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The Future is Female: STEAM Education Analysis

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by

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DEDICATION

This dissertation is dedicated to all the little girls with ideas in their heads. Kids are the most creative inventors on the planet. They are naturally curious and want to explore the world around them. I hope the future generation of little girls will grow into women who learn to embrace their unique ideas and use them to make the world a better place through innovation.

I would also like to dedicate this dissertation to my family. Dear Mom, Dad, Doug, Colette, Michelle, Mike, Robert, Gabby, Bridget, Dexter, and Brandy, thank you for your love and continued support. You are the driving forces behind me that always encouraged and supported me in my pursuit of being a teacher and a researcher. Most importantly, you were the first ones to believe in my ideas.

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each and every one of my people. Their unwavering support made this work possible.

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ABSTRACT

The purpose of this mixed-methods action research study was to explore the impact of an online Science, Technology, Engineering, Art, and Math (STEAM) Program for young females ages 7 to 10. The researcher sought to understand how females this age internalize the stereotype "boys are better than girls." Especially this idea that boys are better in school when it comes to subjects in STEM (Science, Technology, Engineering, and Math). This study aimed to understand if increasing females' access to STEAM education made an impact on gender stereotypes and mindsets.

This study could be used as a resource for schools developing STEAM programs and curriculum. The STEAM program delivered in this study was online and required "minimal help" from parents. Curriculum design included hands-on science experiments (including clean up) and schoolwork aligned with the Next Generation Science Standards (NGSS), Common Core ELA/Literacy (CCELA), Common Core Math Standards (CCMS), National Core Art Standards (NCAS), Engineering Design Standards (EDS), and International Society for Technology in Education Standards (ISTES). The approach of the action research was through the lens of empowerment theory and feminist theory to engage young females in a deeper understanding of STEAM education.

Keywords: mixed-methods, action research, STEAM education, elementary-aged learners, empowerment theory, feminist theory, cultural, gender-specific role models, challenge-based learning, 5Es, maker-centered learning, diversity, equity & inclusion, growth mindset

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AAUW .... American Association of University Women

BIPoC.. Black, Indigenous, People of Color

BLS .... Bureau of Labor Statistics

CBL .... Challenge-Based Learning

CCELA .... Common Core English Language Arts and Literacy Standards

CCMS .... Common Core Math Standards

CCSS .... Common Core State Standards

CoP .... Community of Practice

CoSTEM .... Committee on STEM Education

COVID-19 .... The Coronavirus

CSA .... Computer Science for All

DCT .... Dual Code Theory

DiP .... Dissertation in Practice

DOE .... Department of Education

EDS .... Engineering Design Standards

ELA .... English Language Arts

ESEA .... Elementary and Secondary Education Act

ESSA .... Every Student Succeeds Act

FLDOE .... Florida Department of Education

ISTES .... International Society for Technology in Education Standards

K-12 .... Kindergarten-12th grade

MCL .... Maker-Centered Learning

NCCAS .... National Core Art Standards

NCLB .... No Child Left Behind

NEA .... National Education Association

NEA .... National Endowment for the Arts

NGSS .... Next Generation Science Standards

NSF .... National Science Foundation

NSTA .... National Science Teaching Association

PBL .... Problem-Based Learning

PBL .... Project Based Learning

PISA .... Programme for International Student Assessment

PK-12 .... Prekindergarten – 12th grade

PoP .... Problem of Practice

PZ .... Project Zero

RISD .... Rhode Island School of Design

RTTT .... Race to the Top

STEM .... Science, Technology, Engineering, and Math

STEAM .... Science, Technology, Engineering, Art, and Math

UNESCO .... United Nations Educational, Scientific & Cultural Organization

USC .... University of South Carolina

CHAPTER 1

INTRODUCTION

According to the Bureau of Labor Statistics (BLS, 2020), science, technology, engineering, and math (STEM) are fields that, historically, have been dominated by males, mainly White males. Despite recent major increases in access to education, gender inequalities persist, particularly in the academic areas of math, science, engineering, and technology. Marcus and Page (2016) stressed that while many beneficial developments have taken place in the area of education, females and their families continue to lose significant opportunities leading to inequalities in the workplace as well as in the wider society. This gender inequity calls for the continuous development of skills and capabilities of females in these areas of education. There is a need to increase females' awareness of their own power to learn, to actively participate in their own learning, to build more self-confidence in their abilities to succeed in these areas of study, and to engage both, girls and boys equally to combat gender stereotypes.

