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# Impact Of A Steam Lab On Science Achievement And Attitudes For Girls

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IMPACT OF A STEAM LAB ON SCIENCE ACHIEVEMENT AND ATTITUDES FOR GIRLS

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DEDICATION

I would like to dedicate this dissertation to my husband, Paul and two wonderful children, Olivia and Paul IV. Thank you for your love and support.

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ABSTRACT

This research identifies a problem of practice with standardized science test scores declining over the last eight years. The Sea Turtle Elementary School for the Creative Arts (STESCA; pseudonym) schedule allowed 150 minutes per week for science instruction, compared with 450 minutes per week for mathematics instruction. Science instruction has been implemented primarily through direct instruction and the use of textbooks and videos. In addition to the limited instructional time for science and predominant use of direct instructional methods, there is a lack of racially diverse and female role models evident in the curriculum. With STESCA's standardized science test scores declining over the last eight years, the staff has embraced the integration of STEAM (Science, Technology, Engineering, Arts, Math) into the curriculum. The identification of the problem led to the question: Will implementing a STEAM lab that promotes inquiry, cooperative learning, and hands-on activities have a positive impact on science achievement and attitudes towards science of elementary age girls? To answer the question, an action research study was utilized using the four stages: planning, acting, developing, and reflecting (Mertler, 2014). The approach of the action research is through the lens of feminist pedagogy. The action research study was comprised of a one-group pretest-posttest pre-experimental design.

*Key Words:* action research, STEAM, STEM, progressivism, constructivism, interdisciplinary, feminine pedagogy, social justice

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# CHAPTER 1

# INTRODUCTION

When Sea Turtle Elementary School for the Creative Arts (STESCA; pseudonym) became arts-infused 12 years ago, there was 100% staff commitment. Both student achievement and staff morale improved significantly from 2006-2009. In the last eight years, STESCA has had an influx of new staff who lacked continuous training in arts-infused curriculum which hampered the effectiveness of the program. The school has seen a decline in the South Carolina Palmetto Assessment of State Standards (SCPASS) science scores and has strayed from the arts-infused mission of the school. Recently, the school has embraced STEAM (Science, Technology, Engineering, Arts, Math) which is an interdisciplinary approach to teaching science, technology, engineering, art, and math using real-world applications (Sousa, 2013). To make the transition to a STEAM school, STESCA has implemented a STEAM lab, provided professional development, hosted grade level STEAM days for parents to participate in STEAM activities, and applied for the AdvancedEd STEM accreditation. “AdvancED STEM Certification is a mark of distinction and excellence that provides institutions and programs within institutions a research-based framework and criteria for awareness, continuous improvement and assessment of the quality, rigor and substance of their STEM educational program” (AdvancedEd, 2018). STEAM is a natural fit for STESCA to expand upon the foundation of arts infused curriculum and integrate the components of STEM (Science, Technology, Engineering, Math).

Although schools in the United States are teaching the disciplines of STEM, students, predominantly females are losing interest in these areas of academic study by the time they reach high school (Buck, Cook, Quigley, Prince, & Lucas, 2014). The goal of a STEAM school is to have students meaningfully invested and engaged in these disciplines to prepare them to be competitive in the global marketplace. Research demonstrated the significance of the arts in education in that it provides the 21st Century skills needed to succeed (Fiske, 2001). According to Partnership for 21st Century Learning (2015), the 21st Century learning skills such as critical thinking and problem solving; creativity and innovation; communication and collaboration should be implemented in the classroom in conjunction with rigorous curriculum standards.

The curriculum models of progressivism, constructivism and the Learner Centered Ideology are the building blocks of the interdisciplinary approach of STEAM (Sousa, 2013). The integrated methodology of STEAM supports John Dewey's theory that education needs to be experiential to be effective. Investigating the impact of STEAM on increased student achievement and attitudes, especially females, is the problem of practice being explored.

**Problem of Practice**

With STESCA standardized science test scores declining over the last eight years, the staff has embraced the integration of STEAM (Science, Technology, Engineering, Arts, Math) into the curriculum. Not only is there a decline in test scores, but also research has found that students, particularly females, are losing interest in science (Huhman, 2012). Young girls begin their education enthusiastic and motivated to learn but become passive, nearly invisible during the upper elementary years (Digiovanni &

Liston, 2004). During the school year 2016-2017, STESCA began the steps towards STEAM accreditation. Part of the accreditation process includes a STEAM lab for grades one through five that provides hands-on, inquiry-based, collaborative activities that support the science units in the various grade levels. The STEAM lab is a collaborative effort between lab teacher and the classroom teacher. Teachers are required to accompany their students to the lab to ensure cohesiveness between the classroom and lab.

## Research Question

The research question for the action research study was: *What impact will authentic learning experiences in a STEAM lab have on science achievement and attitudes towards science of elementary age girls?* Research objectives include:

- Identifying and correcting social issues that influence attitudes and achievement of elementary age girls in science.
- Identifying and providing strategies that increase attitudes and achievement of elementary age girls in science.

## Purpose Statement

The primary purpose of this action research study was to determine if implementing a STEAM lab that promotes inquiry, cooperative learning, and hands-on activities has a positive impact on science achievement and attitudes towards science of elementary age girls. There are numerous studies that have addressed females in science. Bringing Up Girls in Science (BUGS) focused on increasing fourth and fifth grade girls' academic achievement in science using STEM activities (Tyler-Wood, Ellison, Lim, & Periathiuivadi, 2012). Carlone (2011) studied what it meant to be "scientific" with the focus on equity in science. The ASPIRES project (Archer, Dewitt, Dillon, & Willis, 2012) was a 5-year longitudinal survey exploring femininity, achievement, and science among 10-14-year old students. The study examined the stereotypes of girls who identify with science and plan on pursuing science-related future careers. These studies were emphasized because they target specific educational issues in the STEAM lab. Research indicates integrating the arts into the curriculum may advance educational outcomes for children. The impact of a STEAM lab on student achievement among female students is being examined especially since the approach of the action research is through the lens of feminist pedagogy. The STEAM lab instruction encourages students to make real-world connections and is a collaborative process between the lab and the classroom teacher.

## Scholarly Literature

There are social issues that impact the attitudes and achievement of females in science such as the hidden curriculum, lack of feminist pedagogy, gender bias, gender equity, social justice, and diversity. The curriculum theories of progressivism, constructivism, and the Learner Centered Ideology provide the foundations of the interdisciplinary approach of STEAM.  Transdisciplinary integration is one of the most advanced levels of STEM. Transdisciplinary means to go beyond the disciplines. The organizing center is the real-world context where students explore a problem or issue (Drake, Savage, Reid, Bernard, & Beres, 2015). These approaches form the basis of STEAM. Finally, strategies that increase achievement and improve the attitude such as authentic and relevant learning, cooperative learning, and the Maker Movement will be discussed.

**Social Issues**

Hidden curriculum, the lack of feminist pedagogy, gender bias, gender equity, social justice, and diversity are issues that influence the attitudes and achievement of elementary age girls in science. The hidden curriculum is a set of rules and procedures that direct the school environment (Sharpe & Curwen, 2012). Feminist pedagogy recognizes the negative impact of hidden curriculum, highlights the accomplishments of women and people of color, and challenges prejudices and social injustice (Digiovanni & Liston, 2004). The educational inequalities regarding girls, especially minority girls, must be dealt with to insure success as adults (Buck, Cook, Quigley, Prince, & Lucas, 2014). Examples of educational inequalities include the effects of instructional style on boys and girls, some gender-biased curricula, and hidden and overt messages give to students (Gor Ziv, 2015).

**Educational Philosophies**

Influenced by the philosophy of John Dewey (1938, 1966), the progressive movement supported an integrated curriculum that would inspire students because it was pertinent and followed the principles of constructivism (Drake, 2012). Along with Dewey's ideas, progressive education relates to Piaget's ideas about child development (Piaget, 1970) and Vygotsky's ideas about socially situated learning (Vygotsky, 1978). These ideas are known today as constructivist and social-constructivist learning theories. Both learning theories emphasize that knowledge is constructed when learners are actively engaged in learning, during which they are exposed to different experiences and practices (Ertmer, 1993). The STEAM lab provides opportunities for students to construct their knowledge using the STEAM design process. Utilizing the transdisciplinary approach of STEAM promotes meaningful learning through inquiry. Transdisciplinary integration is the most advanced level of STEAM teaching and learning (Vasquez, 2014). The transdisciplinary approach encourages intentional multiculturalism and feminist pedagogy which leads to changing viewpoints and breaking down stereotypes.

**Progressivism.** Progressive education is an educational epistemology that was originated in the works of John Dewey (Barak, 2014). Progressivism emphasizes that experiences are supported by one's knowledge and knowledge is sustained by one's experiences. Progressivists advocate for the integration of traditional subjects into more encompassing, cross-disciplinary subject areas (Elgstrom, 2011). The processes of teaching, problem-based learning, and an integrated curriculum are highlighted with progressivism (Elgstrom, 2011).

**Constructivism.** The foundation of constructivist theory is that knowledge cannot solely be communicated but learners must be engaged in constructing their own knowledge (Ertmer, 1993). A constructivist inquiry-based learning environment has been found to promote actual learning in science education by allowing students to be active participants rather than passive recipients (Brooks, 1999). If interaction with the learning environment does not occur, student learning is not utilized to the fullest (Singh, 2012).

**Transdisciplinary approach.** The transdisciplinary approach begins with a real-life perspective. When transdisciplinary is translated into K to 12 practice, the focus is usually on problem-solving from a student-centered perspective (Drake, Savage, Reid, Bernard, & Beres, 2015). "Transdisciplinary scientific training is aimed at producing scientists who can synthesize and apply theory and technique from various disciplines to address a problem" (Walsh, 2014, p. 48). When students engage in transdisciplinary integration they feel empowered (Larmer, 2016). "Transdisciplinary STEM education is the form of integration most often described in the literature because of its relationship to project-based or problem-based learning" (Vasquez, 2014, p. 13). In problem-based learning, students are presented with an authentic, challenging question or problem that is unusual, complex, and open-ended (Larmer, 2016). Environmental issues, which present social, technical, and scientific challenges, may be addressed most successfully by a transdisciplinary approach (Walsh, 2014)

**STEAM.** Integrating the components of STEM (Science, Technology, Engineering, Math) with the foundation of an arts-infused curriculum leads to STEAM, an interdisciplinary approach to teaching. Creating a classroom environment that utilizes a transdisciplinary curriculum such as STEAM empowers students through differentiation by being student-centered and driven.

> STEAM education, which is based on constructivist and design philosophy, puts students at the center of learning. A constructivist design–based approach to STEAM, values the arts and design as an essential part of the educational experience, while preparing students for the 21st-century workplace that requires creativity and the skills to turn ideas into reality. (Gross, 2016, p. 43)

The STEAM design process provides students with the opportunities to explore and understand the world around them as they become critical, creative, and independent thinkers (Jeong & Kim, 2015). STEAM exemplifies progressivism with the problem-based learning and integrated curriculum. "STEAM and problem-based learning are based on the principle of learning by doing, a powerful and memorable way to learn" (Harper, 2017, p. 71).

**Strategies that support STEAM**

Strategies that increase achievement and improve the attitude not only for girls, but all learners are discussed. These strategies include but are not limited to integrating the Next Generation Science Standards, authentic and relevant learning, cooperative learning, and the Maker Movement. All the strategies mentioned are utilized in the STEAM lab.

**Next Generation Science Standards.** The Next Generation Science Standards (NGSS) are compatible with STEAM in that integration, higher-order thinking skills, and seeking answers to real-world problems are encouraged (Marshall, 2015). The Next Generation Science Standards necessitate inquiry-based instruction, which provides an equitable strategy for achieving mastery. Studies have shown that classrooms utilizing inquiry-based instruction outperform classrooms using traditional methods. This is true for females, males, and all ethnic groups at all ability levels (Marshall, 2015).

**Authentic and relevant learning**. Many adolescents are indifferent to what they are learning because they see little or no worth in what they are expected to learn in school (Shumow, 2014). If students believe that what they are learning might make a difference in preventing or solving social or environmental problems, they are more likely to persist in learning (Shumow, 2014).

**Feminist pedagogy**. Feminist critical pedagogy strives to encourage equality between different groups in society through education and uncover the instruments in education that devalue certain groups (Gor Ziv, 2015). Feminist pedagogies emerge from the feminist beliefs that affirm the basic equality and human dignity of all people, no matter gender, race, culture, sexual preference, religion, physical and mental ability (Digiovanni & Liston, 2004).

**Cooperative learning.** Cooperative learning is based on the belief that learning is most effective when students are actively involved in sharing ideas and working collaboratively to complete academic tasks (Ebrahim, 2012). Promoting the skill of teamwork is particularly significant because competitive environments can be disheartening to girls and to kids from cultures that value interaction and collaboration (Cunningham, 2015).

**Maker movement.** The Maker Movement emphasizes the *design-make-play* learning methodologies that correspond to the STEAM design process. The Maker Movement highlights the importance of identifying problems, problem-solving, and the power of social learning through sharing and collaborative work to solve issues both big and small (Smith, 2016).

## Significance and Limitations of Study

The action research study is significant in that it provides a potential solution for the decline of SCPASS science scores at the elementary school being studied. By replacing the traditional methods of teaching science with interactive small groups and arts enhanced science experiments, students engage in authentic and meaningful learning experiences. The study also provides strategies to address the negative social issues that permeate the field of science and STEM for females. The hidden curriculum, lack of feminist pedagogy, gender bias, gender equity, social justice, and diversity are issues that influence the attitudes and achievement of elementary age girls in science. An action research model is utilized to address inquiries in this study. The main goals of action research are to enhance the lives of children and to enhance the lives of professionals (Mills, 2007). This study focuses on science achievement rather than STEAM as a whole, but both STEAM and science literature drive the theory behind the research.

There are some limitations to this study. One limitation is the sample size of students participating in the study. The target group is females in fourth and fifth grades, approximately 141 students. The sample size does not allow for the study to be generalizable to other schools. A second limitation is that STESCA, being a school of choice, has a transient population. Students transferring from other schools might not have the science progression that is available at STESCA. A third limitation is the time constraints of the study. Because first through fifth grade participate in the STEAM lab, time in the lab is limited. Students rotate through the STEAM lab on an average of four days, 50 minutes for each lab in a nine-week period. The action research study is six weeks. This will limit the exposure to the experiences and benefits of the STEAM lab. Since the STEAM lab is a collaboration between the lab teacher and classroom teacher, STEAM strategies should be implemented in the regular classroom, not just in the lab.

## Overview of the Dissertation in Practice

Chapter One of this action research study provides an overview of the dissertation in practice including problem of practice, research question, purpose statement, related literature review, action research design which involves quantitative data collections, and ethical considerations. Chapter Two provides a more detailed review of related literature examining the historical background and the significance of the arts within education. Problem areas that impact the attitudes and achievement such as the hidden curriculum, lack of feminist pedagogy, gender bias, gender equity, social justice, and diversity will be discussed. Curriculum theories that have influenced STEAM and the importance of the Next Generation Science Standards will be examined. Finally, strategies that increase achievement and improve the attitude such as authentic and relevant learning, cooperative learning, and the Maker Movement will be discussed. Chapter Three is the "Action Research Methodology". This chapter includes the introduction, purpose of the study, statement of the problem of practice, the research design, and conclusion. Chapter Four includes the findings, discoveries, reflections, and analyses. Chapter Five states the focus, overview of the study, a summary of the study, a discussion of major points of the study, and action plan, implications of the findings, suggestions for future research, and a conclusion.

## Glossary

*Action Research:* Any systematic inquiry conducted by teachers, administrators, counselors, or others with a vested interest in the teaching and learning process or environment for gathering information about how their particular schools operate, how they teach, and how their students learn (Mertler, 2014).

*Constructivism:* The constructivist theory foundation is that knowledge cannot solely be communicated but learners must be engaged in constructing their own knowledge (Ertner, 1993).

*Feminist Pedagogy:* Feminine pedagogies emerge from the feminist beliefs that affirm the basic equality and human dignity of all people, no matter gender, race, culture, sexual preference, religion, physical and mental ability (Digiovanni & Liston, 2004).

*Gender Bias*: A prejudicial stance towards males or females.

*Gender Equity:* Gender equity implies fairness in the way women and men are treated.

*Hidden Curriculum:* Hidden curriculum refers to the unwritten, unofficial, and often unintended lessons, values, and perspectives that students learn in schools (Abbott, 2014).

*Interdisciplinary:* A curriculum that connects the various disciplines in some way (Drake, 2012).

*Progressivism:* Progressivism emphasizes the processes of teaching, problem-based learning, and an integrated curriculum. The emphasis is on exploratory learning, learning by doing, personalized learning, and students' social skills (Elgstrom, 2011).

*Social Justice:* Social justice includes a vision of society in which the distribution of resources is equitable, and all members are physically and psychologically safe and secure (Bell, 2013).

*Transdisciplinary Approach:* An interdisciplinary approach that begins with a real-life context (Drake, 2012).

## CHAPTER 2

## LITERATURE REVIEW

Schools in the United States are actively teaching the disciplines of STEM. However:

> The inequities in STEM education along racial and ethnic, linguistic, cultural, socioeconomic, gender, disability, and geographic lines are especially troubling because of the powerful role a foundational STEM education can play and because the gaps are so pronounced in STEM. (Tanenbaum, 2016, p. 1)

The current educational system in the United States continues to reflect the needs of an industrial age. It does not reflect the beliefs, priorities and requirements of the creative age and the needs of our students (Scholes, 2011). "As western society can no longer succeed with an education system handed down from the industrial age to prepare assembly line workers, there is a need to reinforce the values, priorities and requirements of the creative age" (Scholes, 2011, p. 970). STEM content and the needs of society lend themselves to a connection to the arts, and research supports the importance of the arts in education in that it provides the $21^{st}$ Century skills needed to succeed (Fiske, 2001). The $21^{st}$ Century learning skills include critical thinking and problem solving, creativity and innovation, and communication and collaboration-- all of which, according to Partnership for $21^{st}$ Century Learning (2015), should be fostered in the classroom alongside rigorous curriculum standards. The goal of a STEAM (Science, Technology, Engineering, Arts, and Math) school is to have students meaningfully invested and engaged in these disciplines to prepare them to be competitive in the global marketplace.

The integrated approach of STEAM supports John Dewey's theory that education needs to be experiential to be effective. John Dewey believed that students should be able to move and explore through hands-on activities and experiences (Dewey, 1938). The question arose, "What impact will authentic learning experiences in a STEAM lab have on science achievement and attitudes towards science of elementary age girls?" The teacher-researcher was interested in pursuing the impact of STEAM on increased student achievement and improved student attitude towards science, especially for females. This review of literature contextualizes a study of the impact of a STEAM lab as means to improve student attitude toward learning science and student achievement on science tests.

The literature review section is organized by first examining the historical background that has influenced the current educational climate. The next section of the literature review focuses on the curriculum theories that have been the building blocks of STEAM. These theories include progressivism, constructivism, STEM, STEAM, significance of the arts in STEAM, and the transdisciplinary approach. The importance of the Next Generation Science Standards is highlighted and how the standards connect and support STEAM. The fourth section of the literature view highlights the problematic areas, such as the hidden curriculum, lack of feminist pedagogy, gender bias, gender equity, social justice and diversity that impact the attitudes and achievement of girls in science. The significance of authentic learning is examined, along with ways the arts support STEAM integration. Finally, strategies that increase achievement and improve the attitude for not only girls, but also all learners are discussed. These strategies include but are not limited to authentic and relevant learning, cooperative learning, hands-on activities such as the Maker Movement, and STEAM.

## Historical Context

In 1983, The National Commission on Excellence in Education published *A Nation at Risk* to highlight the dangers facing the U.S. as the result of the decline in student achievement in academic areas (Schiro, 2013). The concerns generated from this report led to new educational initiatives, many of which promoted a Scholar Academic agenda, an ideology that highlights the influence of academic disciplines and pursuit of accumulated scholarly knowledge (Schiro, 2013). Examples of outcomes from the 21st century accountability movement which includes The Race to the Top Fund and its predecessor, the No Child Left Behind Act were curriculum standards, teacher effectiveness, student achievement, and high-stake testing (Schiro, 2013). This standards-based curriculum planning system is reminiscent to what Ellwood Cubberley (as cited in Sleeter, 2013) described almost a century ago, when he described schools as "factories in which the raw products (children) are to be shaped and fashioned into products to meet the various demands of life" (as cited in Sleeter, 2013, p. 266).

Continued concerns about the declining education system especially in the areas of science, technology, engineering, and mathematics (STEM) led to Congress passing the America COMPETES Act in 2007 (Sousa, 2013). Nonetheless, test results from the 2011 National Assessment of Educational Process (NAEP) showed only a slight increase in science scores. Although numerous factors contribute to students' performance, Blank (2012) found strong correlations that the national trends increased over time and attention spent on English/language arts and mathematics may be contributing to the low level of science performance in the United States. Test results also showed that students performed poorly in using higher-level thinking skills, problem solving, and critical-thinking skills (Sousa, 2013). "Unfortunately, contemporary education appears to place little emphasis on enhancing emotional intelligence in conjunction with developing creativity while policy-makers and administrators tend to focus on the external structures of education such as standards, curriculum and accountability" (Scholes, 2011, p. 972).

The passage of Every Student Succeeds Act (ESSA) in 2015 appears to be a step in the right direction. The bill encourages an approach to testing by allowing for the use of multiple measures of student learning and progress, along with other indicators of student success to make school accountability decisions and moving away from an exclusive focus on standardized tests to drive decisions around the quality of schools. This revelation led to the question, "What types of activities would increase student engagement, raise motivation, focus on relevant issues, and, most importantly, develop creativity?" (Sousa, 2013, p. 2). The answer may lie in bridging the gap with a merger between art and science. Integrating arts-related skills into STEM courses could be one effective way to increase student interest and achievement that leads to the interdisciplinary approach known as STEAM (Sousa, 2013).

