidentiality of participants, the researchers gathered a random selection of 100 active K-6 teachers currently employed in elementary teaching positions within the selected geographic region identified for the study using contact information gathered from State departments of PK-12 education and teacher contact information available on the school district online directories of all schools within the geographic region.

To randomly select participants, the researchers selected an equal number of participants from each school district within the geographic region until 100 names had been selected. To accomplish this task, every 25th name of all available teachers within the region was selected for participation. Additionally, when choosing the participants, the researchers eliminated participants that did not fit the demographics and moved on to the next available teacher on the master list of contacts. Such eliminations were substitute teachers, physical education teachers, educators who taught courses beyond 6th grade, and any teachers identified as from non-specified content areas. Once the sample was formed, the STEM Efficacy Survey (See Appendix 1) was emailed to all participants, along with an informed consent letter stating that participation was completely voluntary and anonymous. However, seven participants agreed to participate in the pilot study, and 18 joined the actual research.

Data Collection

The STEM Efficacy Survey was used to collect the data. The STEM Efficacy Survey was a 24-question survey. The first ten questions asked demographic questions such as gender, age, teaching experience, education received, and potential training in STEM education. The next four questions inquired about the implementation of STEM in the classroom in the participants' schools. Finally, the last ten questions were on a Likert-type range and queried participants to reflect on questions about their opinions towards STEM education. These three sections of the survey comprised the aforementioned 24-question instrument.

The questionnaire consisted of multiple-choice, write-in, and 5-point Likert-type questions (1= strongly disagree,2= disagree,3= undecided,4= agree,5= strongly agree). The researchers developed the survey based on the current literature. The researchers then used a desk or expert review (Grover et al., 2009), getting opinions of two different experts with Ph.D. and Ed.D. degrees in the field of STEM education, to evaluate the content, usability, and to determine the content validity of the survey questions. Due to time constraints, COVID restrictions, and the nature of the research, a measure of construct validity was not undertaken for this study. Afterward, the questionnaire was sent to teachers from a random pool from multiple schools and school districts, and the researchers presumed that the participants would have varying levels of STEM implementation and previous STEM teaching experiences. Participants were asked to answer questions related to demographic questions about themselves, integrated STEM implementation, professional development experiences associated with integrated STEM education, and perceived confidence levels in teaching integrated STEM education. Only seven teachers answered the questionnaire. Adjustments and corrections of the questionnaire were made after the pilot study. Three questions were removed, and two were clarified to increase the instrument's reliability quotient. After these changes, the questionnaire was found to have acceptable reliability (Cronbach's alpha = .82). After being satisfied with the reliability and validity of the instrument, the researchers created a pool of 100 randomly selected elementary teachers in the South-central Region of the United States. Once distributed, the instrument accepted responses from this pool of 100 teachers for two weeks. The questionnaire utilized a Google Form that allowed for anonymous responses to protect each participant's identity.

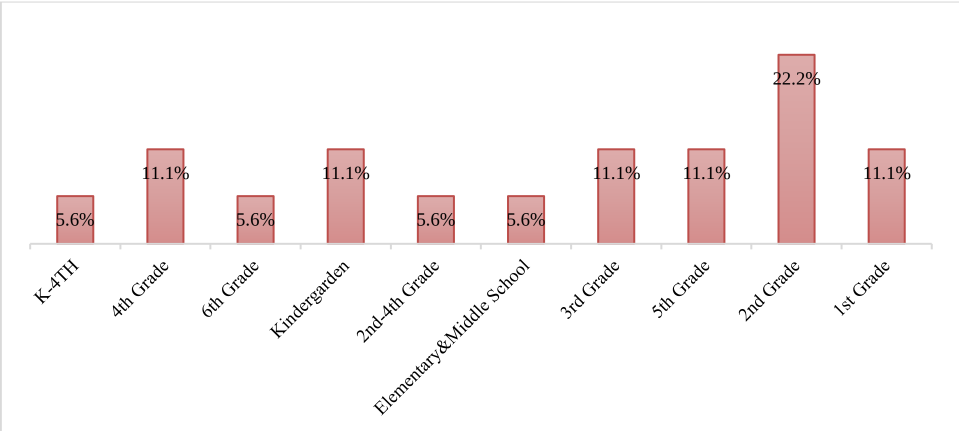
Additionally, this Google Form required participants to log in to ensure each participant only submitted one response. This login did not compromise the confidentiality of the questionnaire. After participants (only 18 participants) submitted their responses, all questionnaire responses were stored on a password-protected account until the assigned research window had closed. Once collected, the data was analyzed using Microsoft Excel. The questions that utilized multiple choice and the Likert range were scored, while the write-in data were grouped into categories.