In an effort to engage more pupils in the fields of math, science, engineering, and technology, a new program named STEM was created by the U.S. government to advocate for teachers and schools to begin actively teaching these subjects in more creative and inclusive ways to enhance equity for female and students of color as well (Handelsman & Smith, 2016). In 2009 with President Obama's "Educate to Innovate" Campaign, the goals of STEM were defined and made public for educators and schools to begin implementing policy towards improving STEM participation by students in the United States.

Unfortunately, a problem of practice (PoP) arose when young female students found themselves lacking success in the STEM classroom. As a result, the Next Generation Science Standards (NGSS) created *A Framework for K-12 Science Education* (2011), which included a new conceptual framework for science in grades K-12. STEAM was an update to STEM and now included Science, Technology, Engineering, Math, and the Arts. The philosophy behind this new framework was that students who were taught STEAM in the science classroom were more likely to combat implicit bias and stereotype threats that persisted in STEM subjects for decades (Parker, 2018). However, a review of the PoP literature uncovered an overarching theme in STEAM education: ***The lack of data on the effectiveness of STEAM curriculum and the effectiveness of interventions on the engagement of young female students in elementary school.***

English Language Arts (ELA) and mathematics comprise the Common Core State Standards (CCSS) required for students in schools across the nation. However, social studies and science have their own set of standards and are not part of the CCSS (Drake, 2012; Lambert, 2019; O'Connor, 2014). Nevertheless, science is one of the core academic subjects as outlined by individual state standard boards and the National Science Teaching Association (NSTA), which define science and STEAM as critical for students to make sense of the world through informed decision making processes. The problem in education is that subjects, such as math, ELA, science, and social studies, are usually taught independently from one another when the best way students learn is by combining concepts through real-world context. Hence, the creation of STEAM. The concept of teaching the core academic subjects together is associated with terms such as multidisciplinary, transdisciplinary, and interdisciplinary learning.

In the most recent Programme for International Student Assessment (PISA) rankings, the United States placed 38th in math and 24th in science out of a total of 71 countries. As a result of these low rankings, it became important for the United States to find ways to strengthen education in science and math and, subsequently, student confidence and participation in STEAM fields (Funk & Parker, 2018; Human, 2012). Success in education generates a stronger future workforce (Mace, 2018). The notion is that strengthening science and math education in schools will result in more students pursuing degrees and jobs in those same fields.

Since science and math are oftentimes joined together in interdisciplinary learning, it became a natural place for engineering and technology to integrate into the curriculum and become STEM. When the NSTA released the NGSS Lead States (2013), they included engineering as part of the science education curriculum. This development resulted in many high schools and middle schools implementing STEM programs and as schools further developed existing STEM programs, some transitioned into STEAM to increase student diversity of ideas and engagement (Allina, 2018; Long & Davis, 2017). STEAM programs developed to incorporate holistic education and integrate the arts and promoted creativity and innovation in education (Long & Davis, 2017).

Research on STEAM education found an increased in creativity and problem solving among students, which concomitantly increased students' participation in STEAM: specifically the people who benefit the most from arts integration into STEM were marginalized groups in society, such as females, students of color, and nonbinary students (Heinecke, 2018; Killerman, 2017; Perignat & Katz-Buonincontro, 2019; Pitrone, 2019; Quigley & Herro, 2019).

This dissertation studies STEAM curriculum and integration in science education at the elementary level. As further research develops on STEAM, programs are beginning to integrate into science and STEM programs in schools, many programs shifted from STEM to STEAM because the curriculum focused on encouraging students to take risks, collaborate, and work creatively on solutions (Allina, 2018; Perignat & Katz-Buonincontro, 2019; Weber, 2014). The main difference is the inclusion of the arts into STEM as STEAM provides interdisciplinary art and design so students to apply creativity, design, and innovation into STEM (Allina, 2018; Catterall, 2017; Dangelmaier & Hermann, 2017; Jolly, 2014; Mukherjee, 2018).