## Problem of Practice

One consequence of the No Child Left Behind Act (NCLB) is that science is not getting the same attention as reading and mathematics (McMurrer, 2007). Science education time is shrinking, presumably because of pressure placed on schools to increase math and reading scores. According to Blank (2012):

> Time spent in classroom instruction in science has declined during the time period of state and federal accountability testing and reporting, and during the past decade when the NCLB requirements were implemented by states, the instructional time on reading and math has gone up while instructional time on science has continued to decline. (p. 19)

This paper identifies a problem of practice with standardized science test scores declining over the last eight years at Sea Turtle Elementary School for the Creative Arts (STESCA; pseudonym). The STESCA schedule allowed 150 minutes a week for science instruction, compared with 450 minutes a week for mathematics instruction. Science instruction has been implemented primarily through direct instruction and the use of textbooks and videos. In addition to the limited instructional time for science and direct instructional methods, there has been a lack of racially diverse and female role models that is evident in the curriculum. Because STESCA's standardized science test scores have been declining over the last eight years, the staff has embraced the integration of STEAM (Science, Technology, Engineering, Arts, Math) into the curriculum. The identification of the problem led to the question: Will implementing a STEAM lab that promotes inquiry, cooperative learning, and hands-on activities have a positive impact on science achievement and attitudes towards science of elementary age girls? To answer the question, an action research study was utilized using the four stages: planning, acting, developing, and reflecting (Mertler, 2014). Data was collected through pre- and post-assessments, teacher-researcher observational journal, as well as attitudinal surveys.

## Curriculum Theories

"STEAM education has the potential to fulfill the promise of progressive educators such as Dewey (1934) and Freire (2000), who foresaw education as moving toward a student-centered model, in which students are engaged and central to knowledge production" (Gross, 2016, p. 38). Both Dewey and Freire built their philosophies around the core concepts of experience, growth, inquiry, communication, and problem-solving (Deans, 1999). The main objective of the STEAM lab is to provide a stimulating environment through inquiry, cooperative learning, and hands-on activities.

The curriculum theories of progressivism, constructivism, and the Learner Centered Ideology provide the foundations of the interdisciplinary approach of STEAM. Transdisciplinary integration is one of the most advanced levels of STEM. These approaches form the basis of STEAM.

### Progressivism

"Progressive education is a pedagogical epistemology that originated in the works of John Dewey, aiming to make schools more effective agencies of a democratic society" (Barak, 2014, p. 3). Experiences are supported by one's knowledge, and knowledge is sustained by one's experiences. As Dewey states in *Experience and Education*, "There is an intimate and necessary relation between the processes of actual experience and education" (Dewey,1938, p.120). He felt that when children understood why learning was essential, they could apply the learning to their own lives, thus making it relevant (Platz & Arellano, 2011). Elstrom and Hellstenius (2011) wrote that progressivism emphasizes the processes of teaching, problem-based learning, and an integrated curriculum. The emphasis is on exploratory learning, learning by doing, personalized learning, and students' social skills. Progressive educationists encourage:

> A holistic approach to a learner, embedded assessment for learning (not of learning), and learning that is educational as well as entertaining. Progressive educationists encourage respect for diversity, recognizing each individual for his or her own abilities, interests, and cultural identity. (Barak, 2014, p. 3)

The integrated approach of STEAM supports John Dewey's theory that education needs to be experiential to be effective. Students participating in the STEAM lab use all their senses in an experiential manner as they utilize the design process.

**Constructivism**

The constructivist theory puts the construction of knowledge in one's mind as the basis of the educational effort. Its foundation is that knowledge cannot simply be communicated but learners must be engaged in constructing their own knowledge (Ertmer, 1993). "Such a philosophy focuses on allowing students to be active participants rather than passive recipients receiving science information and explanations from teachers and/or textbooks" (Singh, 2012, p. 198). If interaction with the learning environment does not occur, student learning is not utilized to the fullest (Singh, 2012). A constructivist inquiry-based learning environment has been found to promote effective learning in science education (Brooks, 1999). According to Yager and McCormack (as cited in Cetin-Dindar, 2016) when students are actively engaged in their learning environment and can form better connections between the science in their textbooks and the science that is required to solve real-world issues, authentic learning occurs.

> In a constructivist learning environment, students are encouraged thoughtful reflection on experience, learn to analyze real world issues, learn how to investigate, enhance social negotiation, develop their collaboratively learning and inquiry skills, build communication skills, apply and integrate the content of different subjects, improve their learning strategies skills, and reach a collective outcome over a period of time. (Cetin-Dindar, 2016, p. 235)

Constructivist pedagogy has proved to be a particularly effective method because students can design, test and revise their ideas about how things work through collaborative, scientific inquiry with other students (Peoples, O'Dwyer, Wang, Brown, & Rosca, 2014). The Learner Centered ideology encompasses the constructivist view. Learner Centered advocates focus on the needs and concerns of individuals, not on the needs of society or the academic disciplines (Schiro, 2013). "Learning is a function of the interaction between people and their environment: It take place when inquiring learners engage a stimulating environment" (Schiro, 2013, p. 120). A thought-provoking environment is achieved though the learner, the environment, and the learner's act of involvement with that environment through direct experience (Schiro, 2013). The main objective of the STEAM lab is to provide a stimulating environment through inquiry, collaboration, and hands-on activities. By utilizing the STEAM design process, teachers inherently use constructivist practices.

**STEM**

Science, technology, engineering, and mathematics (STEM) disciplines are the object of ever-increasing interest and attention to help prepare students for the job demands in today's society. The idea of STEM was introduced in the 1990's by the

National Science Foundation. STEM education is a method to learning that eliminates the barriers separating the four disciplines and integrates them into rigorous, real-world, relevant learning experiences for students (Vasquez, 2014). The focus on STEM has developed to address the concerns that the United States is inadequately preparing students to compete with international students in the 21st century global market (Molina, 2016). It is important that students not only have a solid foundational understanding of the big ideas in science, but they also need to be expert problem solvers and critical thinkers prior to the end of high school (Isabelle, 2017).

The National Research Council's 2011 synthesis of research and commissioned papers on STEM schools concluded that to spark student interest in STEM, instruction must help students grapple with big ideas and fundamental questions about the natural world and experience real-world applications of their knowledge (Goodwin, 2015). While many students start their education with a positive opinion of STEM and the aptitude needed to pursue and succeed in STEM careers, the STEM aptitude attrition rate occurs among both females and people of color (Molina, 2016). Application is at the core of STEM education.

**STEAM**

"The purpose of education should be understanding rather than simply knowing; its focus should be the active process of learning and creating rather than the passive acquisition of facts" (Root-Bernstein, 1999, p. 316). STEAM is an interdisciplinary approach to teaching science, technology, engineering, art, and math using real-world applications. Previous results suggest that STEM education would likely benefit our students and the success of our nation's workforce. Research supports the importance of the arts in education in that it provides the 21st Century skills needed to succeed. These two educational methods have merged to form STEAM, an educational approach that integrates science, technology, engineering, arts, and math. "Math, science, and technology have flourished in the past only when and where all the arts have flourished. They will flourish or fail together in the future" (Root-Bernstein, 1999, p. 317). Creating a classroom environment that utilizes a transdisciplinary curriculum such as STEAM empowers students through differentiation by being student-centered and driven. "In an effort to initiate, sustain, and support student engagement, problem-based instruction places students in authentic, contextualized problem-solving environments that bridge classroom experiences with daily life. All these aspects further support the needs of diverse students" (Buck, Cook, Quigley, Prince, & Lucas, 2014, p. 436). In STEAM education, students demonstrate whether they comprehend the disciplinary concepts and skills as they relate and connect their learning to new situations. This application is the real power of an integrated approach (Vasquez, 2014). "Without some blended mastery of STEM with arts and humanities, students will find themselves increasingly "in over their heads" (Kegan, 1998) and "poorly equipped to deal with mental and ethical demands of the 21st century" (Charette, 2015, p. 81). STEAM is complimentary with 21st century skills, mainly the "4 Cs" of communication, creativity, critical thinking, and collaboration (Saraniero, 2015).

> If we truly want students who can think critically, solve problems, and communicate their thoughts clearly, then some kind of systematic, cross-disciplinary instruction is required. An integration of STEM with the arts and humanities will help students learn how to learn. (Charette, 2015, p. 82)

The STEAM design process provides students with the opportunities to explore and understand the world around them as they become critical, creative, and independent thinkers (Jeong & Kim, 2015). STEAM supports the Next Generation Science Standards which require students to engage in doing science by modeling, analyzing, and designing. "Students will need to explore, study, and investigate before they can provide evidence-based claims or model complex concepts and phenomena observed in the natural and designed world" (Marshall, 2015, p. 18). By providing a STEAM lab for students, the components of STEAM which include exploring, questioning, designing, analyzing, making, problem-solving, critical thinking, and collaborative interactions are provided for all students to increase achievement and attitudes in science.

**The Significance of the Arts in STEAM**

The "A" in STEAM represents the arts. One of the main goals of both science and art is discovery. An effective way to enhance student interest and achievement is by integrating arts-related skills and activities into the science curriculum (Biffle, 2016). *The Champions of Change: The Impact on Arts in Learning* initiative states that longitudinal data of 25,000 students validate that participation in the arts is related to higher academic performance, increased standardized test scores, more community service and lower dropout rates. These developmental and cognitive benefits are acquired by students regardless of their socioeconomic status (Fiske, 2001).

The skills that the arts develop are also considered the 21$^{st}$ Century learning skills. The 21$^{st}$ Century learning skills are critical thinking and problem solving; creativity and innovation; communication and collaboration (Fiske, 2001). "These "twenty-first century skills" will be needed by every student in order to survive successfully as an adult in an increasingly complex and technologically driven world" (Sousa, 2013, p. 15).

Participation in the arts prepares students to solve impending problems by encouraging risk taking, experimentation, and freedom to fail. Trying new ideas, finding multiple solutions, and making the most of mistakes are artistic orientations (Cornett, 2007). "Active engagement in the 'arts' has been linked with empirical research denoting positive influences on creativity, motivation, language and literacy development, mathematical and scientific aptitude, memory, attention and cognition" (Scholes, 2011, p. 971). The arts offer opportunities to participate in all phases of development, not just intellect. Numerous studies have demonstrated that by integrating the arts into other content areas, such as STEM, long-term retention of content will occur (Sousa, 2013; Rinne, Gregory, Yarmolinskaya, & Hardiman, 2011).

> Arts and sciences do not compete; they are complementary. The arts create a very subjective view of the world, while science creates an objective view of the world. A person's brain needs both views in order to make suitable decisions. (Sousa, 2013, p. 10)

There is a need in the work realm for artistic and creative problem solvers. Employees who can use diverse problem-solving approaches such as intuition, synthesis, and evaluation to solve problems and make judgments are at a premium (Cornett, 2007). Research specifies that human resource directors believe that employers consider creativity vital for the future with directors ranking creativity and innovation as the most crucial student graduate skill in 10 years' time (Scholes, 2011). "As we move into a complex 21st century world, it is clear that STEM disciplines can benefit from an artistic infusion that connects disciplines in ways that are powerful and motivating for learning" (Henriksen, 2014, p. 4). To prepare the future work force, integrating arts-related skills into STEM courses could be one effective way.

**Transdisciplinary Approach**

Several researchers have endorsed restructuring school science using pedagogical frameworks that focus on real-world issues relevant to the students' lives (Fortus, 2005). "Researchers, educators, employers, and policy makers have stressed the need for educational practices that prepare students to solve problems through critical thinking and collaborative multidisciplinary teamwork" (Walsh, 2014, p. 48). The transdisciplinary approach begins with a real-life perspective. "A transdisciplinary unit usually begins with the identification of a question, an issue or a problem – the more "problematic", the better" (Drake, Savage, Reid, Bernard, & Beres, 2015, p. 23). Environmental issues, which present social, technical, and scientific challenges, may be addressed most successfully by a transdisciplinary approach (Walsh, 2014). "Transdisciplinary integration, grounded in constructivist theory (Fortus, 2005), has been shown to improve student's achievement in higher-level cognitive tasks through the application of scientific processes and mathematical problem solving" (Vasquez, 2014, p. 12). Using the transdisciplinary approach, scientific training is designed to produce scientists who can synthesize and apply theory and methods from many disciplines to address a problem (Walsh, 2014). By pursuing answers to real-world problems, students see purpose and meaning in school (Marshall, 2015). When students engage in transdisciplinary integration they feel empowered. "They see that they can make a difference. When they see a problem in their community or the wider world, they have the confidence-and the inclination-to contribute to a solution" (Larmer, 2016, p. 69). Creating a classroom environment that utilizes a transdisciplinary curriculum empowers students through differentiation by being student- centered and driven.

STEAM education, which is based on constructivist and design philosophy, puts students at the center of learning (Gross, 2016). The curriculum theories of progressivism, constructivism, and the Learner Centered Ideology lay the foundations of exploratory learning, that learners must be engaged in constructing their own knowledge, and that learners must be engaged with their environment. Transdisciplinary integration empowers students through differentiation by being student- centered and driven. STEM education eliminates the barriers separating the four disciplines and integrates them into rigorous, real-world, relevant learning experiences for students. All the components mentioned are the basis of the integrated approach of STEAM.

## Social Issues

Interest in science declines more for females than their male classmates, and women continue to be underrepresented in several science fields (National Research Council, 2012). The hidden curriculum, lack of feminist pedagogy, gender bias, gender equity, social justice, and diversity are issues that influence the attitudes and achievement of elementary age girls in science.

### Hidden Curriculum and Lack of Feminist Pedagogy

In the classroom, there is the overt curriculum, what is obvious to the observer. There is also the hidden curriculum, what is covertly taught. Within the hidden curriculum are two levels: the classroom environment and the content. The first level is the classroom environment. This includes the structure of the classroom such as the seating arrangements and the power structure (unspoken rules) between students and teacher. The second level is the content being taught (Jachim & Posner, 1987). The hidden curriculum of content relates to gender, race, class, and/or sexual orientation. These hidden agendas include the lack of power of students, the lack of female and racially diverse role models, gender bias, the lack of a diverse curriculum, poverty and culture (Wei, 2013). "Hidden curriculum refers to the unwritten, unofficial, and often unintended lessons, values, and perspectives that students learn in schools" (Abbott, 2014, p. 1).

Within the hidden curriculum of content are the gender roles. Women are noticeably absent from curriculum. Very little is mentioned about women in the fields of science and mathematics (Digiovanni & Liston, 2004). Numerous studies have also shown that the masculine image of scientists has created an obstacle for elementary girls' participation in science education (Buck, Cook, Quigley, Prince, & Lucas, 2014). The role of teachers' unconscious acceptance of gender-role stereotypes in science is communicated in their behaviors and teaching practices (Bailey, 1997). "By overemphasizing the role of males, the curriculum cultivates the message that women are not as important or as worthy as men" (Digiovanni & Liston, 2004, p. 124). Peggy McIntosh (1983) examines how history emphasizes that nonwhite males and women are seen as unworthy of studying in a serious and sustained way, and not worth including in the version of reality passed on to students (McIntosh, 1983). Gender-specific courses and careers remain. A majority of males still dominate computer, physics, science and engineering programs whereas a majority of females major in music, drama, dance, English, French, and Spanish (Sadker, 1999).

> Feminist pedagogy provides vision and clarity to critique the status quo, challenge current prejudices and inequities, recognize silences of the hidden curriculum, reinscribe the achievements of women and people of color, and enhance the likelihood that all young women and men will achieve their potential. (Digiovanni & Liston, 2004, p. 129)

By examining the hidden curriculum in the classroom, educators can begin to address the inequities faced by many of the students.

**Gender Bias and Gender Equity**

"Although most girls espouse a 'gender equity' view of their future options, perceiving that 'any' course and careers are open to them regardless of their sex/gender, their actual choices remain gender-traditional" (Archer, Dewitt, Dillon, & Willis, 2012, p. 968). The continuous bombardment of media continues to convey a pervasive message: in areas requiring knowledge and skills based in science, technology, and math, women can achieve and contribute less than men (Lightbody, 2002). All too often the media depicts girls and women (or those with disabilities or individuals of color) in less than equitable situations. In the United States, women make up approximately 50% of the workforce, yet only 29% are employed as scientists and engineers (National Science Board, 2016). The combination of cultural identity and gender has a significant impact on students' attitude toward school and level of achievement (Buck, Cook, Quigley, Prince, & Lucas, 2014).. Gender bias leads to a lack of gender equity in the classroom and workforce. Equity issues continue in science education, and these concerns need to be at the lead of our educational resolves (Buck, Cook, Quigley, Prince, & Lucas, 2014). The educational inequalities regarding girls, especially minority girls, must be dealt with to insure success as adults (Buck, Cook, Quigley, Prince, & Lucas, 2014).  In 1994, Congress adopted the Gender Equity in Education Act which sought to bridge the achievement gap in math and science between boys and girls (Weber, 2010). However, gender is still one of the most noteworthy factors influencing the attitude towards science (Hacieminoglu, 2016).

**Social Justice**

Social justice is vital to foster an educational system that benefits all who participate (Molina, 2016). Educators bring to their teaching values and beliefs formed by their own experiences of teaching and being taught (Flinders, 2013). A necessity of social justice teaching is that educators approach instruction in ways that support the active, engaged learning of all students (Molina, 2016).

> If there is no discussion of how race, gender, or class impacts those within the classroom, oppression can be perpetuated and students who are different from the white male norm will find that their lived experiences and existence are denied within the classroom. (Digiovanni & Liston, 2004, p. 127)

By understanding social identity, one can identify privileges or oppression that are associated with the categories of social identity. Privilege occurs when one group has something of significance that is denied to others merely because of the groups they belong to such as race, ethnicity, or gender, rather than because of anything they have done or failed to do (Johnson as cited in Adams, Blumenfeld, Hackman, Peters, & Xuniga, 2013). Schools tend to view students of poverty and culture through the lens of trying to fix their deficits instead of building upon their gifts and strengths. In many instances, education has focused on the qualities and strength that were lacking in students, rather than considering the gifts they brought to the classroom (Tileston & Darling, 2008).

> In low-income communities of color with limited social capital and educational resources, school is not often a space of liberation but rather continued marginalization unless there are active and conscious efforts to teach and learn in a creative context that goes beyond the low expectations for children living in poverty. (Molina, 2016, p. 19)

It is necessary for educators to incorporate content significant to students' lives, including both students' experiences and the communities in which they live (Molina, 2016).

**Diversity**

Educators enter the profession with beliefs that are found within their own sociocultural background, culture plays an important part in how they believe, think, learn and teach. Regrettably, not all teachers know how to embrace the differences among themselves and their students and engage in fair teaching (Deaton, 2013). Student demographics continue to change nationwide; the traditional racial and ethnic minority students have become the numeric majority (Januszyk, 2016). Traditionally marginalized communities contend that textbooks and other sources of curriculum were too often culturally immaterial to students of color, and not applicable to students of non-English language backgrounds (Sleeter, 2013). Teaching science means addressing diverse student populations. "While scientists have traditionally been portrayed in popular culture as white males, nowadays scientists of color and female scientists serve as role models for students who otherwise might not consider science relevant to their lives or careers" (Januszyk, 2016, p. 47). The content is written and taught from a Euro-American perspective. Cultural bias is one reason why the content being taught seems irrelevant to diverse learners (Tileston & Darling, 2008).

> Most teachers in North America were raised in a middle-class environment and see through the lens of a Euro-American cultural value. From that perspective, teachers have done an incredible job of empowering white-middle class children to learn and succeed. Having the same culture and background as your students provides you with a context through which you communicate expectations, rule, beliefs, appropriate behaviors and assumptions about human development and learning. (Tileston & Darling, 2008, p. 24)

Educators need to discover ways of accommodating for diverse cultures in ways that are respectful of the differences (Flinders, 2013). Ladson-Billings' (1994) and Gay's (1995) research on bilingual education and culturally relevant pedagogy, corroborated how vital it is for all students, and especially second-language learners to build their academic skills on family-based knowledge and everyday life experiences (Flinders, 2013).

## Strategies that Support STEAM

Strategies that increase achievement and improve the attitude for not only girls, but also all learners are discussed. These strategies include but are not limited to the importance of the Next Generation Science Standards, authentic and relevant learning, cooperative learning, and the Maker Movement. The teacher-researcher utilized these strategies in the STEAM lab

## Next Generation Science Standards

With the new Next Generation Science Standards being implemented, change is on the way in how we teach, what is learned, and how we assess (Marshall, 2015). There will be a shift from lower-order thinking skills to higher-order thinking skills. The Next Generation Science Standards integrates specific practices with core concepts. "Students will engage in science and engineering practices and use disciplinary cores ideas and crosscutting concepts to make sense of new information, explain phenomena in the world around them, solve problems, and make informed decisions" (Roseman, 2015, p. 24). The Next Generation Science Standards necessitate students to participate in doing science by modeling, designing, and analyzing. These actions, by their very nature, encourage creativity, critical thinking, meaning, and relevance. (Marshall, 2015). The Next Generation Science Standards encourage inquiry-based instruction which provides an equitable strategy for attaining mastery. Studies have shown that classrooms that utilize inquiry-based instruction outperform classrooms that use traditional manners. This also holds true for females, males, and all ethnic groups at all ability levels (Marshall, 2015). The Next Generation Science Standards go hand in hand with STEAM in that it encourages integration, higher-order thinking skills, and seeking answers to real-world problems (Marshall, 2015).