RESULTS

The results of the teachers' demographic section of the questionnaire are listed below. Of these respondents, eighteen were female, with four in the 20-30 age range, five in the 30-40 age range, five in the 40-50 age range, and four in the 50-60 age range. After completing the demographics questions, the participants answered the remainder of the questions about the implementation of STEM.

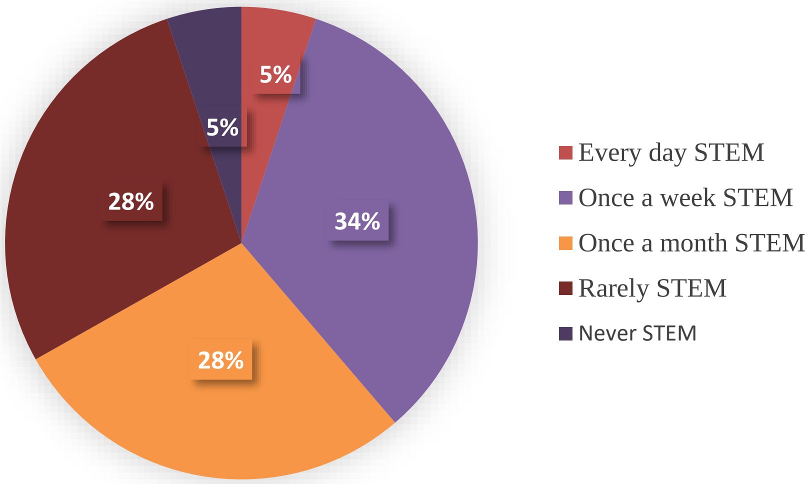
The results of the survey's eighteen teachers' demographic section are listed here. Since teachers in the southern states of the USA were assigned to teach different levels, the participants` grade levels varied. Among the eighteen, there was a distribution of the grade levels they teach. This distribution can be seen in Figure 1. Of the eighteen, fifteen (83.3%) respondents received their master's degree as their highest education, two (11.1%) received their bachelor's degree, and one (5.6%) was in the process of completing her master's degree at the time of the survey. Of these eighteen, twelve (66.7%) did not receive formal STEM training as a preservice teacher, while six (33.3%) did. Similarly, thirteen (72.2%) respondents had completed professional development concerning STEM education since becoming an in-service teacher. In comparison, five (27.8%) did not.

Figure 1.
Participants Grade Level



Following, the participants answered the remaining questions about the implementation of STEM. Thirteen (72.2%) of the respondents mentioned their implementation of integrated STEM education in the classroom, while five (27.8%) did not. However, many respondents indicated they incorporated STEM into the classroom at different times, as seen in Figure 2.

Figure 2.
Integration in the Classroom



After examining the initial results of the study, the researchers were able to analyze the participants' responses closely. The respondents' answers for their varying backgrounds in STEM education and their varying integration were reflected in their answers in the remainder of the survey. As seen in Figure 2, the participants varied in integrating STEM into the classroom. Most teachers reported that they rarely or once a month integrate STEM into the class. A small number of the teachers, %5, have never used integrated STEM in the classroom. Moreover, 34% of the teachers integrate STEM once a week, while 5% of the teachers use it daily.

Problem-based learning (PBL) is vital to STEM education and the engineering design process. PBL learning is covered with ill-structured learning challenges where multiple outcomes can occur. The survey questionnaire asked the participants multiple questions concerning how confident they felt using problem-based learning in STEM classrooms. Most participants responded yes when asked if they used PBL in the classroom. Fourteen (77.8%) answered that they used PBL, while four (22.2%) responded that they did not.

When examining the responses to questions about PBL, the teachers seemed to exhibit a strong understanding and high confidence level. As PBL is an integral STEM technique and a great way to integrate the engineering design process, the researchers assumed that those confidence levels would carry over to responses regarding the engineering design process. However, this was not the case. When asked if they utilized the engineering design process in the classroom, thirteen (72.2%) of the respondents responded no, and only five (27.8%) answered yes.

Then, the participants provided varying responses to the questions related to elementary teachers` confidence in understanding the engineering design process and problem-based learning (See Table 1).