The overall goal of the presidential administrations (i.e., Bush, Obama, and Trump) in launching initiatives to address science, technology, engineering, and math in schools has been to better prepare students with the skills required for STEM degrees and the workforce (Department of Education [DOE], 2017, 2018; Eger, 2010; Handelsman & Smith, 2016; Holdren, 2013; Mukherjee, 2018). National policy created an opportunity for schools to improve traditional science education with STEM and STEAM programs (Mukherjee, 2018). An outcome of STEAM education was an increase the number of participants in STEM fields (Handelsman & Smith, 2016; Holdren, 2013). Allina (2018) studied Rhode Island School of Design (RISD) and their work with Rhode Island's U.S. House of Representatives to implement STEAM policy. Questions from policy makers wondered if STEAM was to increase the arts, or to promote science, technology, engineering, and math (Allina, 2018). The Rhode Island U.S. House of Representatives formed a committee to review the purpose of STEAM policy and found that STEAM education increased student engagement, innovation, and better prepared students for a changing world (Allina, 2018).

Rhode Island School of Design applied a STEAM curriculum and found that students began to excel in the field of art or applying the arts to nontraditional fields (Allina, 2018). Through a partnership between the RISD and the U.S House of Representatives, STEAM policy developed sought to center the arts and design in STEM, influence implementation in K-20 schools, and encourage artists and designers in the workforces for innovation outcomes (Allina, 2018).

In 2009, the Florida Department of Education (FLDOE) wrote *Education from STEM to STEAM Preparing Florida's Students to Thrive in the 21st Century* to educating the whole child through STEAM and arts integration. This was the first time educational policy was passed by any state to include STEAM. FLDOE (2009) applied STEAM in educational policy to encourage better quality public schools through arts integration in curriculum. The FLDOE (2009) argued that STEAM education crossed socioeconomic and racial barriers. However, as a practice many educators and administrators seek to understand what a STEAM curriculum is and how to design instruction that will engage an increasing number of learners (Casteel, 2018; Mukherjee, 2018; Negreiros, 2017).

Statement of the Problem of Practice

Courey (2016) explained that females as young as 6 years old internalize the stereotype threat that girls are bad at math and science. The effects of this stereotype threat are that women make up less than 25% of the STEM workforce (Beede, Julian, Langdon, McKittrick, & Doms, 2011). To address the gender gap in STEM, Weist (2014) recommended educators to use gender neutral teaching strategies (e.g., rotating who is called on, equal mixed-gender groupings, incorporate role models, fostering student independence). One reason STEM programs develop into STEAM programs, Catterall (2017) found, was to increase student creativity, empathy, and happiness.

The Every Student Succeed Acts (2015) signed by President Obama wrote a law to mandate funding for public schools PK-12 to provide STEAM education in schools. Catterall (2017) worked with four teachers at STEAM schools and none of them knew how to write or teach STEAM. As STEAM policy from the government began to mandate STEAM curriculum in schools, there is very little data on *how* a STEAM curriculum should be designed by educators and what framework to use for implementation (Catterall, 2017). The academic research on the impact of STEAM curriculum on engagement and achievement, specifically of young female students in elementary school is minimal. Conversely, there are numerous articles that encourage the use of STEAM as a practice for young females to increase engagement over the use of STEM alone (Dangelmaier & Hermann, 2017; DeJarnette, 2018; Eger, 2010). This study was designed to address these problems and sought to understand the impact of a STEAM curriculum on elementary-aged females.

The PoP sought to address the engagement of females in STEAM using a transdisciplinary STEAM curriculum designed to incorporate female role models and cultural representation of women in these fields. A limitation of the study and a contribution to the PoP was the outbreak of the coronavirus (COVID-19) pandemic. Schools closed, which transitioned all educators to online professionals for Spring 2020 and in many places Summer 2020. Students learned remotely from home through distance learning methods. The COVID-19 outbreak resulted in students learning on laptops, tablets, and cell phones. The researcher of this study works in K-6 elementary education and learned through the pandemic that many families did not have a device for their youngest children. The researcher witnessed families scrambling to purchase equipment for their students to attend school virtually. This dissertation was conducted using distance learning and adds to the PoP for this study.

Research Question

Given these problems, this action research study was designed to understand:

1) What impact did an empowerment curriculum, utilizing transdisciplinary curriculum, challenge-based learning and cultural, gender-specific role models have on elementary-aged females' participation and engagement in STEAM education?