## Authentic and Relevant Learning

Most adolescents see little or no worth in what they are expected to learn in school and, as a result, they report being uninterested and disengaged (Shumow, 2014). By seeing that science has meaning and purpose beyond their own self-interest, students might value science. "Adolescents are starting to turn their attention to the broader world and their place in it and are often concerned about social justice, moral ideals, and the well-being of others" (Shumow, 2014, p. 65). If students believe that what they are learning might make a difference in preventing or solving social or environmental problems, they are more likely to persist in learning (Shumow, 2014). "When youngsters have no reason to raise questions, the processes that enable them to learn how to discover intellectual problems go undeveloped" (Flinders, 2013, p. 283). Some of the achievement gap seen between the performance of less-privileged students and that of more-privileged students reflects the disadvantaged students' perceptions that what they are being asked to learn does not speak powerfully to them (Perkins, 2016). "There is a deep belief in making learning purposeful and relevant by tapping interest and engaging students in hands-on/brains-on experiences" (Cornett, 2007, p. 28). A main objective of education has to do with what psychologists refer to as transfer of learning. Are students able to apply what they have learned or what they have learned how to learn? Can they participate in the type of learning they will need to deal with complications and concerns outside of the classroom? (Flinders, 2013). By making connections to STEM-related course content to experience found in the work world, the process gives teachers an answer to student's frequent question, "Why do we need to know this?" (Hoachlander, 2015).

**Feminist Pedagogy**

Feminist pedagogy recognizes the negative impact of hidden curriculum, highlights the accomplishments of women and people of color, challenges prejudices and social injustice (Digiovanni & Liston, 2004). Feminine pedagogies emerge from the feminist beliefs that affirm the basic equality and human dignity of all people, no matter gender, race, culture, sexual preference, religion, physical and mental ability (Digiovanni & Liston, 2004). "Critical feminist pedagogy is concerned with how education creates and entrenches existing structures of power and seeks to provide practical tools for redressing inequality both within the classroom and in society at large" (Gor Ziv, 2015, p. 197). It therefore seeks to discover how the downgrading of women takes place through specific educational practices, such as the effects of instructional style on boys and girls, some gender-biased curricula, and hidden and overt messages given to students (Gor Ziv, 2015). "Feminist critical pedagogy seeks to promote equality between different groups in society through education and expose the mechanisms in education that marginalize certain groups" (Gor Ziv, 2015, p. 198). By recognizing different kinds of oppression in education, students develop self-awareness and begin to recognize the various forms of oppression which later manifests into an independent social outlook (Gor Ziv, 2015). The goal of educators should be to expose stereotypes, help students learn to identify them, and encourage students to move past them to see each individual's characteristics, interests, and strengths (Lightbody, 2002). Educators need to be aware of the gender differences in communication styles. Typically, males tend to answer questions quickly and more confidently while females tend to wait longer to respond to a question, reflecting on the question, choosing their own words carefully and constructing an answer before they speak (Lee, 2003). Ways to encourage girls in science are by displaying posters and having literature of women scientists and/or minorities. Other means of encouragement are by having a female science or STEM teacher as a role model for girls (Lee, 2003). Many students, particularly girls and underrepresented minorities are interested in people-oriented "helping" careers. Activities that highlight how engineering benefits people, animals, the environment, and society demonstrate the social value of what is being studied (Cunningham, 2015). Maralee Mayberry (1999) provides the following description of feminist classroom pedagogy:

> Feminist educators develop and use classroom process skills, many of which are used in collaborative learning environments…. where students work together to design group activities that demonstrate an awareness of race, class, and gender dynamics that permeate the larger society. Through dialogue and conversation, students and teachers negotiate a curriculum that articulates their needs and concerns. These classroom strategies are designed explicitly to empower students to apply their learning to social action and transformation, recognize their ability to create a more humane social order, and become effective voices of change within the broader social world. (as cited in Digiovanni & Liston, 2004, p. 125).

**Cooperative Learning**

"Cooperative learning represents a shift in educational approach from completive-based to collaborative based instruction in order to address diversity in the classroom" (Ebrahim, 2012, p. 295). Cooperative learning is based on the belief that learning is most effective when students are actively involved in sharing ideas and working collaboratively to complete academic tasks (Ebrahim, 2012). Cooperative learning has been utilized within elementary education for quite some time, but many teachers do not realize the implications of cooperative learning for females and people of color. Promoting the skill of teamwork is particularly significant because competitive environments can be disheartening to girls and to kids from cultures that value interaction and collaboration (Cunningham, 2015). Many cultures value the collective which is in direct conflict with the Euro-American perspective of individualist (Tileston & Darling, 2008). "Cooperative learning allows more students the opportunity to participate and work within a classroom than does traditional whole group instruction because it provides a learning setting that is collaborative rather than competitive" (Digiovanni & Liston, 2004, p. 128). Another benefit of cooperative learning is that "small-group work tends to stimulate a higher level of cognitive activity among larger numbers of students than does listening to lectures and thus provides expanded opportunities for cognitive restructuring" (Crowther, 1999, p. 21). In the STEAM lab, collaborative learning is demonstrated by having all students work in small groups or with a partner to promote discussions and problem-solving skills. Freire (1994) suggests learning situations that are collaborative, active, and community oriented (as cited in Deans, 1999). During the six weeks of collecting data, cooperative learning utilizing single-gender was one of the strategies. In a study examining gender and gender pairing in cooperative learning, Ding (2011) concluded that females in single-gender dyads outperformed females in mixed-gender dyads.

**Maker Movement**

The Maker Movement, a hands-on program, emphasizes the *design-make-play* learning methodologies that correspond to the STEAM design process. John Dewey, John Friedrich Frebel, Maria Montessori, and Jean Piaget all promoted making as fundamental to the process of learning (Bevan, 2014). Jean Piaget wrote that educators should "lead the child to construct for himself the tools that will transform him from the inside—that is, in a real sense, and not just on the surface" (Piaget, 1973, p. 10). Some researchers contend that making, if implemented with an equity lens that pays attention to emotional, intellectual, and cultural resources children bring to the activity has a particularly influential potential for engaging young people who have been generally underrepresented in STEM fields (Bevan, 2014). There is a growing body of evidence indicating that schools are reducing the amount of instruction in science and social studies because these subjects are not a focus of grade-level, high-stakes testing (Au as cited in Flinders, 2013). The good news is there is research-based evidence that says it is possible to renew this natural drive to learn by designing environments that engage learners in important activities, that reduce a student's anxiety and fear, and offer a level of challenge according to students' skills (Honey, 2013). "In schools, the Maker Movement is a natural fit, as integration is already the norm—the convergence of subject areas and the blending of skills and concepts results in the construction of knowledge through personally meaningful experiences" (Smith, 2016, p. 31). The Maker Movement highlights the importance of identifying problems, problem-solving, and the power of social learning through sharing and collaborative work to solve issues both big and small (Smith, 2016). "It improves STEM education by getting kids excited about science and technology…It promotes values that are ends in themselves, such as creativity, problem-solving, collaboration, and self-expression" (Honey, 2013, p. 14). The STEAM lab utilizes the Engineering Design process which is comprised of brainstorming, design, create, test and refine which parallels the design-make-play methodology of the Maker Movement.

**Authentic Learning, Attitudes, and Achievement**

There have been numerous studies exploring authentic learning, including the integration of the arts, and its impact on student attitudes and achievement. The following studies were chosen to examine authentic learning and experiences as well as the nature of the relationship between STEAM and STEAM in the areas of art and science and the impact they can have on each other.

**Authentic Learning Through Arts Integration**

Two studies conducted by Brown, Benedett, and Armistead examined the effects of arts enrichment on school readiness with at-risk preschool students (Brown, 2010). The first study that took place between 2004 and 2005 looked at achievement with an arts enrichment preschool that served low-income children. These students practiced school readiness skills through early learning of music, creative movement, and visual arts classes, which emphasized authentic learning. Students who attended the preschool for two years demonstrated higher achievement in language, literacy, mathematics, and science skills than those who attended for one year, suggesting that maturation alone did not account for achievement gains (Brown, 2010). The second study by Brown, Benedett, and Armistead occurred in 2006 (Brown, 2010). It compared students attending the arts enrichment preschool to those attending a nearby alternative preschool on a measure of receptive vocabulary that has been found to predict school success. This later study addressed the question of whether integrated arts enrichment provides an improvement with regard to educational outcomes. At the end of one year of attendance, students in the arts program showed greater receptive vocabulary than those at the comparison preschool. These two studies support the claims that integrating the arts into the curriculum may advance educational outcomes for children.

**Authentic Learning and Motivation**

Cetin-Dindar (2016) contends that student motivation must be a concern if the aim of science education is to go beyond rote memorization and enable meaningful understanding. To understand student motivation, she investigated the relationship between a constructivist learning environment and students' motivation to learn science by administering the Constructivist Learning Environment Survey (CLES) and Science Motivation Questionnaire to 243 elementary students from a public school in Turkey. Cetin-Dindar's study aimed to reveal:

> the relationship between constructivist learning environment and students' motivation to learn science by testing whether students' self-efficacy in learning science, intrinsically and extrinsically motivated science learning increase and students' anxiety about science assessment decreases when more opportunities for personal relevance, student negotiation, shared control, critical voice, and uncertainty for scientific knowledge is provided. (Cetin-Dindar, 2016, p. 236)

The findings of the study revealed that the students were negatively motivated to learn science in more constructivist learning environment. The reasons for this could be varied. One of the reasons could be that the students were accustomed to learning subjects in a traditional manner that is oriented towards a teacher-centered instruction. By students having to take more responsibility in their learning environment, negative effects on student motivation could emerge (Cetin-Dindar, 2016). However, additional findings of this study showed that the students were more motivated to learn science when they had more opportunities of authentic problem solving. Therefore, to motivate students to learn science, science educators should stress more on the connectedness of science at school to real life (Cetin-Dindar, 2016). In his study Elementary School Students' Attitude toward Science and Related Variables, Hacieminoglu (2015) confirmed "that students have a more positive attitude towards science preferred to undertake meaningful learning rather than rote learning, resulting in the achievement of higher scores" (p. 46). Cetin-Dindar (2016) study is applicable to the proposed action research project because the STEAM lab focuses on real-world connections.

**Authentic Learning and Achievement**

Bringing Up Girls in Science (BUGS) was a 3-year project funded by the National Science Foundation. BUGS was an afterschool program for fourth and fifth grade girls that provided authentic learning experiences in environmental science as well as valuable female mentoring opportunities in an effort to increase participants' academic achievement in science (Tyler-Wood, Ellison, Lim, & Periathiuivadi, 2012). "Programs for females should not duplicate programs for male students, but should be equitable, emphasizing hands-on, real-life laboratory experiences while incorporating verbal/language arts components where many females excel" (Tyler-Wood, Ellison, Lim, & Periathiuivadi, 2012, p. 47). The design of the study was quasi-experimental. There was a group of 32 fourth and fifth grade girls with a matched comparison group with similar characteristics from another school district. Results indicated that the BUGS participants demonstrated significantly greater amounts of gain in science knowledge as measured by the Iowa Test of Basic Skills in Science (ITBS-S). The BUGS participants also had higher perceptions of science careers than the BUG contrast group (Tyler-Wood, Ellison, Lim, & Periathiuivadi, 2012). Even though this study focuses on science rather than STEM as a whole, both STEM and science literatures drive the theory behind the research (Tyler-Wood, Ellison, Lim, & Periathiuivadi, 2012). There is a correlation between this study and the action research study because the impact of a STEAM lab on student achievement among female students was examined.

**Authentic Learning and Social Issues**

Carlone (2011) examined what it meant to be "scientific" with the focus on equity in science. In this comparative ethnography, the researchers examined how primarily female students of color did not identify with the culturally produced meanings of "science" and "smart science person." One solution that was implemented in the study was to shift the focus from improvement of science achievement and skills to improving science attitudes. In this study, the researchers stressed the ways:

> the normative practice of sharing scientific ideas promoted *scientific investigation* as a collaborative, generative endeavor, *scientific knowledge* as shared and jointly constructed, and *science person* as someone who builds on and questions others' ideas, contributes to the class's scientific knowledge, and someone who asks good questions and makes careful insightful observations. (Carlone, 2011, p. 482)

Science curriculum and/or pedagogy needs to change so that it includes the experiences, worldviews, learning styles, and/or interests of students from diverse backgrounds (Carlone, 2011). The importance of the study is how female students did not identify with "science" and "smart science person." The action research study focused on how to increase achievement and attitudes towards science with all students, especially the female students.

The participatory action research project, Seeking to Improve African American Girls' Attitudes Toward Science, addressed the question of "How can we improve attitudes toward science education of the African American girls at an elementary school?" (Buck, Cook, Quigley, Prince, & Lucas, 2014). Although there continues to be equity issues in science education for girls, there have been some improvements in meeting their needs. However, this is not true for all girls. "Only 10% of Black students performed at proficient or advanced levels, whereas 43% of Caucasian students scored at these levels" (Buck, Cook, Quigley, Prince, & Lucas, 2014, p. 432). Much of the research on females and science does not consider race or cultural identity (Buck, Cook, Quigley, Prince, & Lucas, 2014). "The combination of gender and cultural identity has a significant impact on students' achievement and attitude toward school" (Buck, Cook, Quigley, Prince, & Lucas, 2014, p. 433). The establishment of a science lab that encouraged inquiry and collaboration along with a female lab teacher had great impact on the girls' attitudes and achievement level. The researchers also discovered that there needs to be a more cohesive connection between the science lab and regular classroom. This study connects to the action research study because the STEAM lab is a collaborative process between the lab and the classroom teacher.

Young (2017) examined the achievement and attitudes of Black girls in science. Although Black girls consistently outperform Black boys in science, the dual marginalization of race and gender inhibits the success of Black girls in science (Young, 2017). "Navigating the culture of science, which is significantly different from Black culture, can cause distress and serve to alienate Black girls from science" (Young, 2017, p. 3). The interactions in the science classroom are essential mediators of Black girl attitudes and achievement in science. The results of the study concluded that most Black girls believe that they can be successful in science, but that science is not appealing to them. This is important for educators to address if a goal is to diversify the STEM workforce. Early science engagement has a substantial effect on the persistence and performance in scientific domains for all students" (Young, 2017, p. 14). This study supports the proposed action research study of utilizing a STEAM lab to increase attitudes and achievement of females in science.

The ASPIRES project, funded by the U.K.'s Economic and Social Research Council, was a 5-year longitudinal survey exploring femininity, achievement, and science among 10-14-year old's. It was comprised of a quantitative online survey that was administered to a sample of more than 9,000, 10-year-old English students, and in-depth interviews with pupils and their parents. Using a feminist poststructuralist theoretical lens, the study examined the stereotypes of girls who identify with science and plan on pursuing science-related future careers (Archer, Dewitt, Dillon, & Willis, 2012). The research found that even though most children age 10 to 11 years enjoy science, the majority already see science careers as "not for me." "Social structures (e.g. of gender class, race) thus play an important role in shaping the identities, choices, and aspirations that people perceive as possible and desirable" (Archer, Dewitt, Dillon, & Willis, 2012, p. 970). Even though this study is focused on science, it can still be applied towards STEAM. The approach of the action research is through a feminist pedagogy lens. There are connections of the study that can help meet the needs of female students.

The primary purpose of this action research study was to determine if implementing a STEAM lab that promotes inquiry, cooperative learning, and hands-on activities has a positive impact on science achievement and attitudes towards science of elementary age girls. Six of the eight studies focused on increasing achievement and attitudes towards science for female students. These studies demonstrate types of activities that promote student engagement, increase motivation, focus on relevant issues, and, most importantly develop critical thinking and problem solving in an innovative and creative manner.

## Conclusion

There has been a decline of standardized science test scores and students, particularly female students, are losing interest in science (Huhman, 2012). Young girls begin their education excited and eager to learn but become passive, almost invisible during the upper elementary years (Digiovanni & Liston, 2004). "To increase the number of women in STEM careers, it is important to prevent the widening of the gap between girls' and boys' attitudes towards science" (Tyler-Wood, Ellison, Lim, & Periathiuivadi, 2012, p. 48). The primary purpose of this action research study was to determine if implementing a STEAM lab that promotes inquiry, cooperative learning, and hands-on activities has a positive impact on science achievement and attitudes towards science of elementary age girls

To help answer the research question, the literature review examined the historical background that has influenced the current educational climate. The next section of the literature review focused on the curriculum theories that have influenced STEAM. These theories include progressivism, constructivism, STEM, STEAM, the significance of the arts in STEAM, and the transdisciplinary approach. The importance of the Next Generation Science Standards is highlighted and how the standards connect and support STEAM. The fourth section of the literature review focused on the problematic areas, such as the hidden curriculum, lack of feminist pedagogy, gender bias, gender equity, social justice and diversity that impact the attitudes and achievement of girls in science. The significance of authentic learning is examined. Finally, strategies that increase achievement and improve the attitude for not only girls, but also all learners are discussed. These strategies include but are not limited to authentic and relevant learning, cooperative learning, the Maker Movement, and STEAM.

# CHAPTER 3

# METHODOLOGY

One consequence of the No Child Left Behind Act has been that science is not getting the same attention as reading and mathematics (McMurrer, 2007). Science instructional time is shrinking presumably because of pressure placed on schools to increase math and reading scores. McMurrer (2007) states that,

> to accommodate this increased time in ELA and math, 44% of districts reported cutting time from one or more other subjects or activities (social studies, science, art and music, physical education, lunch and/or recess) at the elementary level. (p. 1)

At STESCA, scheduling allows 150 minutes a week for science instruction, compared with 450 minutes a week for mathematics instruction. A district goal is to increase science and mathematics instruction through integration. Logistically, this has proven difficult because of mandated curriculum schedules.

A review of the South Carolina Palmetto Assessment of State Standards (SCPASS) science data from the previous eight years reveals a significant decrease in scores. The decision was made to integrate Science, Technology, Engineering, Arts, and Math (STEAM) into the curriculum and to pursue STEAM accreditation. Administration gave full support of becoming STEAM accredited by investing in staff development and the hiring of S2TEM Centers, SC to assist in developing the action plan. The school participated in a staff development given by S2TEM Centers, SC.

The action research study focused on what impact the STEAM lab had on increased student achievement and attitude in the female student population. The objective was to not only become a STEAM accredited school, but to investigate the effects of a STEAM lab on increased student achievement and attitudes toward science. "One problem with focusing solely on knowledge and skills outcome measures is that many students who are academically competent in the school subject matter ultimately view school's knowledge and skills as irrelevant for their future careers and/or everyday lives" (Carlone, 2011, p. 460).

After observing the excitement generated by all the students during STEAM activities, the Problem of Practice was narrowed further to examine whether the integration of STEAM increases science achievement and attitudes towards science of elementary age girls. The *Engineering and Science Attitudes Assessment* was administered to all fourth and fifth grade female students at the beginning of 2016-2017 school year. Out of the 186 female students that took the survey, 77% of the girls responded either negatively or did not know to the question "I would enjoy being a scientist when I grow up" compared to 73% of the boys and 81% of the girls responded negatively or did not know to the question "I would enjoy being an engineer when I grow up" compared to 69% of the boys (Elementary, 2016).

**Purpose of the Study**

The primary purpose of this action research study was to determine if implementing a STEAM lab that promotes inquiry, cooperative learning, and hands-on activities has a positive impact on science achievement and attitudes towards science of elementary age girls. Employing the transdisciplinary approach of STEAM encourages meaningful learning through inquiry. The transdisciplinary approach encourages intentional multiculturalism and feminist pedagogy which leads to changing viewpoints and breaking down stereotypes.

## Problem of Practice

According to the SCPASS test for science, scores in fourth grade at STESCA have decreased from the period of 2009-2014 by 14.7 points. There was a major decrease from 2013-2014 of 10.8 points. Science instruction has been implemented primarily through direct instruction and the use of textbooks and videos. Research supports that many students view school's knowledge and skills as irrelevant for their everyday lives (Carlone, 2011). Students, especially females, are losing interest in science. By integrating STEAM into the curriculum, students will become more actively engaged in their learning environment (Cetin-Dindar, 2016). STEAM empowers students through differentiation by being student-centered and driven.

## Research Design

The action research study took place in an elementary school that serves first through fifth grades.

### Research Site

The site for the action research project was STESCA, a school with 804 total students enrolled (46% boys and 54% girls). STESCA became an arts-infused school in the school year 2005-2006. During that school year, 100 percent of the staff committed to providing an appropriate learning environment using an arts-infused approach for teaching the South Carolina Academic Standards and the Visual and Performing Arts, recognizing that the arts are critical and essential to education. "Research has shown that students highly involved in the arts are more likely to have higher grades, better standardized test scores, and lower dropout rates; the connection is particularly strong among low-income students" (Catterall, 1998, p. 4). In the last eight years, STESCA has had an influx of new staff who have not had the ongoing professional development needed to be truly arts-infused.

STESCA is in a resort and retirement area. It is a dichotomous community with one part having financial stability, traditional two-parent family structures, access to enrichment opportunities and higher academic performing students. In contrast, another segment of the population served by STESCA has predominantly single parent families or parents that must hold multiple jobs, significant language and communication problems, high illiteracy rates and poor academic success (Keefner, 2015).

Below are selected findings from a needs assessment that support these conclusions:

- 20% of the children live in single-parent homes - 5% of the children in single-parent homes have only the mother as the provider and caretaker.
- 64.50% state reported poverty index for 2013 for the student population, up from 51% in 2007.
- Within our school community, 294 English language learners, and/or their families coming from 16 Spanish speaking countries, and one student from each of the following countries: Taiwan, Russia and Belgium, face many challenges educationally and socially, including the fact that our non- and/or limited-English speaking parents are often working several jobs and unable to provide homework support.

- Among the ELL parents there is an estimated 70 to 75% illiteracy rate in English and Spanish which makes it nearly impossible for them to provide their children with any academic support (Keefner, 2015).