As seen in Table 1, elementary teachers` confidence in understanding the engineering design process, project-based or problem-based learning varied. Most teachers responded that they seek better ways to integrate STEM into their classrooms. Of these respondents, 5.6 % of the teachers strongly agreed, 22.2 % of the teachers agreed, and 61.1 % of them were neutral. Only 11.1 % of teachers strongly disagreed with this statement. Notably, by combining the teachers who responded that they strongly agree or agree to integrate STEM, only 38.9% expressed their confidence in teaching integrated STEM. On the other hand, 33.3% of the teachers were indecisive about their capacity to teach integrated STEM.

Table 1.
Teachers` Responses about the Engineering Design Process and Problem-Based Learning

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I make an effort to continually find better ways to teach integrated STEM in my classroom.	11.1%	0%	61.1%	22.2%	5.6%
I am confident in my ability to teach integrated STEM curriculum and activities effectively.	11.1%	16.7%	33.3%	22.2%	16.7%
Even if I try very hard, I am not able to teach integrated STEM as well as some other subject areas.	5.6%	33.3%	33.3%	16.7%	11.1%
I feel confident in my understanding of the engineering design process.	38.9%	27.8%	11.1%	5.6%	16.7%
I feel confident in my understanding of the problem or project-based learning.	0%	16.7%	27.8%	33.3%	22.2%
I am comfortable using ill-structured problems (problems with many correct answers) with my students.	0%	5.6%	22.2%	44.4%	27.8%
I am confident that I can answer students' questions during integrated STEM lessons and activities.	0%	22.2%	27.8%	33.3%	16.7%
I am comfortable not always knowing the answers to the STEM challenges or problems that I present to my students.	0%	11.1%	22.2%	38.9%	27.8%
Problem or project-based learning and integrated STEM requires the teacher to present design problems where the solution is unknown. As a teacher, this causes me some anxiety.	5.6%	38.9%	38.9%	11.1%	5.6%

In comparison, a total of 27.8% of the teachers were not confident about their skills to teach integrated STEM and other subjects; that was calculated by combining the teachers who responded that they disagreed or strongly disagreed with integrating STEM. Most teachers were questioning their capacity to teach integrated STEM. Of these respondents, 11.1% of the teachers strongly agreed, 16.7% agreed, and 33.3 % were neutral. Only 33.3% of the teachers disagreed, and 5.6% strongly disagreed. Respondents indicated they were not confident in understanding the engineering design process but did not use it.

Furthermore, most teachers were not confident about their understanding of the engineering design process, including determining and researching the problem, planning possible solutions, choosing the best solution, building a prototype, testing a prototype, redesigning a prototype, and sharing results with the audience. Of these respondents, 38.9% of the teachers strongly agreed, and 27.8% disagreed. Only 11.1% of them were neutral, 5.6% disagreed with it, and 16.7% strongly disagreed.

Additionally, most teachers have confidence in their understanding of the problem or project-based learning. From participant teachers, 22.2% of the respondents strongly agreed, 33.3% agreed, and 27.8% were neutral. Only a limited number of participants, 16.7%, replied as disagree, have no confidence in their understanding of the problem or project-based learning, and understanding of the problem.

Through this analysis, points of discussion and implications can be drawn from the participant's responses to answer the research's guiding questions. Over 70% of the participants felt comfortable using ill-structured problems with their students. Nevertheless, most teachers were comfortable not knowing the answers that they posed during the STEM challenges. Only 11.1% lack confidence in STEM challenges that can be solved through different solutions. Surprisingly, though teachers' backgrounds in STEM, project, and problem-based STEM are limited, teachers did not feel anxious about using design problems where teachers do not know the answer, project, or problem-based STEM in the classroom. In this study, teachers highlighted their position by marking strongly disagree (5.6%) and disagree (38.9%) in the survey. While 38.9% of them were indecisive, the rest of the participants, %16.7 who selected their position as strongly agree (%5.6) and agree (%11.1), mentioned that the use of design problems while implementing project or problem-based STEM in the classroom, they felt anxious. Based on the results, teachers who have higher self confidence in their ability to teach integrated STEM and previous formal training tend to use integrated STEM more often than others with no or less STEM education training. This result will be further delineated in the discussion section below.