The development of the STEAM summer program evolved into a remote, digital summer camp experience due to the outbreak of the coronavirus. Parents and participants were offered to join the program for free and learn about cultural, gender-specific role models in STEAM and conduct interactive synchronous experiments with a group of their peers.

Theoretical Framework

The theoretical frameworks of this study were grounded in empowerment and feminist theories. The literature on empowerment theory came primarily from the fields of education, community psychology, social work practice, and diversity, equity, and inclusion (DEI) work (Kieffer, 1981; Lo, 2005). The literature stressed that power could not be given but rather can encourage individuals, such as teachers, to emphasize competence building and help students recognize their strengths and achieve their fullest potential to be able to control their own life and learning outcomes (Lord & Hutchison, 1993). Empowerment theory focuses on the developmental process through which individuals that possess less access to resources were able to attain education, access, and power through knowledge acquisition (Krajewski et al., 2010). Scholars stressed that this power gave people the ability to influence life outcomes and shape future society, specifically as it applies to this study (Freire, 1970; Gutierrez, Parsons & Cox, 1998; Kieffer, 1981; Krajewski et al., 2010; Rappaport & Hess, 1984).

Empowerment theory was important for this study because, in terms of education and curriculum design, it involved efforts from teachers and administrators alike, to promote gender responsiveness and ensure equitable attention to girls and boys (and the spectrum). Additionally, empowerment theory as a curriculum design in practice encourages active learning among students and the individual perspective that success is a result of effort and not luck (Marcus & Page, 2018; Sterns, Bottia, Savalos, Mickelson, Moller & Valentino, 2016; Turner & Maschi, 2015). The literature on empowerment was appropriate for this study as it also indicates that challenging gender stereotypes through gender-inclusive curriculum and discourse has led to improved learning outcomes for females (Berwick, 2019; Fink, 2015; Weist, 2014).

Similar to empowerment theory, feminist theory aimed to understand gender inequality focusing on gender power relations and the promotion of women's rights and interests (Marcus & Page, 2018; Poorman, 2003; Turner & Maschi, 2015). Beauvoir, in her book *The Second Sex* (1949), wrote that throughout history, the man had been considered the "Default," while the woman had been considered the "Other." Therefore, women have been defined not as themselves, but as relative to men. As a result, women have internalized their position in society as subordinated to the male gender. The argument is that motherhood left women pinned to their body and to the household, leading to their gradual domination based on physiology (Beauvoir, 1949). It was not until the Industrial Revolution of the 19th century and the suffrage movement that women began to demonstrate that it is not inferiority that has determined their historical insignificance, but their historical insignificance that has determined them to be inferior. Feminist theory was important to this study to understand the societal construct of gender as females are taught to be feminine while males are taught to be masculine. Slowly, females at a very young age begin to believe that there are some fields that are only for men (AAUW, 2010; Beauvoir, 1949; Lord & Hutchison, 1993).

Both empowerment theory and feminist theory were ideal as a theoretical framework for this study as they emphasize assets and strengths instead of deficits. These theories inform the academic discourse around reducing gender stereotyping of women in education and society. Additionally, these theories support curriculum focused around a design to increase the engagement of young female students, which encourage rigor, problem solving, forming supportive relationships, and relevance to the real-world (American Association of University Women [AAUW], 2017; Drake, 2012; Katz-Buonincontro, 2018; Krajewski et al., 2010).

Given these basic theoretical tenets, this study aimed to offer young females the opportunity to participate in a free 2-week STEAM program. The program aimed to teach participants the skills to solve STEAM challenges using a transdisciplinary approach, challenge-based learning (CBL) curriculum and encouraged gender-inclusive practices, such as integrating female professionals into the curriculum. In this online learning environment, students were asked to solve problems (i.e., STEAM challenges) using items they could find around the house. Additionally, parents were asked to purchase a few minimal items only if they did not already have them around the house (see Appendix C).

Empowerment theory aims to teach students to trust their strengths instead of focusing on their weaknesses (Perkins & Zimmerman, 1995; Pitrone, 2019). Additionally, the notion of empowerment encouraged young females to trust their instincts, test out a hypotheses, and persist even after failing. Female students learn that the concept of failure is part of STEAM education and not due to their sex or level of ability (Berwick, 2019; Casteel, 2018; Quinton, 2014). Students develop iterations of ideas as a practice in STEAM education and the message to persist occurs with the application of empowerment theory (Pitrone, 2019). Fink (2015) recommended elementary STEAM educators teach students to learn to believe in themselves, which results in students' ability to ideate, reiterate, and persist (Catterall, 2017; Cimpian, 2018; Fink, 2015).