**Student Participants**

The target group for the action research study was female student participants in fourth and fifth grades during the 2017-2018 academic year. Students in fourth and fifth grades are required to take the South Carolina Palmetto Assessment of State Standards (SCPASS) science test each spring. Information from state testing determines if the school has met the requirements of the federal guidelines for accountability. Included in the study were 141 females with 50% females in fourth grade, and 51% in fifth grade. Demographically, 12% were African-American, 41% Hispanic, 40% white, and 7% other-Asian and two or more races. Of the 141 females, 65% qualified for free and reduced lunch; 9% were served by IEP's; 25% were served with Gifted and Talented services; and 28% were served with ESOL services.

**Role of Researcher**

The teacher-researcher participated in the action research study as an active participant-observer. According to Diane Demotte Painter (2002),

Teacher-researchers simultaneously act as participants and observers as they conduct research in their own classrooms. With these dual roles, they complete the following tasks:

- Develop research questions based on their own curiosity about teaching and learning in their classrooms.
- Systematically collect data and research various methods of conducting research.

- Analyze and interpret the data and the research methodology.
- Write about their own research.
- Share findings with students, colleagues, and members of the educational community.
- Discuss with colleagues' relationships among practice, theory, and their own research.
- Examine their underlying assumptions about teaching and learning.
- Assume responsibility for their own professional growth. (DeMont Painter, 2002, p. 1)

The teacher-researcher pondered the following questions based on experiences within the school and classroom: "What are strategies to improve science scores?" "What are the benefits of STEAM?" "How does one motivate girls to enjoy and excel in science?"

**Planning Stage**

The planning stage consisted of identifying and limiting the topic; gathering information, reviewing the related literature; and developing a research plan (Mertler, 2014). To identify and limit the topic for the proposed action study, the teacher-researcher participated in the following activities:

- Participated in an online STEAM conference.
- Attended the South Carolina Alliance for Arts conference.
- Researched and wrote a paper about the benefits of becoming a STEAM school. The paper included standardized testing data in which the teacher-researcher compared schools in the district that integrated the STEM or STEAM approach.

- The paper was submitted as a proposal on behalf of the principal for consideration to the School Improvement Council.
- The teacher-researcher was appointed to be the school representative at the Region Four GT STEM Leadership Institute.
- The teacher-researcher presented implementing STEAM in the school at a staff development day.
- The school hired S2TEM Centers, SC to help to develop an action plan.
- The teacher-researcher served on the STEAM leadership team that was formed to bring STEAM to STESCA.
- The teacher-researcher began teaching a STEAM lab. The STEAM lab allows for observation and participation in an authentic contextualized problem-solving environment that makes connections to real life.

**Ethical Considerations**

"Teacher-researchers are teachers first. They respect those with whom they work, openly sharing information about their research. While they seek knowledge, they also nurture the well-being of others, both students and professional colleagues" (Hubbard & Power, 1999, p. 64). Ethical teaching should be a natural part of the educational process (Fichtman Dana & Yendol-Hoppey, 2014). An important component of the planning stage is the research ethics. The two prevailing criteria for research ethics are to make sure there is no harm done to an individual and to have consent of the participants (Mills, 2007). The district process requires that the teacher-researcher must submit a request to the district office for approval before any research can proceed. All the female students in fourth and fifth grade had a parental consent form and an assent form on file (see

Appendix A and B). Results of the research will be disclosed to all participants, the local school and district, and possibly to a wider audience at conferences.

Teachers should be continually reflecting on students' progress, assessments, attitudes, and adjust accordingly to meet all students' needs. Inquiry should be intentional with the best interest of students' and colleagues in mind. Although implementing inquiry, hands-on activities, problem-solving, and real-life learning experiences are a natural part of a STEAM lab, teaching becomes research when data at the beginning of the school year is compared to the end-of-year data to determine the impact of the STEAM lab on learning.

It is imperative that the teacher-researcher informs the parents, school, and district of the action research project by using a principle of accurate disclosure. The principle of accurate disclosure describes the study, the requirements and the duration of the study (Mertler, 2014). Other ethical considerations are principle of beneficence (how the study benefits others), principle of honesty, and principle of importance (how it will be used in the field of education) (Mertler, 2014). Once data has been collected, the teacher-researcher must keep the data secure and confidential.

Another important component of action research is the issue of personal bias. The teacher-researcher needs to be cautious about not collecting data that simply validates the research and to acknowledge discrepant data (Mills, 2007). The teacher-researcher should remain open and objective and honestly reflect on what is seen. Mills (2007) states, "If we conduct our research in a systematic, disciplined manner, we will go a long way toward minimizing personal bias in our findings" (p. 121).

**Planning Guidelines**

The time frame for collecting data for the action research study was a six-week period utilizing a quantitative research methodology. The teacher-researcher recorded student attitudes and reactions to the authentic learning activities occurring within the STEAM lab through a journaling process. The following steps were utilized to gather data:

- Prior to the action research cycle the teacher-researcher administered the *Engineering and Science Attitudes Assessment* (see appendix C) developed by the Engineering is Elementary, Museum of Science, Boston (Elementary, 2016) to all females in fourth and fifth grades to gauge the attitude and interest towards science.
- The science Measures of Academic Progress (MAP) was administered in the fall to fourth and fifth grades. The data from MAP determined what specific science strands needed to be addressed.
- At the beginning of the action research cycle, a pre-test was developed through USATestprep ©. Using USATestprep ©, the teacher-researcher can use the system to choose the test they want, the standards they need to assess, and select the best questions for their specific situation (see appendix D, E, F, and G).
- After the initial lesson, the students took a quiz using the educational website Kahoot! ©. This formative data allowed the teacher-researcher to determine whether the student understood the vocabulary terms that had been introduced and whether any reteaching needed to occur.

- Throughout the six weeks of the study, the teacher-researcher implemented authentic learning experiences (see appendix H and I) in the STEAM lab using the STEAM design process (see appendix J) and reflected regularly and journal on student interactions and class observations (see appendix K).
- A post-test using USATestprep © was given at the end of the action research cycle for content.
- The science MAP test was administered in the spring. Fall and spring data were compared.
- The *Engineering and Science Attitudes Assessment* was administered after the intervention in spring 2018.
- Finally, the teacher-researcher compared pre-test and post-test data, and *Engineering and Science Attitudes Assessment*.

**The Acting Stage**

The acting stage consists of collecting and analyzing data. The focus of the action research question was, *"What impact will authentic learning experiences in a STEAM lab have on science achievement and attitudes towards science of elementary age girls?"* To explore achievement, the teacher-researcher administered a pre-and post-assessment related to the South Carolina Academic Science Standards and the Next Generation Science Standards, which was the focus during the six-week study period. The teacher-researcher used five items from USATestprep © for pre- and post-assessment related to two areas: fifth grade Ecosystems and fourth grade Sound. Because the source of the pre- and post-assessment is USATestprep ©, questions are considered valid and reliable, so it was not necessary for the teacher-researcher to evaluate the instrument prior to implementation.

Since this action research is based on the learning within the classroom, the teacher-researcher used descriptive statistics to analyze the data from the pre- and post-assessments. The teacher-researcher did not anticipate generalizing the information to a larger population. Central tendency was measured by comparing the mean, mode, and median and data from the pretest and posttest was displayed using a frequency distribution table. A matched paired t-test of the pre-test and post-test test was used to determine if the growth on MAP and USATestprep© was significant. To explore student attitudes, the *Engineering and Science Attitudes Assessment* was used to explore attitudes across time. The *Engineering and Science Attitudes Assessment* was developed by the Museum of Science of Boston. All items have been tested for validity and reliability as stated on their website. Every student completed the survey in the fall of 2017 and results from this administration were used as the baseline measure. All students completed the *Engineering and Science Attitudes Assessment* in May 2018. The data from the attitude assessment is displayed through a bar graph.

To gain immediate feedback related to student achievement and attitudes, the teacher-researcher was a participant-observer using a journaling technique to collect data to inform the process. During each lab session, the teacher-researcher focused on the reactions and reflections occurring among the female participants in the study.

Due to the time constraints and sample size of this study, the results are suggestive rather than conformational. It is also important to note at this stage to be careful regarding personal bias. The teacher-researcher was diligent in being open and objective to all data and findings, even discrepant data.

**Instructional procedures.** The teacher-researcher implemented two authentic lessons, one for fourth grade and one for fifth grade that used inquiry, cooperative learning, and hands-on activities. The focus strategies that were implemented for the study were cooperative learning using single gender groups; authentic and relevant hands-on activities that connected to the area in which the students live; inquiry utilizing language arts and the verbal component. Cooperative learning was selected because promoting the skill of teamwork is particularly significant since competitive environments can be disheartening to girls and to children from cultures that value interaction and collaboration (Cunningham, 2015). In a study examining gender and gender pairing in cooperative learning, Ding (2011) concluded that females in single-gender dyads outperformed females in mixed-gender dyads. Use of authentic and relevant activities is a key strategy because if students believe that what they are learning might make a difference in preventing or solving social or environmental problems, they are more likely to persist in learning (Shumow, 2014). Activities that highlight ways engineering benefits people, animals, the environment, and society demonstrate the social value of what is being studied (Cunningham, 2015). The third strategy focused on inquiry utilizing language arts and the verbal component. “Programs for females should not duplicate programs for male students, but should be equitable, emphasizing hands-on, real-life laboratory experiences while incorporating verbal/language arts components where many females excel” (Tyler-Wood, Ellison, Lim, & Periathiuivadi, 2012, p. 47).

Each lesson was a three-day cycle per grade level class over a six-week period for a total of 150 minutes (see appendix H and I).

Fifth Grade week 1-6: Ecosystems

Day One:

- Students read about the Red-cockaded woodpecker and hypothesized why it is endangered. Students examined and compared two range maps of where the Red-cockaded woodpecker lives and longleaf pines grow.
- Students viewed a news clip of the effects of Hurricane Matthew on the sea turtle population.
- The teacher-researcher and students had a discussion of why organisms become endangered when their ecosystems are destroyed.
- The teacher-researcher introduced the vocabulary.
- The teacher-researcher and students discussed how abiotic factors influence biotic factors.
- The students played the web-based game Kahoot! © as a formative assessment for the teacher-researcher to determine if the students understood the vocabulary.

Day Two:

- The teacher stated, "Using the STEAM design process, you will create a shelter for species native to Hilton Head that have lost their homes due to the hurricanes."
- Students worked in cooperative groups to build a shelter for a local species.
- Students randomly chose a card that described the species for which they needed to build a shelter. Using their one-to-one devices, students researched the species

to gather information regarding the specie's ecosystem (terrestrial or aquatic), biotic and abiotic factors influences on the species, and type of shelter in which the species lives in.

- Using the engineering design process, students brainstormed, designed, built, tested, and refined a shelter for a displaced species (see appendix M and P).

Day Three:

- Students created an infomercial that described why their shelter offered promise for the species in addition to explaining the impacts of ecosystem loss (see appendix O).

Fourth grade weeks 1-6: Sound

Day One:

- The teacher-researcher introduced unit vocabulary.
- Students explored sound, specifically pitch and volume, using the FOSS Sound Kit.
- The teacher-researcher and students discussed and demonstrated pitch and volume.
- The students played a web-based game Kahoot! © as a formative assessment for the teacher-researcher to determine if the students understood the vocabulary.
- The teacher-researcher stated the problem, "A seeing and language impaired student is joining our class. We need to be able to communicate with the student using sound."

Day Two:

- The teacher stated, “Using the STEAM design process, you will create an instrument that varies in both pitch and volume to communicate with our new seeing and language impaired student”.
- Students worked in cooperative groups to build an instrument that varies in both pitch and volume.
- Using the engineering design process, students brainstormed, designed, built, tested, and refined an instrument for a seeing and speech impaired student (see appendix J and P).

Day Three:

- Students created an infomercial that described how their instrument varies in pitch and volume and is the best to buy for communicating with a seeing and speech impaired student (see appendix P).

**Developing Stage**

The third stage is called the developing stage. As instruction is delivered and pre-assessments and pre-surveys are analyzed, the teacher-researcher reviewed data to adapt or revise portions of the instructional process. “This is the step where the revisions, changes, or improvements arise, and future actions (known as an “action plan) are developed” (Mertler, 2014, p. 36). Reflection is a key component of the developing stage. Mills (2011) provides a “Step to Action Chart” that includes the following steps:

- What was learned from the study?
- Recommendations for actions, related to specific research questions.
- Who is responsible for those actions?

- Who needs to be consulted, informed, or approached for permission for the implementation of future actions?
- Who will monitor or collect future data?
- A timeline for implementing the actions.
- Specification of any needed resources. (p. 155)

Another important component of the development stage is determining the level of action planning, which will be explored with colleagues during and after this action research study. "Action planning can occur on a number of different levels within the school: *individual, team,* and *schoolwide* depending on the scope of the action research effort" (Mills, 2007, p. 165). The action planning level for this action research study was both individual and schoolwide. Although the teacher-researcher conducted this action research study as part of the graduate course requirement, the teacher-researcher was researching the idea of STEAM to implement in the school prior to the class. The action research study was also on a schoolwide level because STESCA is working towards STEAM accreditation from the state.

**Reflection Stage**

Teachers reflect on a continual daily basis over lesson plans, student performance, content, student behavior, how they are teaching, what they are teaching, etc. However, teacher inquiry varies from daily reflection because it is intentional. "Teacher inquiry invites intentional, planned reflection, heightening your focus on problem posing" (Dana & Yendol-Hoppey, 2014, p. 23).

Teacher-researchers reflect continually throughout the action research process as well at the end of the cycle. By integrating reflection during the process, the teacher-researcher makes decisions and revisions as warranted. Mills (2007) suggests two questions for the teacher-researchers to ask themselves:

1. Is your research question still answerable and worth answering?
2. Are your data collection techniques catching the kind of data you want and filtering out the data you don't want? (p. 156)

The data collected from this proposed action study will be shared with the administration of the school as well as with the district.

## Conclusion

One consequence of the No Child Left Behind Act is that science has failed to get the same attention as reading and mathematics (McMurrer, 2007). Science education time has been shrinking presumably because of pressure placed on schools to increase math and reading scores. This paper identifies a problem of practice with standardized science test scores declining over the last eight years. Sea Turtle Elementary School for the Creative Arts (STESCA; pseudonym) schedule allowed 150 minutes a week for science instruction, compared with 450 minutes a week for mathematics instruction. Science instruction has been implemented primarily through direct instruction and the use of textbooks and videos. In addition to the limited instructional time for science and direct instructional methods, there is a lack of racially diverse and female role models evident in the curriculum. With STESCA standardized science test scores declining over the last eight years, the staff has embraced the integration of STEAM (Science, Technology, Engineering, Arts, Math) into the curriculum. The identification of the problem led to the question: Will implementing a STEAM lab that promotes inquiry, cooperative learning, and hands-on activities have a positive impact on science achievement and attitudes towards science of elementary age girls? To answer the question, an action research study was utilized using the four stages: planning, acting, developing, and reflecting (Mertler, 2014).

# CHAPTER 4

# PRESENTATION AND ANALYSIS OF DATA

The following chapter presents and analyzes the data for the action research study.

## Overview of Study

To address declining standardized test scores and loss of interest in science, the teacher-researcher sought to identify strategies that would improve achievement and attitudes towards science.

### Problem of Practice

With Sea Turtle Elementary School for Creative Arts (STESCA) standardized science test scores declining over the last eight years, the staff has embraced the integration of STEAM (Science, Technology, Engineering, Arts, Math) into the curriculum. Not only is there a decline in test scores, but research has found that students, particularly females, are losing interest in science (Huhman, 2012). In 2016-2017, STESCA began steps towards STEAM accreditation. Part of the accreditation process includes a STEAM lab offered to grades first through fifth providing hands-on, inquiry-based, collaborative activities that support the science units in the various grade levels.

### Research Question

The research question for the action research study was: *What impact will authentic learning experiences in a STEAM lab have on science achievement and attitudes towards science of elementary age girls?* Research objectives included:

- Identifying and correcting social issues that influence attitudes and achievement of elementary age girls in science.
- Identifying and providing strategies that increase attitudes and achievement of elementary age girls in science.

## Significance of the Study

The action research study was significant in that it provided a potential solution for the decline of PASS science scores at the elementary school being studied. By replacing the traditional methods of teaching science with interactive small groups and arts enhanced science experiments, students were engaged in authentic and meaningful learning experiences. The study also provided strategies to address the negative social issues that permeate the field of science and STEM for females. The hidden curriculum, lack of feminist pedagogy, gender bias, gender equity, social justice, and diversity are issues that influence the attitudes and achievement of elementary age girls in science.

## Data Collection Methods

The teacher-researcher analyzed a variety of data prior to the action research cycle, during the action research cycle, and following the action research cycle.

**Baseline data.** To gauge the attitude and interest towards science, the teacher-researcher administered the *Engineering and Science Attitudes Assessment* (see appendix C) developed by the Engineering is Elementary, Museum of Science of Boston (2016) to all females in fourth and fifth grades in fall of 2016 and 2017 prior to the intervention. The science Measures of Academic Progress (MAP) was administered in the fall to fourth and fifth grades. The data from MAP helped determine what specific science strands needed to be addressed.

**During the study.** During the six weeks of action research, the following interventions took place:

- The pre-test was administered immediately prior to the intervention. The pre-test was developed through USATestprep© (see appendix D, E, F, and G).
- After the initial lesson, the students took a premade quiz using the educational website Kahoot! ©. This formative data allowed the teacher-researcher to determine whether the student understood the vocabulary terms that had been introduced and whether any reteaching was needed.
- Throughout the six weeks of the study, the teacher-researcher implemented authentic learning experiences (see appendix H and I) in the STEAM lab using the STEAM design process (see appendix J).
- A post summative assessment was given for each grade level. Like the pre-test, it was created using USATestprep© (see appendix F and G).
- A post attitudes assessment was given using the *Engineering and Science Attitudes Assessment* from which the baseline data was taken.
- The science MAP test was administered in the spring of 2018.
- Using this data, the teacher-researcher compared pre-test and post-test data of USATestprep ©, fall and spring MAP data, and the results of the spring *Engineering and Science Attitudes Assessment* to determine the impact of STEAM.

## Sample Characteristics

The target group for the action research study was female student participants in fourth and fifth grades during the 2017-2018 academic year. There was a total of 141 females with 50% females in fourth grade, and 51% in fifth grade. Demographically, there were 12% African-American, 41% Hispanic, 40% white, 7% other-Asian and two or more races (Figure 4.1). The females were given the opportunity not to participate in the study. Of the 141 female students, only six chose to withdraw from the study.

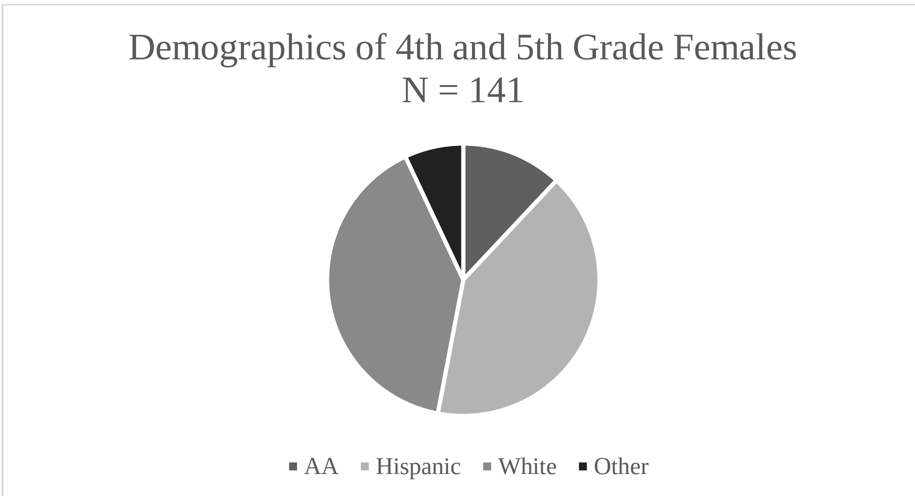



Figure 4.1 Demographics of Females. AA = African Americans

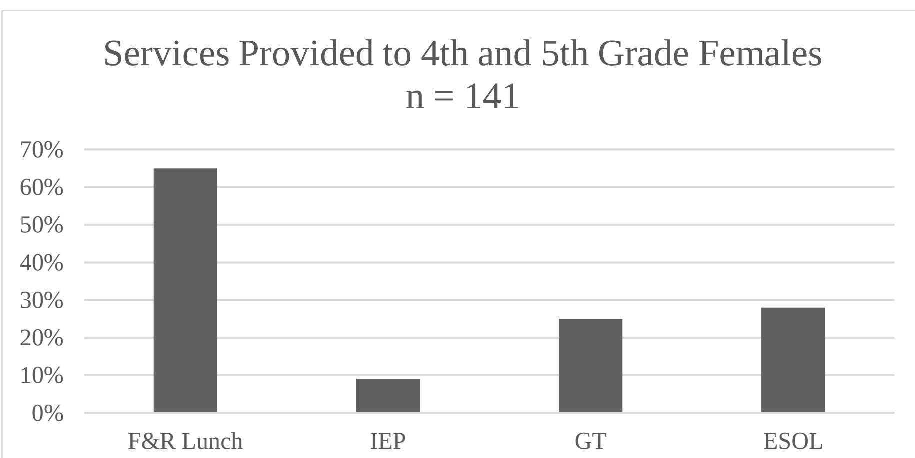



Figure 4.2 Services provided to females. F&R Lunch = Free and Reduced Lunch; GT = Gifted and Talented

Of the 141 females, 65% qualified for free and reduced lunch; 9% were served through an IEP; 25% were served through Gifted and Talented services; and 28% were served through ESOL services (Figure 4.2). Although all 141 students participated in the STEAM lab, six of the females withdrew from the study and not all 141 of the students took every assessment.

## Intervention

The teacher-researcher implemented two authentic lessons, one for fourth grade and one for fifth grade, that used three key strategies during the six-week intervention period. The key strategies that were implemented for the study follow:

- cooperative learning using single gender groups.
- authentic and relevant hands-on activities that connect to the area in which the students live.
- inquiry utilizing language arts and the verbal component.