DISCUSSION

This study explored how elementary teachers perceive their ability to implement STEM in the classroom. The researchers gained insights into these topics using the STEM Efficacy Survey from the participants' responses. The findings we obtained from this study indicated that most participants had confidence in their understanding of Problem-based learning (PBL) and were unwilling to apply the engineering design process in the classroom because of their limited exposure to engineering design process. Many of the teachers indicated that they had some limited training in STEM, whether in preservice teacher education or as in-service teachers. The teachers with previous training in STEM have a tendency to implement STEM in the classroom more often than teachers without previous training. This conclusion has similarities with the previous literature (Shernoff et al., 2017). Teachers struggle with the iterative nature of engineering design and engineering design steps (Mesutoglu & Baran, 2020). Thus, teachers should be exposed to engineering design experiences as learners and teachers (Capobianco et al., 2022). The results of the study indicated a need for improvement for those teachers who claimed their lower confidence in the engineering design process application. Even if teachers have more efficacious views than vogue views about engineering design process and STEM education, elementary teachers should receive formal STEM training to robust their understanding and confidence in STEM (DeCoito & Myszkal, 2018).

The teachers with the most previous formal STEM training experience tend to trust more on their abilities to integrate STEM. This finding echoed past studies that teachers' confidence and beliefs in their abilities to teach integrated STEM change after participation in STEM training, and teachers' confidence and beliefs affect their classroom implementation (DeCoito & Myskal, 2018). These previous STEM training opportunities opened the door for STEM integration, as many respondents indicated that they are willing to integrate STEM more often. This finding is consistent with the findings from Margot and Kettler's (2019) study. Margot and Kettler (2019) pointed out that participation in STEM professional development facilitates teachers' learning of integrated STEM concepts. STEM professional developments also enhance teachers' understanding of STEM and show them how to use STEM integration to teach their subjects (Wang et al., 2011). Since preservice teachers' and in-service teachers' previous STEM experiences, personal interests, and disciplinary backgrounds are essential factors for developing integrated STEM lessons, teaching method courses or professional developments should support be offered to both teachers and preservice teachers (Shernoff et al., 2017; Ryu et al., 2019).

Problem-based learning (PBL) is vital to STEM education and the engineering design process (Daugherty & Carter, 2017). PBL learning is covered with ill-structured learning challenges where multiple outcomes can occur. The study assessed participants' confidence levels while applying PBL in the classroom. Most participants were confident in their understanding of PBL and mentioned their use of PBL in STEM classrooms. These important findings support previous research findings that STEM professional development opportunities and STEM learning experiences from teacher preparation affect teachers' instructional practices, attitudes, beliefs, confidence, and knowledge of STEM (Çiftçi et al., 2022; Gardner et al., 2019; Hasim et al., 2022; Lange et al., 2022).

To effectively implement STEM PBL, teachers should understand its rationale and consider how STEM PBL will be applied in the classroom (Han et al., 2015). While implementing STEM PBL in the classroom, teachers may need to pose questions that may have many correct answers. Therefore, teachers may be presented with questions or responses that they do not always know how to answer. In the study, teachers' comfort level was asked about not always knowing the answers to the STEM challenges they presented to students. As a teacher, it can be uncomfortable or unnerving not to know all the answers. For this reason, the researchers assumed that most teachers' responses would have anxiety feeling. Surprisingly, over half of the respondents were comfortable with not knowing all the answers. Similarly, many participants were content with presenting design problems with an unknown solution. These results might be related to how teachers value STEM education. Park et al. (2017) found that teachers who value STEM education have more confidence and comfort when implementing STEM and engineering design processes as teachers' STEM teaching experience increases. This study showed that teachers were generally confident and comfortable utilizing PBL in the classroom. As PBL is an effective way to integrate STEM, this finding shows that the more confident teachers are, the higher the chance of using integrated STEM education in the classroom (Widowati et al., 2021).

Furthermore, the PBL is an integral STEM technique and a great way to integrate the engineering design process. In the study, the researchers assumed that those confidence levels would carry over to responses regarding the engineering design process. However, this was not the case. Many respondents indicated that they did not apply the engineering design process in the classroom, though they claimed they felt confident in their understanding of the engineering design process. Teachers' unwillingness to apply the engineering design process may indicate that implementing STEM in the elementary classroom may bring different challenges for teachers. Integrating engineering design into a curriculum requires teachers to understand the nature of the engineering design process (Hammack & Ivey, 2017). Though engineering design is a systematic and iterative process to solve problems, teachers think of the engineering design process as linear rather than iterative (Mesutoglu & Baran, 2020; Ozkizilcik & Cebesoy, 2024). They also struggle with engineering design steps, including identifying the problem. Therefore, teachers should develop a more profound knowledge of engineering design in a STEM context (Mesutoglu & Baran, 2020). Participating in engineering design activities will help teachers understand engineering design and gain experience in integrated STEM (Ozkizilcik & Cebesoy, 2024). Increasing exposure and understanding of the engineering design process will likely increase STEM implementation (Hynes, 2012; Mesutoglu & Baran, 2020).