Education for women historically began as something available for the privileged. In the 17th century, Ford (2010) explained women were educated in the arts to keep them in their place instead of empowering them. When women are taught science, technology, engineering, and math in addition to the arts, the dominant structure where women's principal role was to take care of the house and the children was challenged (Ford, 2010)

Empowerment theory applied in this study as a curriculum and taught participants to trust in their own voice and feel confident in STEAM subjects. The application of feminist theory was based on the participant demographics in the program. The researcher worked to understand the impact of a transdisciplinary STEAM-based curriculum on young females. This study was designed to understand the effects young females to determine if curriculum design affected participation and engagement in STEAM. If the data reflected in practice suggested the themes from empowerment and feminist theories, then these results could help other educators and administrators who are working to create transdisciplinary elementary education. Additionally, this study could be used to benefit the STEAM curriculum, pedagogy, and policy to provide greater equity, access, and engagement for all learners, including males and nonbinary students.

Purpose of the Study

The goal of this study was to improve science, technology, engineering, art, and math education for all students through defining and testing a STEAM curriculum for elementary-aged females in an online learning environment. The purpose of this study was to understand the impact of teacher curriculum design on young females' engagement and participation in STEAM. Historically, STEAM subject fields have been male-dominated (Courey, 2016; Weist, 2014). Therefore, this study used the lens of gender-inclusive practices in curriculum design for STEAM education to examine how the interventions impacted young females' engagement and future goals to pursuit science, technology, engineering, art, and math education and potential careers.

This action research study was designed to understand the impact of a transdisciplinary STEAM curriculum on learners, specifically young female participation and engagement. The design aimed to know what impact teacher instructional methods have on involvement in STEAM education. Additionally, this study looked at the effect of STEAM curriculum strategies by designing a 2-week long STEAM program that included a transdisciplinary CBL and gender-specific, cultural, instructional practice, and instructional design methodology. It also explored the correlation between the level of participation and motivation experienced by young female learners ages 7 to 10 years old. In conclusion, the data collected were analyzed to determine how a STEAM program impacted young females' opinions, thoughts, and beliefs about the fields of STEAM.

Overview of Methodology

This study was conducted by a practicing science and STEAM teacher for students ages 7 to 10. Therefore, the researcher applied action research methodology. The methodology design is based on practices designed for working teachers. Efron and Ravid (2013) explained that action research studies include identifying a problem, collecting research, analyzing, implementing, and sharing data. Furthermore, action research studies encourage teacher-researcher studies based on problems in their own community because studies of this type provide immediate feedback and solutions for implementation (Efron & Ravid, 2013). To complete this study, the researcher worked with the University of South Carolina (USC), the Institutional Review Board (IRB), parents, and student participants in an online learning community.

The goal of assessing teacher instructional interventions using an online STEAM-based curriculum was to determine which strategies enhance engagement and mindsets for young females. With this goal in mind, the researcher designed an online learning summer camp 2-week module. The module included a STEAM-based curriculum that incorporated CBL methodology as a teacher instructional strategy to foster engagement and participation. The 2-week module was 16 hours long, which is equivalent to one semester of STEAM classes. At the researcher's school, students attend STEAM one time a week for 16 weeks over the course of one semester.

The study's design used mixed-methods methodology to incorporate both quantitative and qualitative measures to assess the effectiveness of a STEAM program. Student and parent data were collected using Google form surveys. The quantitative methods analyzed student initial and follow-up surveys to identify patterns in the responses. The qualitative measures analyzed parent answers to open response questions on the observation forms and also identified patterns and similarities in participants' responses. Triangulation was used to cross-analyze the patterns in the responses and compare them to one another (Efron & Ravid, 2013).

Student surveys were distributed online to complete the initial and follow-up survey (see Appendix A & B). The study took place in a STEAM program called Inventor's Camp - STEAM Themed where students participated in a curriculum that used empowerment curriculum and transdisciplinary CBL methodology as a strategy designed to engage young females in the fields of science, technology, engineering, art, and math.