Cooperative learning was selected as a key strategy as promoting the skill of teamwork is particularly significant because competitive environments can be disheartening to girls and to kids from cultures that value interaction and collaboration (Cunningham, 2015). In a study examining gender and gender pairing in cooperative learning, Ding (2011) concluded that females in single-gender dyads outperformed females in mixed-gender dyads. Integrating authentic and relevant activities was a key strategy because students' belief that what they are learning may lead to resolution of social or environmental problems and leads to greater persistence in learning (Shumow, 2014). Activities that highlight how engineering benefits people, animals, the environment, and society demonstrate the social value of what is being studied (Cunningham, 2015). The third key strategy focused on inquiry utilizing language arts and verbal communication in the form of a student created video informercial based on the content. "Programs for females should not duplicate programs for male students, but should be equitable, emphasizing hands-on, real-life laboratory experiences while incorporating verbal/language arts components where many females excel" (Tyler-Wood, Ellison, Lim, & Periathiuivadi, 2012, p. 47). Each lesson was comprised of three 50-minute lessons per grade level class over a six-week period.

## Analysis and Findings

The lesson was a 3-day, 50-minute cycle for a total of 150 minutes for each of the eight fifth grade classes and each of the seven fourth grade classes. This was insufficient time for the lessons, engineering process, and video creation so the videos were created after the STEAM lab cycle, under the supervision of the classroom teachers. Although the lesson was a hands-on, inquiry-based lab for the first day of each lesson, students did not have a grasp of the vocabulary. In response, the teacher-researcher created a Kahoot! © activity, as a formative assessment to determine whether the students understood the vocabulary terms and retaught as needed.

Results for each of the three data sources were analyzed using matched subjects for a pre- to post- change. A matched pairs t-test was used to determine if the results were significant.

### Engineering and Science Attitudes Assessment

The *Engineering and Science Attitudes Assessment* was administered to measure students' attitudes towards science and engineering and their perceived potential participation in a STEAM career. Table 4.1 displays the 12 questions and results for fourth and fifth grade girls of fall and spring, N = 124 for Fall data, N = 134 for Spring data. The overall scores are not matched:

Table 4.1 Engineering and Science Attitudes Assessment Percentage Results

| Statement | Strongly Disagree | | Disagree Somewhat | | Not Sure | | Agree Somewhat | | Strongly Agree | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| I would enjoy being a scientist when I grow up. | 33 | 25 | 13 | 18 | 33 | 31 | 10 | 23 | 6 | 5 |
| I would enjoy being an engineer when I grow up. | 38 | 27 | 15 | 23 | 21 | 27 | 10 | 14 | 5 | 9 |
| I would like a job where I could invent things. | 28 | 18 | 9 | 21 | 14 | 27 | 27 | 28 | 15 | 16 |
| I would like to help plan bridges, skyscrapers, and tunnels (architect). | 47 | 4 | 19 | 18 | 14 | 28 | 5 | 5 | 5 | 7 |
| I would like a job that lets me design cars. | 44 | 38 | 9 | 20 | 15 | 20 | 8 | 16 | 14 | 8 |
| I would like to build and test machines that could help people walk. | 11 | 11 | 12 | 13 | 21 | 27 | 22 | 19 | 17 | 34 |
| I would enjoy a job helping to make new medicines. | 18 | 31 | 14 | 17 | 24 | 25 | 17 | 24 | 14 | 19 |

(continued)

Table 4.1 Engineering and Science Attitudes Assessment Percentage Results (continued)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| I would enjoy a job helping to protect the environment. | 5 | 2 | 7 | 5 | 18 | 18 | 21 | 30 | 44 | 46 |
| I would like a job that lets me figure out how things work. | 16 | 18 | 9 | 13 | 27 | 29 | 18 | 20 | 17 | 21 |
| I like thinking of new and better ways of doing things. | 12 | 5 | 8 | 10 | 17 | 20 | 27 | 31 | 29 | 36 |
| I like knowing how things work. | 5 | 6 | 10 | 7 | 15 | 11 | 29 | 31 | 37 | 45 |
| Engineers help make people's lives better as part of their job. | 13 | 5 | 4 | 8 | 26 | 13 | 18 | 23 | 37 | 52 |

This table reveals varied changes in responses from fall to spring. Although the female students scored negatively (43% disagree compared to 27% agree, and 31% were unsure) to the question, “I would enjoy being a scientist when I grow up” there was a decrease in the negative response from pre- to post- response (pre-survey 46%, post-survey 43%). Fifty percent of the students disagreed with wanting to be an engineer compared to 23% agreeing, and 27% unsure to be an engineer. However, there was a decrease from pre-survey (53%) to post-survey (50%). The question “I would like a job where I could invent things” had a response of 39% disagree compared to 44% agree and 27% unsure. Twenty-two percent of students disagreed with wanting to help plan bridges, skyscrapers, and tunnels compared to 28% not sure, and 7% agreeing. Though the negative response for this question decreased from pre-survey (66%) to post-survey

(22%). For the question “I would like a job that lets me design cars” there was a 58% disagree, 20% not sure, and 22% agree. From pre-survey (53%) to post-survey (58%) there was an increase in the negative response. The question, “I would like to build and test machines that could help people walk” drew more positive than negative responses. Twenty-four percent disagreed, 27% of the students were unsure, and 53% agreed to this question. The pre-survey to post-survey showed an increase of positive responses from 39% to 53%. “I would enjoy a job helping to make new medicines” had a response of 48% disagreed, 25% unsure, and 43% agreed. This question had an increase in the negative response from pre-survey (32%) to post-survey (48%). “I would enjoy a job helping to protect the environment” had very positive responses. Students responded with a 7% disagree, 18% unsure, and 76% agree. “I would like a job that lets me figure out how things work” had 31% disagree, 29% unsure, and 41% agree responses. Responses to “I like thinking of new and better ways of doing things” were 15% disagreed, 20% were unsure, and 67% agreed. “I like knowing how things work” had the responses of 13% disagreed, 11% unsure, and 76% agreed. This question increased from pre-survey (66%) to post-survey (76%). The statement “Engineers help make people’s lives better as part of their job” had a 13% disagree response, 13% unsure response, and 75% agree response. To better understand these changes the teacher-researcher examined positive (agree somewhat and strongly agree) and negative (strongly disagree and disagree somewhat) responses separately.

Figure 4.3 compares the positive responses for fall 2017 and spring 2018. All questions except for “I would like a job where I can invent things” (8% decrease) showed increased frequency of positive responses. The greatest increase was in response to “I like knowing how things work" (13% increase), and "Engineers help make peoples' lives better as part of their job" (15% increase). These two questions correlate with the fourth and fifth grade lessons which could have contributed to the increase in positive responses.

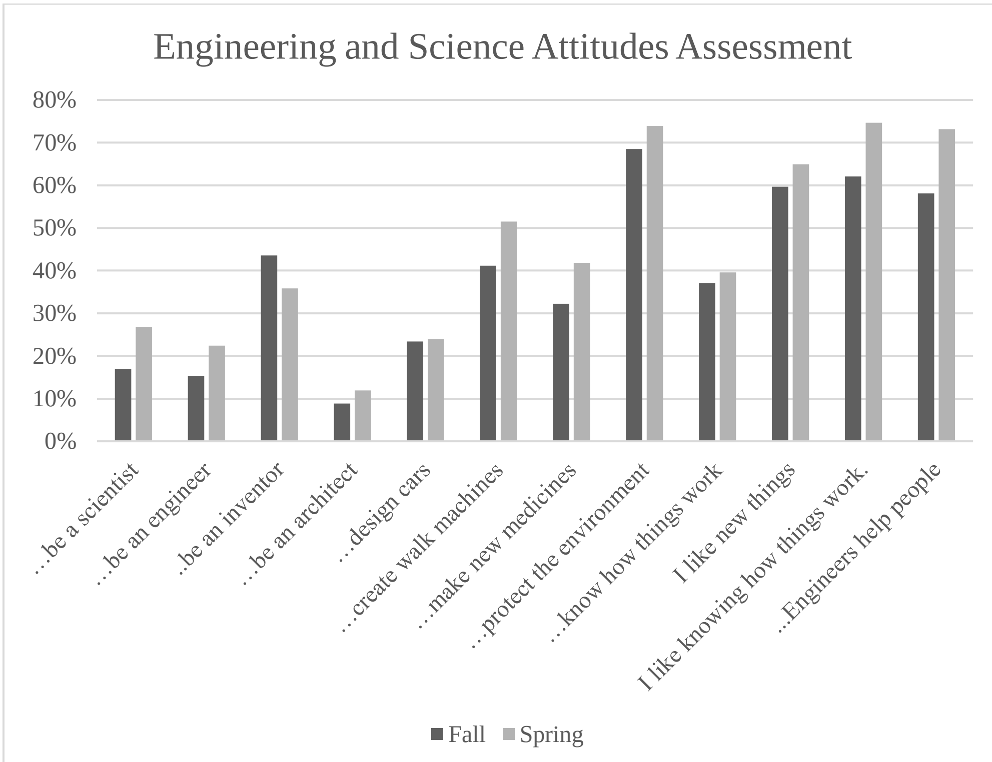



Figure 4.3 Engineering Attitude Survey in Agreement Fall to Spring

In contrast to Figure 4.3, Figure 4.4 reveals a slight increase in negative responses to the three questions related to designing cars (1% increase), making new medicines (3% increase), and having a job figuring out how new things work (3% increase). The greatest decrease in negative responses was to "I would like to help plan bridges, skyscrapers, and tunnels (be an architect)" (7% decrease), as well as a 6% decrease for both wanting to be a scientist and engineer. Although changing attitudes takes time, the decreases in the negative responses shows promise.

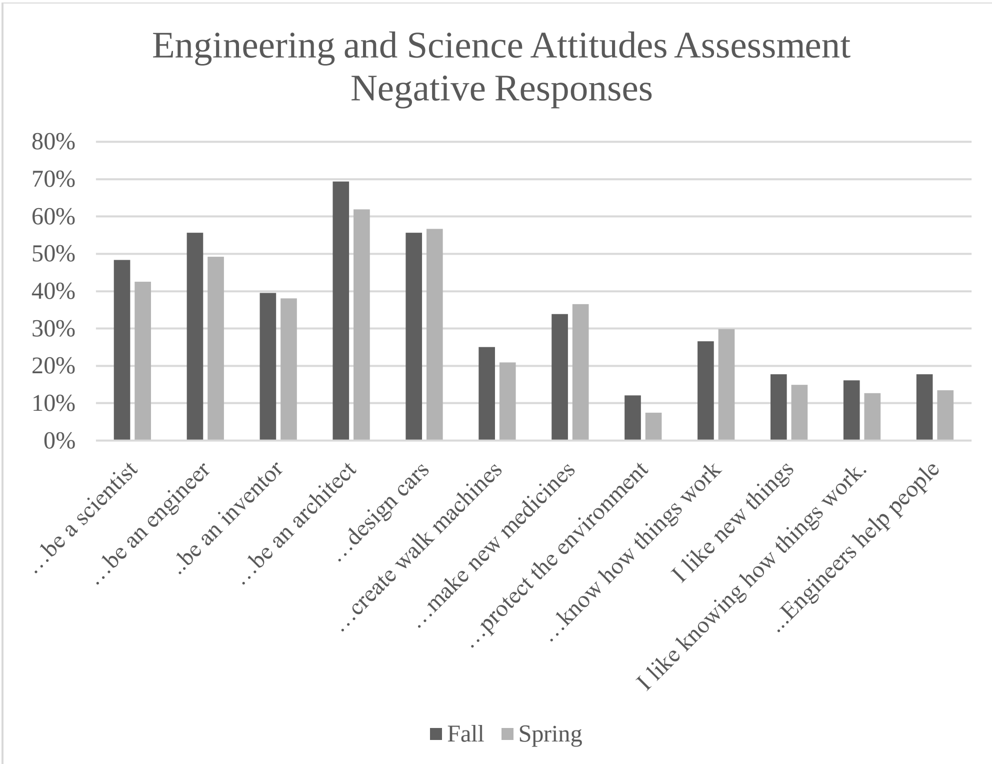



Figure 4.4 Engineering Attitude Survey in Disagreement Fall to Spring.

**MAP Assessment**

MAP scores are reported by two measures. First, student achievement was measured using the Rasch unit or (RIT). A RIT score is an estimation of student instructional level. Additionally, MAP measures science achievement with a percentile rank from 1-99. Within the sample of 141 fourth and 5 grade girls, only 132 had both fall 2017 and spring 2018 MAP Scores. Of the 132 students 60 (45%) had RIT scores, which increased from fall to spring, 64 (48%) decreased, and eight (6%) were unchanged. (See Figure 4.5). Examining the data at individual grade levels reveals that of the fourth-grade students, 54% increased, 41% decreased, and 4% were unchanged. The fifth-grade students showed a 34% increase, 56% decrease, and 8% were unchanged.

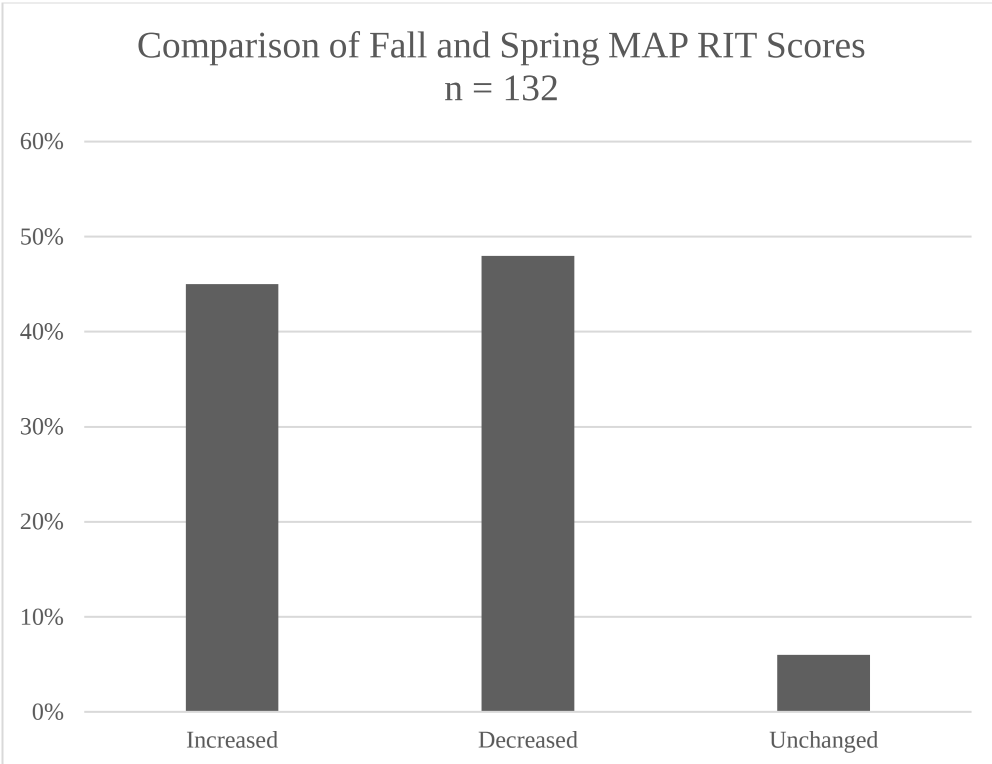



Figure 4.5 Comparison of Fall and Spring MAP RIT scores.

An analysis of the fall and spring RIT scores revealed a higher average RIT score for the Spring administration. (See Table 4.2)

Table 4.2 Science MAP mean RIT scores Fall 2017 and Spring 2018

| Testing Date | Mean RIT | SD | Min | Max | Range |
|---|---|---|---|---|---|
| Fall 2017 | 198.7 | 16.4 | 158 | 229 | 71 |
| Spring 2018 | 205.3 | 16.0 | 177 | 228 | 51 |

*Note.* n = 132

The spring assessment (Table 4.2) had a higher mean score, approximately the same variability and a smaller range of scores. This suggests that the students performed a bit better in the spring than they did in the fall.

**T-test**

A matched pairs t-test was used to determine if the average difference between the Fall and Spring RIT scores was significant. There was a significant difference in the

Spring 2018 (M=205.3, SD=16.0) and Fall 2017 (M=198.7, SD=16.4) as seen by the t-value of 3.31 and the p-value of 0.0006. At the 5% significance level, these findings are significant. It can be concluded the fall and spring RIT scores are significantly different.

**USATestprep© Assessment**

Within the sample of 141 fourth and fifth grade girls, only 116 took both the pre- and post-test. For a more specific examination of learning based on the standards addressed during the study, USATestprep© standardized testing was utilized. Content knowledge assessed was specific to an understanding of the properties of sound as forms of energy for fourth grade and an understanding of relationships among biotic and abiotic factors within terrestrial and aquatic ecosystems for fifth grade. Each assessment included five items. Results are presented in Figure 4.6. Of the 116 students 78 (68%) had scores which increased from pre- to post-, 19 (16%) decreased, and 19 (16%) were unchanged. This data demonstrated that the strategies utilized provide a potential solution for declining test scores.

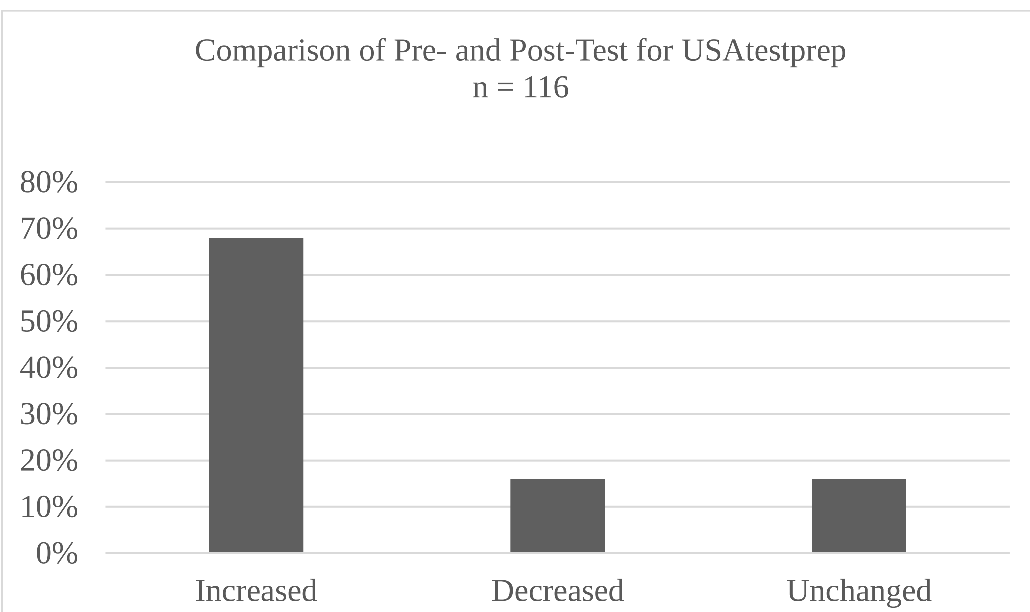



Figure 4.6 Results of USATestprep© Assessment

An analysis of the pre-and post- USATestprep© scores revealed growth following the STEAM lab experience. Table 4.3 highlights the pre- and post-test frequencies and Figure 4.7 displays a comparison of the pre- and post- frequencies for each of the six high scores. The frequency table and bar chart display the number of questions answered correctly.

Table 4.3 Pre- and Post- USATestPrep© Assessment Results

| High Score | Pre-Test Frequency | Post-Test Frequency |
|---|---|---|
| 0 | 7 | 0 |
| 1 | 30 | 12 |
| 2 | 28 | 25 |
| 3 | 31 | 23 |
| 4 | 14 | 36 |
| 5 | 6 | 20 |

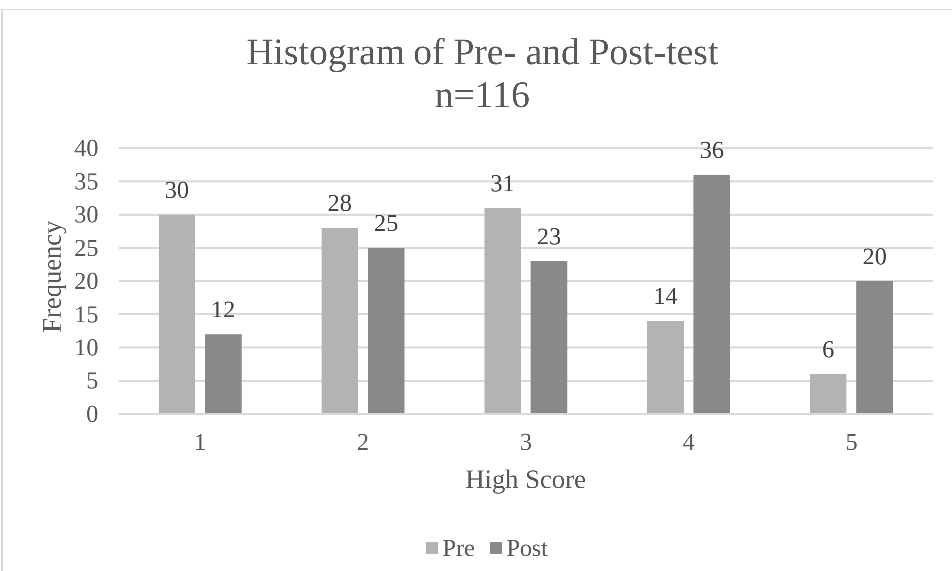



Figure 4.7 Frequency of USATestprep© pre- and post-test data

To analyze the findings from the USATestprep© pre- and post-test, the raw data was paired for each student and the difference was analyzed. Students that did not have both a pre-test and post-test score were not included in the data set (Table 4.4).