Limitations

A few factors that limited the effectiveness of this study were the unprecedented COVID-19 pandemic, the small sample size—which was also impacted by the pandemic, potential response bias, and a clear need for further research.

When the survey was open to responses, COVID-19 affected schools and teacher workload in the schools where the survey was implemented. Along with the unprecedented times of the pandemic, the geographic region where the study was completed was experiencing an abnormal winter storm that led to power outages and closed schools during the survey implementation. The researchers believe these two abnormalities may have been attributed to the lower response rate.

Furthermore, after the pilot test was issued, one of the participants shared in a discussion with the researchers that it was difficult to answer questions like the ones in the survey, as they require one to be introspective and honest. When answering questions and self-reporting, there is always a risk present as it requires the respondent to interpret the question, understand what it is asking, and then answer the question (Widhiarso, 2014).

Additionally, self-reporting poses a risk that respondents may have response bias. Smith (2014) discussed that "response biases occur when respondents complete rating scales in ways that do not accurately reflect their true responses. They occur especially among responses to Likert scales that ask the respondent to agree or disagree with various statements" (p. 5539). For this reason, the researcher suggests that readers analyze the study results with scrutiny, as respondents may have exaggerated responses to the Likert scale questions.

This response bias may also occur due to how females perceive their abilities. Studies have shown that girls' and women's confidence in STEM does not always have to do with their actual ability but how they perceive it (Rittmayer & Beier, 2008). While they may not feel confident about certain STEM subjects, there is a possibility that their abilities may be stronger than they realize. Therefore, because all the participants in this study were women and girls and women are more likely to hold low efficacious views towards STEM, they may reflect their attitudes but not their actual ability. Male teachers should be added to another study to capture teachers' prior STEM learning, their self-efficacy, and their relation to the implications of integrated STEM in the classroom.

Finally, the study examined the possible link between teacher preparation, such as university courses and professional development, and teachers' self-efficacy toward implementing STEM. However, as stated in prior research, a person develops attitudes and efficacious views toward STEM at a young age (Daugherty & Carter, 2017; Lubienski et al., 2013). Therefore, assuming that a teacher's efficacy is formed solely due to their teacher preparation, presumably in their 20s, well after their interest levels have been established, would be imprudent. Therefore, while this study examines the intended research questions, it may not provide a comprehensive picture of how self-efficacy is formed and its effects on STEM implementation.

With these limitations in mind, the researchers can more clearly evaluate the data collected from the study. Additionally, the researchers can make recommendations using the data collected.

Recommendations

The researchers propose several recommendations for further training and research on the effects of teacher self-efficacy on STEM implementation. As the study points to the positive impact of STEM interventions on students, it is vital to explore this link to develop compelling STEM opportunities for teacher professional development and STEM-focused teacher education interventions (Claymier, 2014; Dejarnette, 2012; Havice, 2015; Smithsonian Science Education Center, 2016).

After examining the data from the participants' responses, the researchers also recommend more exposure to STEM curricula to increase self-efficacy. As Rittmayer and Beier (2008) discussed, there are four primary sources on which a person's self-efficacy is based: mastery experiences, vicarious experiences, social persuasion, and physiological reactions.

One of the participants answered that a barrier to STEM integration was "a complete lack of resources." By increasing exposure to STEM curriculum and opportunities for mastery experiences, teachers will likely feel more equipped to integrate STEM. Therefore, professional teacher developers should design integrated STEM materials and professional development opportunities for teachers in a manner where they can experience integrated STEM from a student perspective. Furthermore, policymakers and administrators should also develop a budget that provides minimal tools and materials because integrated STEM requires additional tools and materials, including engineering supplies and tools for building, making, and coding, such as wood, plastic, and numeric coding systems.