Researcher interventions were evaluated using parent observation forms, participant surveys, researcher reflections, and transcriptions of the lessons to analyze effectiveness of the STEAM program. The data analysis method is outlined below. The STEAM program took place over a 2-week period for 2 hours a day for a total of 16 hours. This is equivalent to 1 semester of STEAM classes that meets 1 time each week for 16 weeks. This STEAM program was offered to parents for free and was sponsored by the USC as part of a doctoral dissertation action research study.

The researcher applied open coding analysis to define emerging themes in the qualitative data. Burnard (1991) explained that open coding is when a researcher reads through their material repeatedly and groups together common themes. Initially, the researcher worked with Tetra Insights Software to code the data using the playback feature to watch videotapes of lessons alongside transcriptions repeatedly and color code similar word groupings. Next, the researcher loaded the transcripts into NVivo software, which allowed the researcher to run a word frequency query that autogenerated a list of the most frequently used words from the parent observations, participant surveys, researcher reflections, and the video transcriptions. The researcher classified words, sentences and phrases into similar groupings based on word frequencies to develop emerging themes. This action research study was designed to understand thoughts and perceptions around science, technology, engineering, art, and math and how teachers can impact learners through designing transdisciplinary STEAM curricula, especially those that are designed as cultural, gender-inclusive interventions for young females.

Significance of the Study

This study explored the impact of a STEAM program and its effectiveness on increasing participation in these subjects. Few research studies existed on the effectiveness of researcher instructional interventions and transdisciplinary STEAM curriculum for elementary-aged females. Grant and Patterson (2016) conducted a review of literature published on STEAM to understand arts integration into STEM. Over a 25-year period, they found 38 total publications on STEAM-related papers in PK-20 formal, informal, and unknown educational settings. Only 12 of those articles were based on elementary education and just two of these publications focused on STEAM education in an informal setting (Grant & Patterson, 2016). Informal education was described as museum education, afterschool activities, and summer camp programs.

Using this same approach, the researcher searched the PASCAL Catalog USC Libraries Collection between the 2014-2020 using the keywords STEAM, elementary, education, and informal, which resulted in 38 publications. Upon further review, three of the articles related to STEAM and only two took place in informal settings. One of the articles featured STEAM curricula designed for museum educators, another was a PK program in an early childhood learning center, and the remaining article described STEAM curricula an integration into elementary school classrooms.

Quigley, Herro, King, and Plank (2020) acknowledged that STEAM education for elementary educators is on the rise, but the research and the curricula in this field are lacking. Their goal was to describe authentic problem-based learning units (PBL), also referenced in this study as CBL, to engage students in the process of inquiry through a transdisciplinary approach (Quigley et al., 2020). "In this way, students move beyond one correct way to solve a problem, towards an approach that integrates different solutions and perspectives," (Quigley et al., 2020, p. 500).

This action research study specifically focused on elementary-aged females learning STEAM in an informal setting described as an online summer camp program. The STEAM curricula implemented in this program used a transdisciplinary and CBL design to cultivate creative thinking, multiple solutions, and focus on the process of problem solving. While many studies demonstrate young females initially stop participating in science and math during elementary schools, research studies mainly focused on the effects of STEAM education at the college, middle, and high school level

(Damour, 2019; Khazan, 2018; Venditto, 2018). This study aimed to contribute to the academic research narrative, development, and evolution of STEAM from the perspective of an action researcher. This study is classified as phenomenological research, which is when participants all shared a similar lived experience (Creswell & Creswell, 2018). The shared experience was learning during quarantine.

There is a national movement for schools across the nation to implement STEAM programs to provide better quality education for students in schools PK-college (NGSS, 2013; Quigley et al., 2020; Smith, 2016). However, studies indicated that in elementary school boys continue to outperform girls in science and math on standardized assessments (Clewell & Ginorio, 2002). Data have demonstrated that the first noticeable differences in science based on gender appear in the third grade and then again in the eighth and 12th grade, and that progressively, more females lose interest the older they become (Anthony & Ogg, 2019; Clewell & Ginorio, 2002; Digiovanni & Liston, 2004; Huhman, 2012).