Table 4.4 USATestprep© Scores from Pre- and Post-Assessments

| Test Administration | Mean Number Correct | SD | Min | Max | Range |
|---|---|---|---|---|---|
| Pre-test | 2.28 | 1.67 | 0 | 5 | 5 |
| Post-test | 3.23 | 1.74 | 1 | 5 | 4 |

*Note:* Total of five test questions; n=116

The post-test had a higher mean score, slightly more variability and a smaller range of scores. This suggests that the students performed a bit better on the post-test than they did on the pre-test.

**T-test**

A matched pairs t-test was used to determine if the difference between the average pre- and post-assessment scores was significant. There was a significant difference in the post-test (M=3.23, SD=1.74) and pre-test (M=2.28, SD=1.67) conditions, t (4.23), p= .000024. At the 5% significance level, these findings are significant. It can be concluded the pre- and post- USATestprep© scores are significantly different.

## Analysis of Data Based on Research Questions

The research question for the action research study is: *What impact will authentic learning experiences in a STEAM lab have on science achievement and attitudes towards science of elementary age girls?* Research objectives include:

- Identifying and correcting social issues that influence attitudes and achievement of elementary age girls in science.

- Identifying and providing strategies that increase attitudes and achievement of elementary age girls in science.

The *Engineering and Science Attitudes Assessment* demonstrated that although some females are still not inclined to be scientists or engineers when they grow up, there are elements of the science and engineering fields that are appealing to them, such as protecting the environment and learning how to make things work. The findings suggest that there was significant growth made from the pretest to post-test for in both the MAP RIT scores and USATestprep© scores.

The MAP test was given at the beginning and end of the school year and encompassed content beyond the scope of this study. MAP scores indicated that although some students did not show growth, the average RIT score increased by 6.6 points. Furthermore, the minimum score improved 19 points. During the final quarter of the school year, fifth grade students were focused on academic areas other than science which could have been a contributing factor in the lower test scores. The USATestprep© assessment was given prior to and following the key interventions for this action research study. The content tested was specific to the lessons taught during the data collection period. Test results showed an increased number of correct items as well as increased average score. Since the USATestprep© assessment was content specific compared to the MAP data which included content above the scope of the study, data from the USATestprep© could be considered more reliable. These three data sources combined suggest that the STEAM lab experience has a positive impact on science achievement and attitudes and science of elementary age girls.

## Conclusion

The data presented and analyzed represents a baseline to further study attitude and achievement as it relates to the benefits of a STEAM lab. The findings presented in this chapter of the action research study show some statistical differences between groups of students. However, the need for students to see the connection between what engineers and scientists do has not been met. Although the STEAM lab is a collaborative effort between the classroom teacher and STEAM lab teacher, it is not evident that all classroom teachers utilized the required strategies.

# CHAPTER 5

# DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

After analyzing and collecting data from the action research study, the next step is the developing stage. This is where the action researcher takes the data, interprets it, draws final conclusions, and then formulates a plan (Mertler, 2014).

## Overview of Study

With the decline of standardized science test scores and the loss of interest in science by elementary age girls, Sea Turtle Elementary School for the Creative Arts (STESCA) needed to replace the traditional methods of teaching science that included direct instruction, use of videos and textbooks with authentic, inquiry, arts-infused small groups. This problem let to the research question: *What impact will authentic learning experiences in a STEAM lab have on science achievement and attitudes towards science of elementary age girls?* The research objectives included:

- Identifying and correcting social issues that influence achievement and attitudes of elementary age girls in science.
- Identifying and providing strategies that increase achievement and attitudes of elementary girls in science.

### Primary Purpose

The primary purpose of the action research study was to determine if implementing a STEAM lab that promoted inquiry, cooperative learning, and hands-on activities had a positive impact on science achievement and attitudes towards science of elementary age girls.

**Significance of Study**

This action research study offered an alternative to traditional teaching methods with interactive small groups and arts enhanced science experiments to provide authentic and meaningful learning experiences. The study also provided strategies to address the negative social issues that permeate the field of science and STEM for females. The hidden curriculum, lack of feminist pedagogy, gender bias, gender equity, social justice, and diversity are issues that influence the attitudes and achievement of elementary age girls in science.

**Theoretical Framework**

The main objective of the STEAM lab is to provide a stimulating environment through inquiry, cooperative learning, and hands-on activities. The curriculum theories of progressivism, constructivism, and the Learner Centered Ideology provide the foundations of the interdisciplinary approach of STEAM. "STEAM education has the potential to fulfill the promise of progressive educators such as Dewey (1934) and Freire (2000), who foresaw education as moving toward a student-centered model, in which students are engaged and central to knowledge production" (Gross, 2016, p. 38). Transdisciplinary integration is one of the most advanced levels of STEM that begins with a relevant problem.

Progressivism emphasizes that experiences are supported by one's knowledge and knowledge is sustained by one's experiences. Progressivists advocate for the integration of traditional subjects into more encompassing, cross-disciplinary subject areas

(Elgstrom, 2011). A constructivist inquiry-based learning environment has been found to promote actual learning in science education by allowing students to be active participants rather than passive recipients (Brooks, 1999). A constructivist design–based approach to STEAM, values the arts and design as an essential part of the educational experience, while preparing students for the 21st-century workplace that requires creativity and the skills to turn ideas into reality (Gross, 2016). The Learner Centered ideology encompasses the constructivist view. Learner Centered advocates focus on the needs and concerns of individuals, not on the needs of society or the academic disciplines (Schiro, 2013). The transdisciplinary approach begins with a real-life perspective. When students engage in transdisciplinary integration they feel empowered (Larmer, 2016). Creating a classroom environment that utilizes a transdisciplinary curriculum such as STEAM empowers students through differentiation by being student-centered and driven.

**Sample Characteristics and Context of Findings**

The target group for the action research study was female student participants in fourth and fifth grades during the 2017-2018 academic year. There was a total of 141 females with 50% females in fourth grade, and 51% in 5th grade. Demographically, there were 12% African-American, 41% Hispanic, 40% white, 7% other-Asian and two or more races. Of the 141 females, 65% qualify for free and reduced lunch; 9% were served through an IEP; 25% were served through Gifted and Talented services; and 28% were served through ESOL services. Although all 141 students participated in the STEAM lab, not all took every assessment.

STESCA is in a resort and retirement area. Part of the community has financial stability, traditional two-parent family structures, access to enrichment opportunities and higher academic performing students. In contrast, another segment of the population served by STESCA has predominantly single parent families or parents that must hold multiple jobs, significant language and communication barriers, high illiteracy rates and poor academic success (Keefner, 2015).

**Data Collection Methods**

Key strategies were implemented over a six-week period. Data was collected for six weeks from mid-January through mid-March of 2018. This study was limited to six weeks because of scheduling conflicts caused by testing. There were 141 female students from fourth and fifth grade that participated in the action research study. The data collection instruments that were utilized were: Pre/Post *Engineering and Science Attitudes Assessment*; Pre/Post USATestprep©; Fall/Spring MAP assessments.

**Data Analysis Results**

The results from the *Engineering and Science Attitudes Assessment* revealed that overall, students' attitudes towards engineering and science was positive. All questions except for "I would like a job where I can invent things" (8% decrease) showed increased frequency of positive responses. The greatest increase was in response to "I like knowing how things work" (13% increase), and "Engineers help make peoples' lives better as part of their job" (15% increase). Figure 4.4 reveals a slight increase in negative responses to the three questions related to designing cars (1% increase), making new medicines (3% increase), and having a job figuring out how new things work (3% increase). The greatest decrease in negative responses was to "I would like to help plan bridges, skyscrapers, and tunnels (be an architect)" (7% decrease), as well as a 6% decrease for both wanting to be a scientist and engineer. The *Engineering and Science Attitudes Assessment* demonstrated that although some females are still not inclined to be a scientist or engineer when they grow up, there are elements of the science and engineering fields that are appealing to them, such as protecting the environment and learning how to make things work. Intentionally making connections to be a scientist or an engineer while students are engaged in building a structure could be a possible solution to change the negative perceptions of the fields of science and engineering.

The USATestprep© assessment was given prior to and following the key interventions for this action research study. The content tested was specific to the lessons taught during the data collection period. To analyze the findings from the USATestprep© pre- and post-test, the raw data was paired for each student and the difference was analyzed. Students that did not have both a pre- and post-test score were not included in the data set. Within the sample of 141 fourth and fifth grade girls, only 116 took both USATestprep© pre- and post-test. Each assessment included five items. Of the 116 students 78 (68%) had scores which increased from pre- to post-, 19 (16%) decreased, and 19 (16%) were unchanged. The assessment supported the standards and indicators that were taught which demonstrated that the students understood the content. A matched pair t-test was used to determine if the difference between the average pre- and post-test scores was significant. There was a significant difference in the Post-test ($M=3.23$, SD: 1.74) and Pre-($M=2.28$, SD:1.67) conditions, $t$ (4.23), $p= .000024$. At the 5% significance level these findings are significant. Test results showed an increased number of correct items as well as increased average score. It can be concluded the pre- and post-USATestprep© scores are significantly different.

The science MAP test was given at the beginning and end of the school year and encompassed content beyond the scope of this study. Within the sample of 141 fourth and fifth grade girls, only 132 had both Fall 2017 and Spring 2018 MAP Scores. Of the 132 students 60 (45%) had RIT scores, which increased from fall to spring, 64 (48%) decreased, and eight (6%) were unchanged. (See Figure 4.5). The spring assessment had a higher average score, approximately the same variability and a smaller range of scores. A matched pair t-test was used to determine if the difference between the average fall and spring RIT scores was significant. There was a significant difference in the spring 2018 (M=205.3, SD: 16.0) and fall 2017 (M=198.7, SD:16.4) conditions, t (3.31), p= .0006. At the 5% significance level these findings are significant. MAP scores indicated that although some students did not show growth, the average RIT score increased by 6.6 points. Furthermore, the minimum score improved 19 points. As a grade level, fifth grade was focused on preparing for the social studies SCPASS instead of science which could be a possible contribution to the overall decrease in RIT scores. It can be concluded the fall and spring RIT scores are significantly different.

The findings suggest that there was significant growth made from the pre-test to post-test for in both the MAP RIT scores and USATestprep© scores. These three data sources combined suggest that the STEAM lab experience had a positive impact on science achievement and attitudes and science of elementary age girls.

**Answers to Research Question**

The research question for the action research study was: *What impact will authentic learning experiences in a STEAM lab have on science achievement and attitudes towards science of elementary age girls?*

Research objectives included:

- Identifying and correcting social issues that influence achievement and attitudes of elementary age girls in science.
- Identifying and providing strategies that increase achievement and attitudes of elementary age girls in science.

Social issues that were addressed during the action research study were the hidden curriculum, the lack of feminist pedagogy, gender bias, gender equity, social justice, and diversity. By providing a STEAM lab that recognized the hidden curriculum of gender roles in science and encouraging a feminist pedagogy, students had the opportunity to challenge gender bias and equity as well as social justice and diversity. Highlighting the key strategy of cooperative learning provided the opportunity for interaction and collaboration, which is significant to girls and students from other cultures. Using authentic and relevant learning engaged the students. Identifying the problem that the students had to solve with something that they could relate to, such as the loss of habitat which happened with the past two hurricanes, students persisted in their learning. Of the female students, 76% agreed compared to 7% that disagreed that protecting the environment was important. The third strategy focused on inquiry utilizing language arts and the verbal component. According to Tyler-Wood (2012), science programs for females should be unbiased, emphasizing hands-on, real-life laboratory experiences while integrating verbal/language arts components where many females excel. To highlight the verbal/language arts component in the lesson, students created video infomercials about their product. The students had to write and present information that they had learned during the STEAM lab experience.

## Results Related to Existing Literature

The teacher-researcher organized existing literature and studies into four categories: authentic learning and arts integration, authentic learning and motivation, authentic learning and achievement, and authentic learning and social issues.

### Authentic Learning and Arts Integration

The "A" in STEAM represents the arts. An effective way to enhance student interest and achievement is by integrating arts-related skills and activities into the science curriculum (Biffle, 2016). The skills that the arts develop are also considered the 21$^{st}$ Century learning skills. The 21$^{st}$ Century learning skills are critical thinking and problem solving; creativity and innovation; communication and collaboration (Fiske, 2001). Participation in the arts prepares students to solve impending problems by encouraging risk taking, experimentation, and freedom to fail. Trying new ideas, finding multiple solutions, and making the most of mistakes are artistic orientations (Cornett, 2007). Through the STEAM design process, students tried different ideas, took risks, and found multiple solutions to their designs. During the action research study art was integrated throughout the process. Visual arts were addressed through the design and creation process of the product. Theatre arts were addressed through the process of writing a script and acting for the infomercial. Creating the infomercial addressed English Language Arts standards with having to communicate through multiple modalities and multimedia sources to present ideas and information.

### Authentic Learning and Motivation

To motivate students to learn science, science educators should stress more on the connectedness of science at school to real life (Cetin-Dindar, 2016). The STEAM lab focused on real-world connections that connected to the students at STESCA. Learning was made relevant by having the students solve problems that related to them on a personal level. Fifth grade students had to create shelters for species native to the area that lost their homes due to hurricanes. The area in which the students live have been affected by hurricanes the past three years. Students have witnessed on a first-hand basis the destruction caused by these storms. Fourth grade students had to build an instrument that could be used to communicate with a seeing and language impaired student that was coming to their school. During the lessons, the teacher-researcher used the observational checklist (see appendix K) to track processes and attitudes of the female students. The observational checklist allowed the teacher-researcher to determine which students needed additional support or to determine if no support was needed. Although this data was not used to determine the outcome of attitudes of the girls towards science and engineer, the checklist provided formative information during the action research study. The increase from fall to spring on the questions, “I like knowing how things work” (13% increase), and “Engineers help make peoples’ lives better as part of their job” (15% increase) from the *Engineering and Science Attitudes Assessment* supports this conclusion.

**Authentic Learning and Achievement**

The findings from this action research study suggest that there was significant growth made from the pre-test to post-test for in the USATestprep© scores. The USATestprep© assessments targeted the specific standards and indicators being addressed. Overall there was a decrease in the MAP scores for fourth and fifth grades combined. Forty-five percent of the students increased, 48% decreased, and 6% stayed in the same from the fall to spring assessment. Examining the data at individual grade levels reveals that of the fourth-grade students, 54% increased, 41% decreased, and 4% were unchanged. The fifth-grade students showed a 34% increase, 56% decrease, and 8% were unchanged. Fifth grade students prepared for social studies SCPASS instead of science SCPASS which could have been a contributing factor to the lower test scores for fifth grade. Spring MAP testing was also administered at the end of a three-week testing cycle that included SC READY, SCPASS, ELA MAP, Math MAP, and finally science MAP. Test fatigue could have been another factor in the lower MAP test scores.

**Authentic Learning and Social Issues**

The hidden curriculum, lack of feminist pedagogy, gender bias, gender equity, social justice, and diversity are issues that influence the attitudes and achievement of elementary age girls in science. The focus of the study was how to increase achievement and attitudes towards science with all students, especially the female students using a feminist pedagogy lens. Feminist pedagogy recognizes the negative impact of hidden curriculum, highlights the accomplishments of women and people of color, and challenges prejudices and social injustice (Digiovanni & Liston, 2004). Science curriculum and/or pedagogy needs to change so that it includes the experiences, worldviews, learning styles, and/or interests of students from diverse backgrounds (Carlone, 2011). Many students, particularly girls and underrepresented minorities are interested in people-oriented “helping” careers. Activities that highlight how engineering benefits people, animals, the environment, and society demonstrate the social value of what is being studied (Cunningham, 2015). The teacher-researcher introduced problems that encouraged helping people and animals, two areas that are of interest to girls. The attitude survey question “I would enjoy a job helping to protect the environment” had very positive responses. Students responded with 7% disagreed, 18% unsure, and 76% agreed. The statement “Engineers help make people’s lives better as part of their job” had a 13% disagree response, 13% unsure response, and 75% agree response. The establishment of a lab that encouraged inquiry and collaboration along with a female lab teacher had impact on the girls’ attitudes and achievement level.

## Practice Recommendations

According to Mertler (2014), there are three levels of action plans: individual, team, and school or district. The action planning level for this action research study was both individual and schoolwide. Although the teacher-researcher conducted this action research study as part of the graduate course requirement, the teacher-researcher was researching the idea of STEAM to implement in the school prior to the class. The action research study was also on a schoolwide level because SCETA is working towards STEAM accreditation from the state.

### Individual Action Plan

The teacher-researcher began this action research study to determine how to increase achievement and attitudes toward science with elementary girls. After reading numerous studies, the teacher-researcher determined that the focus of the action research study should be on the following strategies: cooperative learning with single-dyad groups, authentic and relevant learning; and inquiry utilizing the verbal and language art skills through the creation of a video infomercial.

The teacher-researcher chose problems to solve that the students could relate to such as: 5th grade students had to solve the problem, “Using the STEAM design process, you will create a shelter for species native to their community that have lost their homes due to the hurricanes". Fourth grade students had to solve the problem, "Using the STEAM design process, you will create an instrument that varies in both pitch and volume to communicate with our new seeing and language impaired student".

The third strategy focused on inquiry utilizing language arts and the verbal component. To address the language arts and verbal component, 5th grade students created a video infomercial that described why their shelter offered promise for the species in addition to explaining the impacts of ecosystem loss. Fourth grade students created a video infomercial to describe why their instrument that varied in both pitch and volume would be the best to buy for communicating with a seeing and speech impaired student.

The individual action plan for this action research project will be to continue to implement these strategies in the STEAM lab. However, there needs to be more intentionality regarding the cooperative groups and how they are structured. Roles need to be assigned and rotated in the groups to ensure equity so that all students can participate and be heard. Although the teacher-researcher structured the problems so they would be relevant and authentic, bringing in guest speakers or taking field trips can enhance the experience so that all students can have a stronger connection. The writing of the scripts for the videos took more time that was allotted so time management needs to be addressed.

**Schoolwide Action Plan**

The action research study was also on a schoolwide level because STESCA is working towards STEAM accreditation. The teacher-researcher met regularly with the related arts team for planning to integrate the arts into the curriculum as well as plan for quarterly grade level STEAM days. Grade level STEAM days are an opportunity to share with other grade levels, parents, and the community the processes and results of an arts-infused STEAM approach. Through the collaborative STEAM lab experience, the teacher-researcher demonstrates key strategies that can be implemented in the classroom. There are quarterly grade-level STEAM planning days in which the teacher-researcher will guide classroom teachers into identifying areas in their own classrooms to increase achievement and attitudes for science.

## Limitations and Suggestions

There were some limitations to this study. One limitation was the sample size of students participating in the study. The target group was females in fourth and fifth grades, approximately 141 students. The sample size did not allow for the study to be generalizable to other schools. A second limitation was that STESCA, being a school of choice, has a transient population. Students transferring from other schools might not have the science progression that was available at STESCA. A third limitation was the time constraints of the study. Because of testing and other scheduling conflicts, the action research study was six weeks. Students rotated through the STEAM lab for three 50 minutes per class period for a total of 150 minutes. This limited the exposure to the experiences and benefits of the STEAM lab. This is not enough time to change the opinion or position of the students. Since the STEAM lab was a collaboration between the lab teacher and classroom teacher, STEAM strategies should be implemented in the regular classroom, not just in the lab. The teacher-researcher had to ensure that the classroom teacher was following the protocol, though in some of the classes it did not occur. The lack of prior knowledge and the inability to make connections was evident in classrooms that did not use the strategies that were introduced. Although the STEAM lab is a collaboration between the lab teacher and classroom teacher, the STEAM lab teacher led most of the instruction as well as facilitated the small cooperative group discussions. Classroom teachers need to be more intentional on taking strategies they learn in the lab back to their classrooms and use them.

Although significance growth was demonstrated through both the USATestprep© and MAP assessment, there should be growth after students have been exposed to curriculum. The expectation was there should have been greater growth than demonstrated; however, with the spring science MAP test coming at the end of a 3-week testing cycle, students had test fatigue and may not have put forth the effort into the test.

## Recommendations for Future Research

Recommendations for future research include examining the cultural, racial, and socio-economic factors of the students. While organizing the data from the *Engineering and Science Attitude* Survey, the teacher-researcher observed that the Hispanic and African American females were more negative than the Caucasian female students in their responses. There were also more positive results from females that were above the 50% of MAP testing than in the lower quartiles. The teacher-researcher is interested in examining these areas further. This is the third year of implementing a STEAM lab. The teacher-researcher is interested in completing a longitudinal study that tracks the impact of the STEAM lab on students that began as first graders. Once STESCA achieves the AdvancedEd STEM accreditation, the school can be a model for other schools in the district as well as the state.

## Conclusion

To address the problem of declining science SCPASS scores and negative attitudes towards science, the question was asked: *What impact will authentic learning experiences in a STEAM lab have on science achievement and attitudes towards science of elementary age girls?* By implementing key strategies that addressed the social issues faced by females, the teacher-researcher sought to increase the achievement and attitudes towards science for females in fourth and fifth grades. The data presented and analyzed represents a baseline to further study attitude and achievement as it relates to the benefits of a STEAM lab. The findings of the action research study show some statistical differences between groups of students. More research needs to be done with the subgroups of females: cultural, racial, socio-economic, academic achievement quartiles. Though there was an increase in the positive attitudes towards science, the need for students to see the connection between what engineers and scientists do have not been met. Although the STEAM lab is a collaborative effort between the classroom teacher and STEAM lab teacher, it is not evident that all classroom teachers utilized the required strategies were utilized.

## REFERENCES

Abbott, S. (2014, August 26). The glossary of education reform. *Hidden curriculum*. Retrieved from http://edglossary.org/hidden-curriculum

AdvancedEd (2018). Retrieved from AdvancedEd: https://www.advanc-ed.org

Archer, L., Dewitt, J. O., Dillon, J., & Willis, B. W. (2012). "Balancing acts": Elementary school girls' negotiations of femininity, achievement, and science. *Science Education, 96*(6), 967-989.