Another significant result was the teacher responses associated with the engineering design process. Many participants did not utilize the engineering design process and were not confident in understanding the engineering design process. One limiting factor affecting perceived STEM self-efficacy might be teachers` engineering design content knowledge (Love & Hughes, 2022). Since engineering design requires integrating multiple subjects such as mathematics, science, and technology, teachers find engineering design challenges complex and feel untrained in engineering design content and practices (Moore et al., 2014). Therefore, interventions or professional development programs should be developed to inform teachers of the concepts of the engineering design process and increase that understanding. Since teachers feel confident in project-based learning, project-based learning might be combined with the engineering design process while developing professional development programs. By doing this, the utilization of the engineering design process will likely increase.

Additionally, this study was distributed virtually to a random pool of teachers across one geographic region of the United States. This diverse and random pool served several purposes of the study; however, without a personal connection, the participant pool was less responsive to the researchers' emails. For this reason, the researchers recommend distributing the survey to a pool with higher incentives to respond in hopes of receiving a higher response rate. The researchers also recommend redistributing the survey now that many of the restrictions associated with the pandemic lockdowns have ended in hopes of receiving a higher response rate.

As discussed in previous research, STEM is heavily male-dominated, with women making up only 28% of the workforce (Lubienski et al., 2013). As women tend to hold lower efficacious views towards STEM, the researchers hoped to see how male responses to the survey may have varied from female respondents (Lubienski et al., 2013; Rittmayer & Beier, 2008). Even though the researchers purposefully included male contacts on the participant list, 100% of the respondents were female. For this reason, the researchers suggest re-issuing this study with a larger sample of male educators to compare their responses to those of their female colleagues.

Finally, the research findings illustrate that efficacy may not always reflect actual ability. Hence, the researchers suggest a two-part study. In this study, teachers would complete the survey, be observed while implementing STEM in the classroom, and their practices would be analyzed to determine teachers` STEM self-efficacy. This two-phase study would provide a more detailed and realistic depiction of how one person's views of their ability reflect their actual performance.

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APPENDICES

Appendix 1: STEM Efficacy Instrument

Dear Elementary Teachers,
This scale has been designed to determine your STEM self-efficacy. Please indicate the degree to which you agree or disagree with each statement:1 indicates strongly disagree, a 3 undecided, and a 5 strongly agree.

Please answer the demographic questions first, and then you can move on to Sections II and III.

Section I. Demographic Information

1. Gender:
   ( ) Male
   ( ) Female
   ( ) Prefer not to say

2. Age range:
   a. 20-30
   b. 30-40
   c. 40-50
   d. 60+

3. Grade you currently teach: (write in question) ………………………….

4. Subjects you currently teach: (write in question) ………………………..

5. Type of district where employed:
   a. Urban
   b. Suburban
   c. Rural
   d. Virtual

6. Years of Teaching Experience:
   a. 1-3
   b. 4-10
   c. 11-20
   d. 20+

7. Highest Level of Education Received (write in question) ……………………….

Section II.

8. As a preservice teacher, did you receive formal training in STEM education?
   ( ) Yes
   ( ) No

9. If you answered yes to the previous question, to what extent? (Answer N/A if previous answer was no)
   a. University courses
   b. In-service programs
   c. Degree programs
   d. Other professional development
   e. N/A

10. Since becoming an in-service teacher, have you completed any professional development classes concerning STEM education?
( ) Yes
( ) No

11. Briefly describe what you believe Integrated STEM looks like in the classroom (write in question) …………………………………………………………………………………..

12. Do you currently teach an Integrated STEM curriculum?
( ) Yes
( ) No

13. Approximately how often do you integrate STEM into the classroom?
( ) Every day
( ) Once a week
( ) Once a month
( ) Rarely
( ) Never

14. Do you utilize the engineering design process in the classroom?
( ) Yes
( ) No

15. Do you utilize problem-based learning in the classroom?
( ) Yes
( ) No

Section III.

No	Sentence	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
16	I am confident in my ability to teach integrated STEM curriculum and activities effectively.					
17	Even if I try very hard, I am not able to teach integrated STEM as well as some other subject areas.					
18	I am confident in understanding the engineering design process.					
19	I feel confident in my understanding of problem-based learning.					
20	I am comfortable using ill-structured problems (problems with many correct answers) with my students.					
21	I am confident that I can answer students' questions during integrated STEM lessons and activities.					
22	I am comfortable not always knowing the answers to the STEM challenges or problems that I present to my students.					
23	Problem based learning and integrated STEM requires the teacher to present design problems where the solution is unknown. As a teacher, this causes me some anxiety.					
24	I make an effort to continually find better ways to teach integrated STEM in my classroom.					