Bailey, B. S. (1997, January/February). It's not my style: Using disclaimers to ignore issues in science. *Journal of Teacher Education, 48*(1), 29-35.

Barak, M. (2014). Closing the gap between attitudes and perceptions about ICT-enhanced learning among pre-service STEM teachers. *Journal of Science Education & Technology*, 1-14. doi:10.1007/s10956-013-9446-8

Bevan, B. P. (2014). Tinkering is serious play. *Educational Leadership, 72*(4), 28-33.

Biffle, R. (2016). *Introduction to STEAM (Science, technology, engineering, arts, and mathematics)- Course design, organization and implementation.* Thomas College. paper under review.

Blank, R. (2012). *What is the impact of decline in science instructional time for science is correlated with lower scores on NAEP*. Washington, DC: Noyce Foundation.

Brooks, J. &. (1999). *In search of understanding: The case for constructivist classrooms.* Alexandria, VA: Association for Supervision and Curriculum Development.

Brown, E. B. (2010). Arts enrichment and school readiness for children at risk. *Early*

*Childhood Research Quarterly, 25*(1), 112-124.

Buck, G. A., Cook, K. L., Quigley, C. F., Prince, P., & Lucas, Y. (2014, March). Seeking to improve african american girls' attitudes toward science: A participatory action research project. *Elementary School Journal*, *114*(3), 431-453.

Carlone, H. H.-F. (2011). Assessing equity beyond knowledge and skills-based outcomes: A comparative ethnography of two fourth-grade reform-based science classrooms. *Journal of Research in Science Teaching*, *48*(5), 459-485.

Catterall, J. (1998). Involvement in the arts and success in secondary schools. *In Americans for the Arts Monographs, 1*(9).

Cetin-Dindar, A. (2016). Student motivation in constructivist learning environment. *Eurasia Journal of Mathematics, Science & Technology Education, 12*(2), 233-247.

Charette, R. (2015, December). STEM sense & nonsense. *Educational Leadership, 72*(4), 79-83.

Cornett, C. (2007). *Creating meaning through literature and the arts* (3rd ed.). Upper Saddle, NJ: Pearson.

Crowther, D. (1999, September/October). Cooperating with Constructivism: Getting the word out on the meaning of "constructivism". *Research & Teaching*, 17-23.

Cunningham, C. H. (2015, January). Engineering for everyone. *Educational Leadership, 72*(4), 42-47.

Dana, N., & Yendol-Hoppey, D. (2014). *The reflective educator's guide to classroom research* (3rd ed.). Thousand Oakes, CA: Corwin.

Deaton, C. &. (2013, April-June). Embracing diversity in the science classroom. *Kappa Delta Pi*, 88-92.

Deans, T. (1999). Service-learning in two keys: Paulo Freire's critical pedagogy in relation to John Dewey's pragmatism. *6*. Michigan Publishing.

DeMont Painter, D. (2002). Teacher research could change your practice. *National Education Association*. Retrieved from National Education Association : http://www.nea.org/tools/17289.htm

Dewey, J. (1938). *Experience and education.* New York: Collier Books.

Digiovanni, L., & Liston, D. (2004, Autumn). Feminist pedagogy in the elementary classroom: An agenda for practice. *Encounter, 17*(3), pp. 10-15.

Drake, S. (2012). *Creating standards-based integrated curriculum* (3rd ed.). Thousand Oakes, CA: Corwin.

Drake, Savage, Reid, Bernard, & Beres. (2015). *An exploration of the policy and practice of transdisciplinarity in the IB PYP.* Research, Brock University, Department of Education.

Ebrahim, A. (2012). The effect of cooperative learning strategies on elementary students' science achievement and social skills in Kuwait. *International Journal of Science and Mathematices Education, 10*, 293-314.

Elementary, E. i. (2016). *Engineering and science attitude assessment.* Boston: Museum of Science, Boston. Retrieved from http://www.eie.org/sites/default/files/engineering_attitudes_instrument.pdf

Elgstrom, O. &. (2011). Curriculum debate and policy change. *Journal of Curriculum Studies, 43*(6), 717-738.

Ertmer, P. &. (1993). Behaviorism, cognitivism, constructivism: Comparing critical features from an instructional design perspective. *Performance Improvement Quarterly, 6*(4), 50-72.

Fichtman Dana, N., & Yendol-Hoppey, D. (2014). *The reflective educator's guide to classroom research* (3rd ed.). Thousand Oakes, CA: Corwin.

Fiske, E. (. (2001). *Champions of change: The impact of arts on learning.* Arts Education Partnership, Washington, DC.Flinders, D. &. (2013). *The curriculum studies reader* (4th ed.). New York, NY: Routledge.

Fortus, D. K.-N. (2005). Design-based science and real-world problem solving. *International Journal of Science Education, 27*(7), 855-879.

Goodwin, B. &. (2015, January). STEM schools produce mixed results. *Educational Leadership, 72*(4), 84-85.

Gor Ziv, H. (2015, November). Feminist pedagogy in early childhood teachers' education. *Journal of Education and Training Studies, 3*(6), 197-211.

Gross, K., & Gross, S. (2016) TRANSFORMATION: Constructivism, design thinking, and elementary STEAM, *Art Education, 69*(6), 36-43.

Hacieminoglu, E. (2016). Elementary school students' towards science and related variables. *International Journal of Environmental & Science Education, 11*(2), 35-52.

Harper, C. (2017, October). The STEAM powered classroom. *Educational Leadership,* 70-74.

Henriksen, D. (2014, February). Full STEAM ahead: Creativity in excellent STEM teaching practices. *The STEAM Journal, 1*(2), 1-8.

Hoachlander, G. (2015, January). Integrating STE&M. *Educational Leadership, 72*(4), 74-78.

Honey, M. &. (2013). *Design, make, play: Growing the next generation of STEM innovators.* New York, NY: Routledge.

Huhman, H. (2012, June 20). STEM fields and the gender gap: Where are the women? *Forbes/Forbes Women*. Retrieved from www.forbes.com/sites/work-in-progress/2012/06/20

Isabelle, A. (2017). STEM is elementary: Challenges faced by elementary teachers in the era of the Next Generation Science Standards. *The Educational Forum, 81*(1), 83-91.

Jachim, N., & Posner, J. (1987). The hidden curriculum. *ETC: A Review of General semantics, 44*(1), pp. 83-85.

Januszyk, R. M. (2016). Addressing student diversity and equity. *Science Teacher*, *83*(4), 47-50.

Jeong, S., & Kim, H. (2015). The effect of a climate change monitoring program on students' knowledge and perceptions of STEAM education in Korea. *Eurasia Journal of Mathematics, Science, and Technology Education, 11*(6), 1321-1338.

Keefner, G. (2015). *Executive summary: Hilton Head Island Elementary School for the Creative Arts.* Advanced Education, Inc.

Larmer, J. (2016, March). It's a project-based world. *Educational Leadership, 73*(6), 66-70.

Lee, S. (2003, February). Achieving gender equity in middle school science classrooms. *Science Scope*, 42-43.

Lightbody, M. (2002, March). Countering gender bias in the media. *Science Scope*, 40-42.

Marshall, J. (2015). In step with the new science standards. *Educational Leadership, 72*(4), 16-22.

McIntosh, P. (1983). *Interactive phases of curricular revision: A feminist perspective.* Wellesley, MA: Wellesley College Center of Research on Women.

McMurrer, J. (2007). *Choices, changes, and challenges: Curriculum and instruction in the NCLB era.* Washington, DC: Center on Educational Policy.

Mertler, C. (2014). *Action research: Improving schools and empowering education* (4th ed.). Thousand Oakes, CA: SAGE Publications.

Mills, G. (2007). *Action research: A guide for the teacher researcher* (3rd ed.). Upper Saddle River, NJ: Pearson Education, Inc.

Molina, R. B. (2016). Supporting STEM success with elementary students of color in a low-income community. *Distance Learning, 13*(2), 19-25.

National Research Council. 2012. A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Washington, DC: The National Academies Press. https://doi.org/10.17226/13165.

National Science Board. 2016. *Science and Engineering Indicators 2016*. Arlington, VA: National Science Foundation (NSB-2016-1)

Peoples, S., O''Dwyer, L., Wang, Y., Brown, J., & Rosca, C. (2014). Development and application of the Elementary School Science Classroom Enviroment Scale (ESSCES): measuring student perceptions of constructivism within the science classroom. *Learning Environments Research, 17*, 49-73.

Perkins, D. (2016, March). Lifeworthy learning. *Educational Leadership, 73*(6), 12-17.

Petrinjak, L. &. (2016, Summer). Teaching ELLs through STEM content. *NSTA Reports, 28*(1), 6-7.

Piaget, J. (1973). *To understand is to invent: The future of education.* New York, NY: Grossman.

Platz, D., & Arellano, J. (2011, September). Time tested early childhood theories and practices. *Education, 132*(1), 54-63.

Root-Bernstein, R. &.-B. (1999). *Sparks of genius: the 13 thinking tools of the world's most creative people.* New York, NY: Houghton Mifflin Company.

Roseman, J. &. (2015, January). Alignment or not? *Educational Leadership, 72*(4), 24-27.

Sadker, D. (1999). Gender equity: Still knocking at the classroom door. *Educational Leadership, 56*, 22-26.

Saraniero, P. (n.d.). Growing from STEM to STEAM. *ArtsEdge*. Kennedy Center. Retrieved from https://artsedge.kennedy-center.org/educators/how-to/growing-from- stem-to-steam.

Schiro, M. (2013). *Curriculum theory: Conflicting visions and enduring concerns* (2nd ed.). Thousand Oaks, CA: SAGE Publications.

Scholes, L. &. (2011, October). Engaging the creative arts to meet the needs of twenty-first-century boys. *International Journal of Inclusive Education, 16*(10), 969-984.

Shakeshaft, C. (1995). Reforming science education to include girls. *Theory Into Practice, 34*(1), 74-79.

Sharpe, G., & Curwen, T. (2012). The hidden curriculum in elementary education-Beyond the straight line: theoretical, critical and reflective analysis of the hidden curriculum in elementary school education in Ontario, Canada. *Review of Higher Education and Self-Learning, 5*(15), 57-68.

Shumow, L. &. (2014, December). Teaching the value of science. *Educational Leadership, 72*(4), 62-67.

Singh, A. Y. (2012, April). Constructivist teaching practices used by five teacher leaders for the Iowa chautatuqua professional development program. *International Journal of Environmental & Science Education, 7*(2), 197-216.

Sleeter, C. &. (2013). Standardizing knowledge in a multicultural society. In D. &. Flinders, *The Curriculum Studies Reader* (4th ed., pp. 253-268). New York, NY: Routledge.

Smith W. & Smith, B. (2016, September). Bringing the maker movement to school. *Science & Children, 54*(1), 30-37.

Sousa, D. &. (2013). *From STEM to STEAM.* Thousand Oaks, CA: Corwin.

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research.* Thousand Oaks, CA: Sage Publications.

Tanenbaum, C. (2016). *STEM 2026: A vision for innovation in STEM education.* Washington, DC: U.S. Department of Education, Office of Innovation and Improvement.

*The partnership for 21st century skills*. (2007). Retrieved from Partnership for 21st

Century Skills: http://www.p21.org/index.php

Tileston, D., & Darling, S. (2008). *Why culture counts: Teaching children of poverty.* Bloomington, IN: Solution Tree Press.

Tyler-Wood, T., Ellison, A., Lim, O., & Periathiuivadi, S. (2012). Bringing up girls in science (BUGS): The effectiveness of an aftershool environmental science program for increasing female students' interest in science careers. *Journal of Science Education & Technology, 21*, 46-55.

Vasquez, J. A. (2014, December). STEM-Beyond the acronym. *Educational Leadership, 72*(4), 11-15.

Vockell, E. &. (1996). *Educational Research.* Upper Saddle River, NJ: Merrill/Prentice Hall.

Walsh, M. &. (2014). Introducing transdiciplinary problem solving to environmental management systems and geology students through a case study of disturbed coastal systems. *Journal of College Science Teaching, 43*(3), 48-53.

Weber, L. (2010). *Understanding race, class, gender, and sexuality* (2nd ed.). New York, NY: Oxford University Press, Inc.

Wei, L. (2013). Who and what should we educate our students to be? An inquiry into the curriculum of multiculturalism in the classroom. *Taboo: The Journal of Culture & Education, 13*(2), pp. 86-90. doi:Accession No. 108837155

Winterscheidt, J., & Eckard, J. (1978). USATestprep. Georgia.

Young, J. F. (2017). Black girls as learners and doers of science: A single-group summary of elementary science achievement. *Journal of Science Education, 21*(2), 1019.

APPENDIX A

LETTER OF CONSENT

January 30, 2018

To the parents of:

My name is Bebe Cifaldi, I am the STEAM lab teacher. I am conducting a research study as part of the requirements of my degree in EdD in Curriculum and Instruction, and I would like your student to participate. During the STEAM lab this school year, I would like your permission to collect data from your student in the form of written reflections, responses, and assessments.

I may use the data that I collect to write an article for a journal in the field of science education or as supporting materials for a presentation that I make at school, state, or national conference. If I do so, I will take extreme care to ensure confidentiality. I will use pseudonyms in my writing/speaking and will not refer to your students, school, or city by name or do anything that might indicate who my participants are.

*I am interesting in learning if the STEAM lab that promotes inquiry, collaboration, and hands-on activities has a positive impact on science achievement and attitudes towards science of elementary age girls*. Little work has been done in this area, and your student will be contributing to the body of knowledge about teaching and learning in my STEAM lab. I believe that this is important work and will be helpful to students and to other classroom teachers.

Your student's participation is strictly voluntary, and there will be no penalty if you choose not to have him/her participate.
Sincerely,

Bebe Cifaldi
STEAM Lab Teacher

HOW DO I GIVE PERMISSION FOR MY CHILD TO PARTICIPATE IN THIS STUDY?

If you agree to have your child participate, you do not need to do anything. If you do NOT agree for your child to participate, you must fill out the information below and return the form to your child's teacher or myself by Monday, February 5th at 12:00.

Student's Name_______________________________________________________

Parent/Guardian Name__________________________________________________

Parent/Guardian Signature_________________________________________Date______

APPENDIX B

ASSENT FORM

I agree to participate in the study that Mrs. Cifaldi is going to conduct about the benefits of the STEAM lab. She has explained to me that my name will not be used and that all of the information she collects will be private. She will not refer to our school or our town by name, either. I have been told that the decision is up to me, and that I do not have to participate, even if my parent/guardian says that it is okay. I also understand that I will be able to withdraw from this study at any time and that there will be no consequences to my grades or to my work in this class.

___Yes, I want to participate in the study.

OR

___No, I do not want to participate in the study.

APPENDIX C

ENGINEERING IS ELEMENTARY: ENGINEERING AND SCIENCE ATTITUDES ASSESSMENT

EA Pre 2/25/2011

## Engineering is Elementary

## Engineering and Science Attitudes Assessment

**Marking Instructions**

- Use a No. 2 pencil or a blue or black ink pen only.
- Do not use pens with ink that soaks through the paper.
- Make solid marks that fill the response completely.
- Make no stray marks on this form.

**CORRECT:** ● **INCORRECT:** ⊘⊠◒◔

**My initials are:**

FIRST INITIAL:

MIDDLE INITIAL:

LAST INITIAL:

**I am a:**

- Girl
- Boy

**I was born in:**

- January
- February
- March
- April
- May
- June
- July
- August
- September
- October
- November
- December

**Today the date is:**

| MONTH | DAY | YEAR |
|---|---|---|
| January | | 2010 |
| February | | 2011 |
| March | | 2012 |
| April | | 2013 |
| May | | 2014 |
| June | | 2015 |
| July | | 2016 |
| August | | 2017 |
| September | | 2018 |
| October | | 2019 |
| November | | 2020 |
| December | | |

*Adapted from Gibbons, S.J., Hirsch, L.S., Kimmel, H., Rockland, R., & Bloom, J. (2004). Middle school students' attitudes to and knowledge about engineering. Paper presented at ICEE Conference 2004, Gainesville, FL.

PLEASE DO NOT WRITE IN THIS AREA

[SERIAL]

We are interested in your opinions about science and engineering in this survey. Please answer each question honestly. Mark how strongly you agree or disagree after each statement. Thank you very much!

| | Strongly Disagree | Disagree Somewhat | Not Sure | Agree Somewhat | Strongly Agree |
|---|---|---|---|---|---|
| **1. I would enjoy being a scientist when I grow up.** | ⓪ | ① | ② | ③ | ④ |
| **2. I would enjoy being an engineer when I grow up.** | ⓪ | ① | ② | ③ | ④ |
| **3. I would like a job where I could invent things.** | ⓪ | ① | ② | ③ | ④ |
| **4. I would like to help plan bridges, skyscrapers, and tunnels.** | ⓪ | ① | ② | ③ | ④ |
| **5. I would like a job that lets me design cars.** | ⓪ | ① | ② | ③ | ④ |
| **6. I would like to build and test machines that could help people walk.** | ⓪ | ① | ② | ③ | ④ |
| **7. I would enjoy a job helping to make new medicines.** | ⓪ | ① | ② | ③ | ④ |
| **8. I would enjoy a job helping to protect the environment.** | ⓪ | ① | ② | ③ | ④ |
| **9. I would like a job that lets me figure out how things work.** | ⓪ | ① | ② | ③ | ④ |
| **10. I like thinking of new and better ways of doing things.** | ⓪ | ① | ② | ③ | ④ |
| **11. I like knowing how things work.** | ⓪ | ① | ② | ③ | ④ |
| **12. Engineers help make people's lives better as part of their job.** | ⓪ | ① | ② | ③ | ④ |
| | Strongly Disagree | Disagree Somewhat | Not Sure | Agree Somewhat | Strongly Agree |

APPENDIX D

USATESTPREP© PREASSESSMENT 5TH GRADE: ECOSYSTEMS

1. An increase in pesticide use has resulted in a decrease in the local blue jay population. What is the BEST explanation for the decreased blue jay population?
    a. Blue jay food supply increased.
    b. Blue jay food supply decreased.
    c. Many blue jays moved into the area.
    d. Infection with the pesticide destroyed most of the blue jay population.
2. All but one of these is a biotic factor in this wetland. What is the abiotic factor?
    a. Water.
    b. Plants.
    c. Predators.
    d. Migratory birds.
3. The animals that live in this valley have basic needs to survive. ALL BUT one of these non-living features is a basic need of the animals living here.
    a. Food.
    b. Oxygen.
    c. Shelter.
    d. Carbon dioxide.

4. Cutting down forests change the populations of more than trees. Imagine the wild life that lived in this forest. After the trees have been cut, fewer animals can suvive here. What are the MOST LIKELY limiting factors in this case?
    a. Food and space
    b. Food and water
    c. Water and space
    d. Food and shelter
5. Last year a tornado destoryed many trees in the forest. A few brown bears have been seen in a small town near whre the tornado occurred. The brown bears have been seen in the town because
    a. Someone is keeping them for pets.
    b. Someone is feeding the brown bears.
    c. The circus brought the brown bears to town.
    d. The tornado destroyed the berries bears eat.

*Permission granted October 2, 2018 to print USATestprep© in dissertation.*

APPENDIX E

USATESTPREP© POSTASSESSMENT 5TH GRADE: ECOSYSTEMS

1. What abiotic factor could be found in a forest habitat?

    a. Beaver

    b. Mushroom

    c. Soil

    d. Tree

2. Consider the wetland habitat pictured here. Imagine a very hot summer with little rain. What would be the limiting factor the populations of *all* the animals living here?

    a. Competition

    b. Food

    c. Space

    d. Water

3. Several species of frogs live in the bog at the end of Marisa's road. Almost any night you can hear them croaking. This spring they seem to be less noisy. What change in the frog's environment could have affected their population?

    a. Lots of flies located in and around the bog

    b. A new species of frog being introduced to the bog

    c. Decreased amounts of precipitation leading to a drought

d. An old tree falling over and beginning to decompose in the bog

4. Two abiotic factors of a habitat COULD include

   a. Birds and bees.

   b. Snails and snowfall.

   c. Mosquitoes and mushrooms.

   d. Clouds and the air.

5. The population of mice in a local forest ecosystem has recently died out due to disease. In the past, these mice were the main predators of the forest beetles. What is the best prediction about what will happen to the beetles?

   a. The drop in the mouse population will lead to a drop in the beetle population.

   b. The drop in the mouse population will lead to no change in the beetle population.

   c. The drop in the mouse population will lead to an increase in the beetle population.

   d. The increase in the mouse population will lead to an increase in the beetle population.

APPENDIX F

USATESTPREP© PREASSESSMENT 4TH GRADE: SOUND

1. Keisha plays the drums in her class band. Every time she strikes the drums the audience hears the deep beat. The sound that the audience hears is created
   a. Due to the vibrations passed the floor of the hass.
   b. By the vibration of the floor on which the drums are placed.
   c. In the drumsicks as they vibrate every time she strikes the drums.
   d. When the surfaces of the drums vibrate after being struck by the sticks.
2. How can you raise the pitch of the sound produced by a drum?
   a. By loosening the drum skin
   b. By stretching the drum skin very tight
   c. By changing the kind of drum stick used
   d. Be beating the drum with a greater force
3. While on the beach for a holiday picnic, you spot a man walking on the shoreline playing his guitar. When you first spotted him, you could barely hear the guitar. As he walks away from you, what will happen to the volume of the sound you hear?
   a. It will lower the volume of the sound.
   b. The volume of the sound will get louder.
   c. The volume of the sound will get fainter.
   d. The volume of the sound will stay constant

4. By now, you know that sound is produced by vibrations. These vibrations can travel through solids, liquids, and gases, but not through________.

   a. Empty space

   b. Granite rock

   c. Living objects

   d. The center of the earth

5. Students in Mr. Rivera's class are studying sound. They know sound travels in waves. Sound waves are compression waves. The sound wave cause particles in solids, liquids, or gases to vibrate back and forth. Mr. Rivera shared this data table with his students. According to the data table sound waves travel the _____ through _____ because the particles are farthest apart.

   a. Slowest; air

   b. Fastest; air

   c. Slowest; aluminum

   d. Slowest; sea water

APPENDIX G

USATESTPREP© POST-ASSESSMENT 4TH GRADE: SOUND

1. What statement BEST describes sound?

    a. It's a form of work.

    b. It's a type of force.

    c. It's a form of energy

    d. It's a type of acceleration.

2. What does the term pitch describe?

    a. A high point of a wave

    b. How high or low a sound is

    c. How loud or soft a sound is

    d. The matter through which a wave travels

3. The table shows the number of times metal wires vibrate per second whe they are plucked one by one. Which wire produced the sound with the highest pitch?

    a. Wire 1

    b. Wire 2

    c. Wire 3

    d. Wire 4

4. If you have ever plucked a guitar string, you know that it keeps making sound for a while after you pluck it. What is actually creating the sound that comes from guitar strings?

a. The vibration of the air is creating the sound.

b. The pitch of the strings is creating the sound.

c. The collection by the ear is creating the sound.

d. The vibration of the strings is creating the sound.

5. Sound with rulers! Fun in science. You make the ruler vibrate to make a sound. How does the sound of the ruler, vibration on the table, compare to the sound of a whistle at PE?

    a. The ruler is louder and has a higher pitch.

    b. The whistle is oulder and has a lower pitch.

    c. The whistle is louder and has a higher pitch.

    d. The whistle is softer and has a higher pitch.

APPENDIX H

EXAMPLE OF THE FIFTH GRADE LESSON PLAN

5th Grade

4th Quarter

"Ecosystems"

Design Your Own Shelter

Enduring Understanding: Engineers design things to solve problems or find ways to make people's lives more enjoyable or easier.

Essential Question: How do we use the engineer design process to solve real world problems?

Engineering Standards

5.S.1: The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.

5.S.1A. Conceptual Understanding: The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers.

5.S.1B. Conceptual Understanding: Technology is any modification to the natural world created to fulfill the wants and needs of humans. The engineering design process involves a series of iterative steps used to solve a problem and often leads to the development of a new or improved technology.

Science Standards

5.L.4: The student will demonstrate an understanding of relationships among biotic and abiotic factors within terrestrial and aquatic ecosystems.

5.L.4A.1: Analyze and interpret data to summarize the abiotic factors (including quantity of light and water, range of temperature, salinity, and soil composition) of different terrestrial ecosystems and aquatic ecosystems.

5.L.4A.2: Obtain and communicate information to describe and compare the biotic factors (including individual organisms, populations, and communities of different terrestrial and aquatic ecosystems.

5.L.4B.4: Construct scientific arguments to explain how limiting factors (including food, water, space, and shelter) or a newly introduced organism can affect an ecosystem.

NGGS 5-ESS3.1: Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Disciplinary Core Ideas:

ESS3.C: Human Impacts on Earth Systems

- Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.

ELA Standard:

5-C.4.1-3.b-e: Speakers use a variety of techniques to address their audience effectively.

Art Standard:

Standard VA5.1: The student will demonstrate competence in the use of materials, techniques, and processes in the creation of works in visual arts.

Vocabulary: abiotic factors, biotic factors, terrestrial, aquatic, salinity, organism, population, community, ecosystem

Engage:

- Students will read about the Red-cockaded woodpecker and hypothesize why it is endangered. Students will examine and compare two maps of where the Red-cockaded woodpecker and longleaf pines grow.
- The teacher and students will have a discussion of why organisms become endangered when their ecosystem is destroyed.
- The teacher will introduce the vocabulary.
- The teacher and students will discuss how abiotic factors influence biotic factors.
- Students will view a news clip of the effects of Hurricane Matthew on the sea turtle population.

- The teacher will state the problem, “Because of Hurricane Matthew and Hurricane Irma, local species have been displaced. They are in need of shelter.”

Explore:

- The teacher will state, “Using the engineering design process, you will create a shelter for species native to Hilton Head that have lost their homes due to the hurricanes”.
- Students will work in cooperative groups to build a shelter for a local species.
- Students will randomly choose a card that describes the species that they will need to build a shelter for.
- Using the engineering design process, students will brainstorm, design, build, test, and refine a shelter for a displaced species.

Explain:

- Students will be able to explain how abiotic factors effect biotic factors.
- Students will be able to explain how limiting factors can effect an ecosystem.
- Students will be able to explain how their design protects their species.
- The teacher will use the observational checklist to assess these skills for each student.

Elaborate:

- Students will create a commercial or a newscast that describes why their shelter offers promise for the species in addition to explaining the impacts of ecosystem loss.

Evaluate:

- A pretest will be administered on the specific standards 5.L.4, 5.L.4A.1, 5.L.4A.2, and 5.L.4B.1.
- Throughout the lesson, the teacher will use the observational checklist to determine if the student is participating and has knowledge of the skills, concepts, vocabulary being taught.
- A rubric will be used to assess the structure being built.
- A rubric will be used to assess the commercial or newscast.
- A posttest will be administered on the specific standards 5.L.4, 5.L.4A.1, 5.L.4A.2, and 5.L.4B.1.
- The pretest and posttest will be compared to determine student growth.

Materials: Recycled materials Native species cards Red Cockaded Woodpecker sheet Map of Long Leaf Pine Map of Red Cockaded Woodpecker range Student device

## APPENDIX I

## EXAMPLE OF THE FOURTH GRADE LESSON PLAN

4th Grade

3rd Quarter

"Sound"

Enduring Understanding: Engineers design things to solve problems or find ways to make people's lives more enjoyable or easier.

Essential Question: How do we use the engineer design process to solve real world problems?

Engineering Standards

4.S.1: The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.

4.S.1A. Conceptual Understanding: The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers.

4.S.1B. Conceptual Understanding: Technology is any modification to the natural world created to fulfill the wants and needs of humans. The engineering design process involves a series of iterative steps used to solve a problem and often leads to the development of a new or improved technology.

Science Standards:

4.P.4 The student will demonstrate an understanding of the properties of sound as forms of energy.

4.P.4B. Conceptual Understanding: Sound, as a form of energy, is produced by vibrating objects and has specific properties including pitch and volume. Sound travels through air and other materials and is used to communicate information in various forms of technology.

4.P.4B.1 Plan and conduct scientific investigations to test how different variables affect the properties of sound (including pitch and volume).

4.P.4B.2 Analyze and interpret data from observations and measurements to describe how changes in vibration affects the pitch and volume of sound.

4.P.4B.3 Define problems related to the communication of information over a distance and design devices or solutions that use sound to solve the problem.

NGSS: 4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

Disciplinary Core Ideas:

PS3.A: Definitions of Energy

- The faster a given object is moving; the more energy it possesses.
- Energy can be moved from place to place by moving objects or through sound, light, or electric currents.

ELA Standard:

Meaning and Context (MC)
Standard 3: Communicate information through strategic use of multiple modalities and multimedia to enrich understanding when presenting ideas and information.

Art Standards:

Standard VA4.1: The student will demonstrate competence in the use of materials, techniques, and processes in the creation of works of visual art.

Vocabulary: pitch, sound, volume, vibration

Engage:

- The teacher will introduce unit vocabulary.
- Students will explore sound, specifically pitch and volume, using the FOSS Sound Kit.
- The teacher and students will discuss and demonstrate pitch and volume.
- The teacher will state the problem, “A seeing and language impaired student is joining our class. We need to be able to communicate with the student using sound. “

Explore:

- The teacher will state, “Using the engineering design process, you will create an instrument that varies in both pitch and volume to communicate with our new seeing and language impaired student”.
- Students will work in cooperative groups to build an instrument that varies in both pitch and volume.
- Using the engineering design process, students will brainstorm, design, build, test, and refine an instrument for a seeing and speech impaired student.

Explain:

- Students will be able to explain pitch and volume.
- Students will be able to explain how their instrument varies in pitch and volume to communicate with a seeing and speech impaired student.
- The teacher will use the observational checklist to assess these skills for each student.

Elaborate:

- Students will create an interview that describes how their instrument is the best to buy for communicating with a seeing and speech impaired student.

Evaluate:

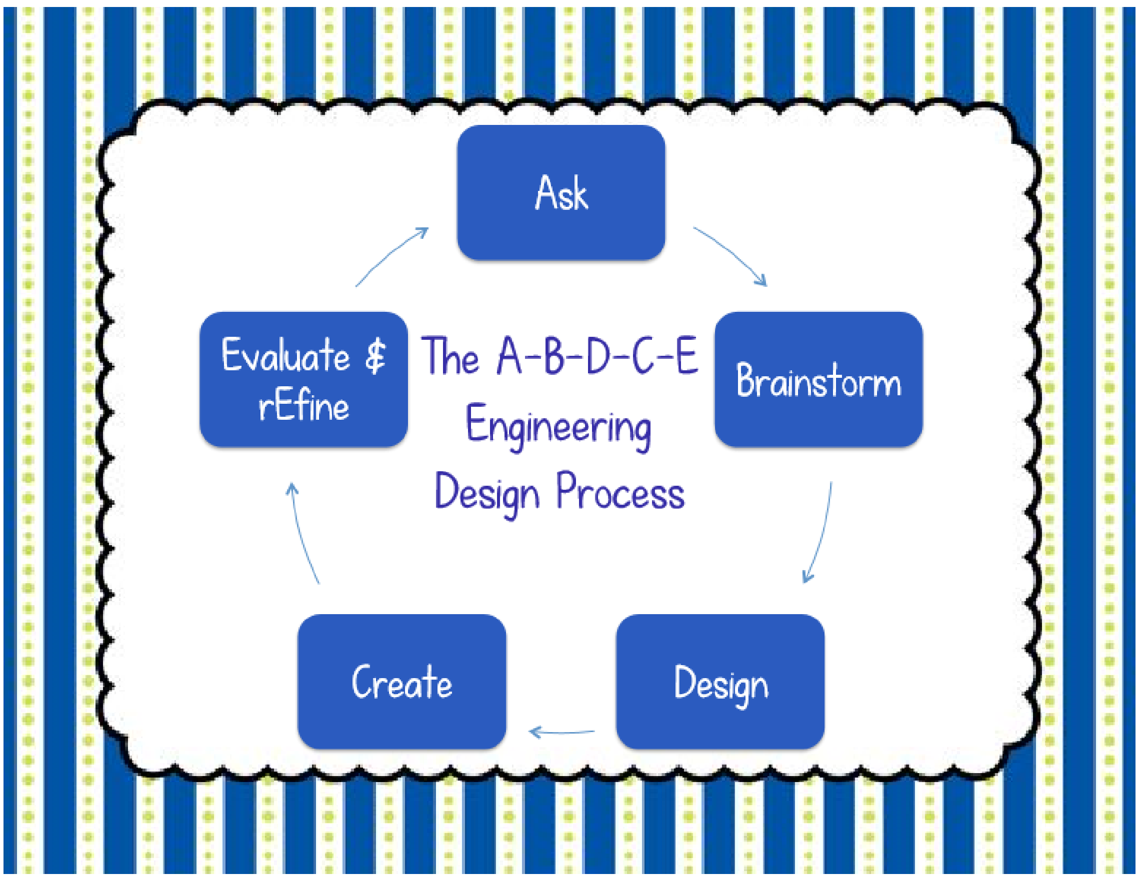
- A pretest will be administered on the standards 4.P.4 and 4. P.4B.
- Throughout the lesson the teacher will use the observational checklist to determine if the student is participating and has knowledge of the skills, concepts, and vocabulary being taught.
- A rubric will be used to assess the instrument being built.
- A rubric will be used to assess the interview.
- A posttest will be administered on the specific standards 4.P.4 and 4.P.4B.
- The pretest and posttest will be compared to determine student growth.

Materials:

- FOSS Sound Kit
- Student devices
- Recycled materials
- Student devices

APPENDIX J

STEAM DESIGN PROCESS



APPENDIX K

OBSERVATIONAL CHECKLIST FOR THE STEAM LAB

Checklist:

Key: Green = full understanding, no teacher support needed

Yellow = Emerging, still need some teacher support

Red = no understanding, need full teacher support

| Engineering Design Process | Student 1 | Student 2 | Student 3 | Student 4 |
|---|---|---|---|---|
| Ask questions to identify problems or needs. | | | | |
| Ask questions about the criteria and constraints of the devices or solutions. | | | | |
| Generate and communicate ideas for possible devices or solutions. | | | | |
| Build and test devices or solutions. | | | | |
| Determine if the devices or solutions solved the problem and refine the design if needed. | | | | |
| Communicate the results. | | | | |
| Scientific Inquiry Process | | | | |
| Asks questions that can be answered using scientific investigations. | | | | |

(continued)

(continued)

| Engineering Design Process | Student 1 | Student 2 | Student 3 | Student 4 |
|---|---|---|---|---|
| Develop, use, and refine models. | | | | |
| Plan and conduct scientific investigations to answer questions, test predictions and develop explanations. | | | | |
| Analyze and interpret data from observations, measurements, or investigations. | | | | |
| Use mathematical and computational thinking. | | | | |
| Construct explanations of phenomena. | | | | |
| Construct scientific arguments to support claims. | | | | |
| Obtain and evaluate informational texts, observations, data collected, or discussions. | | | | |
| Processes and Attitudes | | | | |
| Followed safety procedures. | | | | |
| Worked cooperatively in small groups. | | | | |
| Cleaned up after investigation and followed teacher's instructions. | | | | |

APPENDIX L

RUBRIC FOR STRUCTURE

## Building A Structure : structure

Teacher Name: **Mrs. Cifaldi**

Student Name: ________________________________________

| CATEGORY | 4 | 3 | 2 | 1 |
|---|---|---|---|---|
| **Plan** | Plan is neat with clear measurements and labeling for all components. | Plan is neat with clear measurements and labeling for most components. | Plan provides clear measurements and labeling for most components. | Plan does not show measurements clearly or is otherwise inadequately labeled. |
| **Construction - Materials** | Appropriate materials were selected and creatively modified in ways that made them even better. | Appropriate materials were selected and there was an attempt at creative modification to make them even better. | Appropriate materials were selected. | Inappropriate materials were selected and contributed to a product that performed poorly. |
| **Construction - Care Taken** | Great care taken in construction process so that the structure is neat, attractive and follows plans accurately. | Constuction was careful and accurate for the most part, but 1-2 details could have been refined for a more attractive product. | Construction accurately followed the plans, but 3-4 details could have been refined for a more attractive product. | Construction appears careless or haphazard. Many details need refinement for a strong or attractive product. |
| **Function** | Structure functions extraordinarily well, holding up under atypical stresses. | Structure functions well, holding up under typical stresses. | Structure functions pretty well, but deteriorates under typical stresses. | Fatal flaws in function with complete failure under typical stresses. |
| **Modification/Testing** | Clear evidence of troubleshooting, testing, and refinements based on data or scientific principles. | Clear evidence of troubleshooting, testing and refinements. | Some evidence of troubleshooting, testing and refinements. | Little evidence of troubleshooting, testing or refinement. |

APPENDIX M

RUBRIC FOR INTERVIEW

**Video - Talk Show : product development**

Teacher Name: **Mrs. Cifaldi**

Student Name: ________________________________________

| CATEGORY | 4 | 3 | 2 | 1 |
|---|---|---|---|---|
| **Knowledge** | All students showed excellent knowledge of content, needing no cues and showing no hesitation in talking or answering questions. | All students showed excellent knowledge of content, but 1-2 students once needed note cards to talk or answer questions. | Most students showed excellent knowledge of content, but 1-2 often needed note cards to talk or answer questions. | Most students needed note cards to talk and to answer questions. |
| **Questions & Answers** | Excellent, in-depth questions were asked by host and excellent answers supported by facts were provided by all talk show members. | Questions requiring factual answers were asked by the host and correct, in-depth answers were provided by all talk show members. | Questions requiring factual answers were asked by the host and correct answers were provided by several of the talk show members. | Answers were provided by only 1-2 talk show members. |
| **Interest and Purpose** | Video has a clear and interesting purpose. | Video is interesting but purpose is somewhat unclear. | Video is not very interesting and purpose is somewhat unclear. | Video is not interesting and has no discernable purpose. |

Date Created: **Jan 26, 2018 10:42 am (CST)**

APPENDIX N

RUBRIC FOR INSTRUMENT

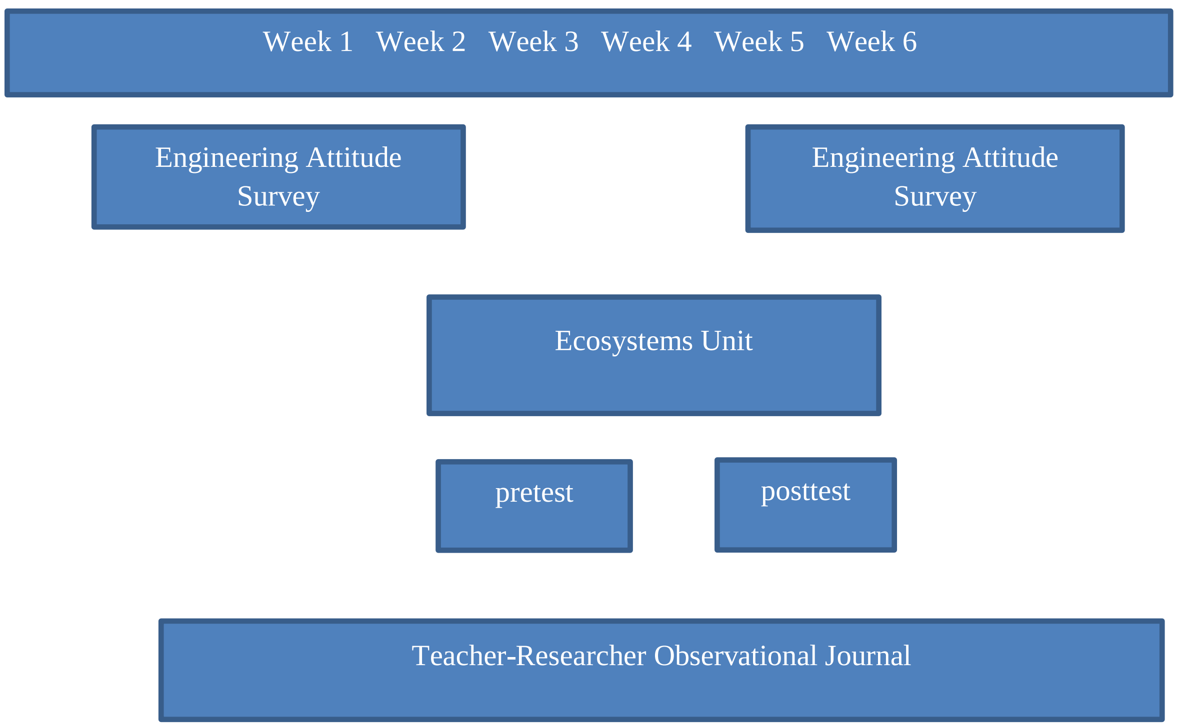
Teacher Name: **Mrs. Cifaldi**

Student Name: ______________________________

| CATEGORY | 4 - Above Standards | 3 - Meets Standards | 2 - Approaches Standard | 1- Below Standard |
|---|---|---|---|---|
| **Drawing** | Provided an accurate, easy-to-read drawing with labels that included the main parts of the instrument. The drawing was done prior to construction. | Provided an accurate drawing with labels that included the main parts of the instrument. The drawing was done prior to construction. | Provided an accurate, easy-to-read drawing with labels that included the main parts of the instrument. The drawing was done during the construction process. | No drawing was provided or it was seriously incomplete. |
| **Construction Materials** | Appropriate materials were selected and creatively modified in ways that made them even better for the purpose. | Appropriate materials were selected. | Most of the construction materials were appropriate, but 1-2 were not. | Construction materials were not appropriate for the purpose. |
| **Quality of Construction** | The instrument shows considerable attention to construction. It is sturdy, neat and will stand up to repeated playing over a period of time. | The instrument shows considerable attention to construction. It is reasonably sturdy and neat and will stand up to being played more than once. | The instrument is neatly constructed but is fragile and will probably not stand up to being played more than once. | Pieces are missing or falling off. Seems \"slapped together\" in a hurry. |
| **Quality of Sound** | Instrument offers a wide dynamic and/or tonal contrast. | Instrument offers some dynamic and/or tonal contrast. | Instrument offers little variety in sound. | Instrument offers no variety in sound. |
| **Critical Attributes** | Student can accurately state whether this is a wind, brass or percussion instrument and point out several features that make it fit in that family. | Student can accurately state whether this is a wind, brass or percussion instrument and point out a few features that make it fit in that family. | Student can accurately state whether this is a wind, brass or percussion instrument. | Student cannot determine what type of instrument s/he built. |
| **Testing/Modification** | Clear evidence of testing and refinements based on data, musical principles or scientific principles. | Clear evidence of testing and refinements. | Some evidence of testing. | No testing or refinements. |
| **Knowledge Gained** | Student can accurately answer 5 questions posed by teacher or peer related to the research, the instrument itself or the process of building it. | Student can accurately answer 3-4 questions posed by teacher or peer related to the research, the instrument itself or the process of building it. | Student can accurately answer 1-2 questions posed by teacher or peer related to the research, the instrument itself or the process of building it. | Student cannot accurately answer questions. |

APPENDIX O

RESEARCH TRAJECTORY FOR ACTION RESEARCH STUDY GRADE 5



APPENDIX P

RESEARCH TRAJECTORY FOR ACTION RESEARCH STUDY GRADE 4