TÜRKÇE GENİŞLETİLMİŞ ÖZET

Öğrencilerin yaratıcı düşünmesini sağlamak, problem çözme becerilerini geliştirmek, iş birliği, iletişim gibi 21. yüzyıl becerilerini geliştirmek için fen bilimleri, teknoloji, mühendislik ve matematiğin entegrasyonuna dayanan STEM eğitimi sıkça kullanılmaktadır (Claymier, 2014; Stohlmann vd., 2012). STEM eğitimi ile dört disiplin entegre edilirken, öğrencilere yaparak ve yaşayarak öğrenme ortamı sunularak 21. yüzyıl becerilerini geliştirecekleri öğrenme deneyimleri sağlanmaktadır (Daugherty vd., 2022). Ayrıca STEM eğitimi öğrencilerin STEM disiplinleriyle ilgili bilgilerinin artmasına ve bu alanları meslek olarak belirlemelerine de etki etmektedir (Autenrieth vd., 2017). STEM disiplinlerinin etkili bir şekilde entegre edilerek öğretilmesinde öğretmenler kritik bir role sahiptir. Bu sebeple öğretmenlerin hizmet öncesi dönemde ve profesyonel meslek hayatında hizmetiçi eğitimler ile STEM eğitimi ile ilgili bilgi ve becerileri kazanmaları gerekmektedir (Radloff & Guzey, 2017). Alan yazında öğretmenlerin STEM disiplinlerinin entegrasyonuna yönelik kendilerini yetersiz gördükleri ve STEM eğitimiyle ilgili yeterli bilgiye sahip olmadıkları belirtilmektedir (Akaygün & Aslan-Tutak, 2016). Ayrıca öğretmenler çoğu zaman bilgi ve beceri sahibi oldukları STEM disiplinlerini öğretme eğilimindedirler (Kelley vd., 2020). Bu nedenle STEM öğretimiyle ilgili kendi becerilerine güven duymadıklarında öğrencilerin STEM alanlarıyla ilgili deneyimlerini de sınırlamaktadırlar (Kelley vd., 2020).

Öğretmenlerin STEM eğitimi ile ilgili bilgi ve becerilerini, STEM alanlarındaki becerilerine ilişkin inanç, tutum ve algılarını almış oldukları STEM eğitim uygulamaları etkilemektedir (Kelley vd., 2020). STEM eğitimine katılan öğretmenlerin öz-yeterliklerinde artış gözlemlenirken, sınıf uygulamalarında STEM eğitimlerine de yer verdikleri gözlenmektedir (Gardner vd., 2019). Bunun yanında öğretmenler STEM eğitiminin uygulanmasına yönelik sınıf yönetimi, farklı disiplinlerle ilgili bilgi eksikliği gibi farklı kaygılar taşımaktadırlar (Geng vd., 2019). Bu sebeple öğretmenlerin özyeterliklerini arttırmaya yönelik mesleki gelişim fırsatları öğretmenlere sunulmalıdır (Geng vd., 2019). STEM özyeterliği yüksek olan öğretmenler STEM eğitimini sınıflarına etkili bir şekilde uyarlamakta ve sınıflarında daha uzun süre uygulamaktadırlar (Rittmayer & Beier, 2008). Alan yazında ilkokul öğretmenlerinin fen bilimleri ve matematik öğretmenlerine kıyasla STEM ile ilgili özyeterliklerinin daha düşük olduğu vurgulanmaktadır (Catalano, 2019). Bu sebeple ilkokul öğretmenlerine mühendislik, mühendislik tasarım süreci, STEM disiplinleriyle ilgili alan bilgisi ve entegrasyon bilgisi kazanabilecekleri mesleki gelişim fırsatları sunulmalıdır. Bu sebeple bu çalışmada ilkokul öğretmenlerinin STEM eğitiminin öğretimine yönelik öz-yeterlik algılarını belirlemek amaçlanmıştır.

Araştırmada tarama (survey) yöntemi kullanılmıştır. Tarama yöntemi olayların, objelerin ve grupların ne olduğunu betimlemeye, açıklamaya çalışan araştırmalarda kullanılır (Büyüköztürk, 2015). Çalışmada veri toplama aracı olarak araştırmacılar tarafından geliştirilmiş olan STEM Yeterlik Anketi kullanılmıştır. STEM Yeterlik Anketi birinci araştırmacı tarafından geliştirilerek, STEM eğitimi alanında uzman iki kişiden görüş alınmıştır. Uzman görüşleri doğrultusunda ankette önerilen değişiklikler yapılmıştır. STEM Yeterlik Anketi 24 sorudan oluşmaktadır. Üç bölümden oluşan anketin ilk kısmında öğretmenlerin demografik bilgileriyle ilgili sorular yer alırken, ikinci kısımda sınıf içi STEM uygulamalarına yönelik sorular bulunmaktadır. Anketin son kısmında ise öğretmenlerin STEM eğitimine yönelik algılarını belirlemeye yönelik sorular yer almaktadır. STEM Yeterlik Anketi orta Amerika'da çalışmakta olan 100 ilkokul öğretmeninden rastgele oluşturulmuş bir gruba çevrimiçi doküman (Google Form) olarak gönderilmiştir. Ancak pandemi koşulları nedeniyle çalışmaya sadece 18 öğretmen katılım sağlamıştır. Bu anket ile öğretmenlerin STEM konusundaki geçmiş deneyimleri, STEM eğitimini sınıflarında uygulamaya ilişkin inançları ve ilkokul sınıflarında STEM eğitiminin öğretimine yönelik özyeterlik algıları belirlenmiştir. Çalışmaya katılan kadın öğretmenlerin eğitim düzeyleri (lisans, yüksek lisans gibi) ve yaş aralıkları değişiklik göstermektedir. 12 katılımcı lisans döneminde STEM eğitimine yönelik herhangi bir STEM eğitimi almamışken, 6 öğretmen lisans eğitimlerinde STEM ile ilgili dersleri almışlardır. Profesyonel olarak öğretmenlik mesleğine başladıktan sonra ise 13 öğretmen hizmet içi eğitime katıldığını, 5 öğretmen ise herhangi bir eğitime katılmadığını belirtmiştir. Öğretmenler ilkokul düzeyinde farklı düzeylerde öğretim yapmaktadırlar. Çalışma kapsamında toplanan bulguların analizi sonucunda çalışmaya katılan kadın öğretmenlerin birçoğunun (72%) sınıflarında STEM eğitimini uyguladıkları belirlemiştir. Bazı öğretmenler (5%) ise derslerinde en az iki disiplinin entegrasyonunu temel alan STEM derslerine her derste yer verdiklerini belirtmiştir. Her ne kadar öğretmenler sınıflarında STEM uygulamalarına yer verseler de öğretmenlerin bazıları (27,8%) STEM eğitimiyle ilgili kendilerini yeterli hissetmediklerini dile getirmişlerdir. Katılımcıların çoğu (77,8%) sınıflarında problem tabanlı STEM uygulamalarına yer verme konusunda kendilerini yeterli bulurken, bazı katılımcılar (22,2%) ise kendilerini yetersiz hissettiklerini belirtmişlerdir. Bunun yanında mühendislik tasarım sürecini sınıflarında uygularken öğretmenlerin çoğu (72,2%) kendini yetersiz hissederken, bazı öğretmenler (27,8%) ise kendilerini yeterli bulduklarını dile getirmişlerdir. Katılımcıların çoğu (72,2%) sınıflarında birden fazla çözümü olan gündelik hayat problemlerini kullanmakta kendilerini yeterli hissettiklerini söylemiştir. Bu araştırmadan hareketle, araştırmacılar STEM eğitimiyle ilgili daha fazla eğitimi olan öğretmenlerin STEM özyeterlik algılarının daha yüksek olduğunu ve sınıflarında daha fazla STEM eğitim uygulamaları yapmaya yatkın olduklarını gözlemlemiştir. Bu çalışmada bazı sınırlılıklarda bulunmaktadır. Çalışma pandemi döneminde gerçekleştirildiğinden hedeflenen katılımcı sayısına ulaşılamamıştır. Küçük bir örneklem ile gerçekleştirilen bu çalışmanın gelecek çalışmalarda büyük örneklemler yapılması önerilmektedir. Ayrıca öğretmenlere hizmetiçi STEM eğitimleri verilerek katılımcıların STEM eğitimiyle ilgili özyeterlik algılarında nasıl bir farklılaşma olduğunun araştırılması da önerilmektedir. Çalışmaya sadece kadın öğretmenler katılım gösterdiğinden planlanacak çalışmalara erkek öğretmenlerinde dahil edilerek kadın ve erkek öğretmenlerin STEM özyeterlik algılarındaki farklılaşmanın belirlenmesi de önerilmektedir.