The outcome of COVID-19 left many students home in social isolation learning from a distance. In 2020, the school year ended online for many students across the United States. Additionally, summer camps were canceled across the nation, and many parents were looking for activities for their children. Given this situation, this action research study aimed to offer a STEAM program to engage and educate young females about this field. As a result, the researcher worked to understand how an online STEAM program using transdisciplinary, CBL, and cultural, gender-specific practices impacted young females. Phenomenological research aimed to identify the statements participants make that support or debunk the stereotype that boys are better than girls (Creswell & Creswell, 2018).

Limitations of the Study

The study was limited in terms of student sample size (*N* = 10) and time constraints (2 weeks for a total of 16 hours). While 15 females attended the program, 10 came to every session. These participants and parents surveys were gathered and analyzed for this dissertation. The study took place with elementary students ages 7 to 10 years old. The sample size reflected results aimed at young females studying STEAM in an online summer program.

These limitations explain the purposeful intent of the study and ask that researchers using this information avoid overgeneralizing results for college-aged students as an example. Efron and Ravid (2013) explained that action researchers create effects on the given sample participating in the study, and in this case, the sample is limited by age, gender, and subject. This study, therefore, provided a starting point for researchers wishing to conduct more rigorous future studies in these areas.

Another limitation was the outbreak of a pandemic resulting in the shutdown of in-person learning for many students. The outcome was a pivot from an in-person program over the course of a semester (16 weeks for a total of 16 hours) to an online program that met for the same amount of time (16 hours). The online component limited the researcher's ability to gather student data, such as, work samples from every child.

A further limitation was the limited availability of research on STEAM programs, curricula, and workforce data. Specifically, research that focused on elementary STEAM education in informal settings limited the researcher's ability to document STEAM alone.

Consequently, this dissertation in practice (DiP) includes related information, facts, and statistics on science and STEM education, programming, policy, and workforce data.

Lastly, the researcher was limited by her perspective as a science educator. Her own bias to engage and increase the amount of women in science, STEM, and STEAM influenced the research, curriculum design, and outcome of this program. The STEAM program at the researcher's school was implemented within an elementary science department. The focus for funding and parent support has been to engage students in STEM through arts-integration. The perspective of a scientist-teacher-researcher influenced this study.

Dissertation Overview

This dissertation is divided into five chapters to address the application of STEAM as an area of pedagogy where students are presented with challenges and are engaged in intentional play and risk using a transdisciplinary approach to learning. It also addresses the issue of PoP that emerged in the effectiveness of this area of study by failing to attract female students; therefore, the further development of STEAM, which includes the arts, to encourage student participation and empowerment (Allina, 2018). This research study assessed the effectiveness of CBL and cultural, gender-inclusive practices as two major components of a STEAM curriculum. The study evaluated the impact on females ages 7 to 10 participating in an online summer camp called Inventor's Camp – STEAM Themed.

Chapter 1 provides the nature and significance of this problem. Important information is provided about the need for and the purpose of this study. It also provides an overview of the historical gender inequalities concerning the participation of females in the areas of STEM. This chapter also emphasizes the need to contribute to the body of academic research on STEAM, to offer an effective, online teacher curriculum for implementing STEAM using a transdisciplinary approach. This chapter presents a theoretical framework, STEAM-based instructional interventions, such as CBL and gender-inclusive practices, and research in support of the curriculum.

Chapter 2 presents the literature review and key findings that indicate why the pattern persists where women avoid STEAM fields. Specifically, from early childhood, many women internalize the perception, and thus the stereotype threat, that STEAM jobs are for the men. Therefore, this study used empowerment and feminist theories to ground this work. These theories provide a research-based context to inquire and study the reasons and concerns for gender stereotypes. Additionally, theories explore interventions that may improve learning outcomes in access to education in STEAM fields.

Chapter 3 explains the action research methodology designed for this mixed-methods study. It describes the data collection instruments and discusses how the theoretical frameworks guided this study. It provides descriptions of the instruments used to collect data and the development of these tools. Finally, this chapter ensures the methodology is in accordance with IRB research standards for the safety of the human subjects (i.e., children that participated in the study).

Chapter 4 presents the analysis of the data collected in this study, an overview of the effectiveness of the STEAM curriculum, and the effects of the interventions on the participants in this study ages 7 to 10. It presents an explanation of the STEAM curriculum and interventions designed for this study. Detailed analysis and description of the results are shared in Chapter 4.

Chapter 5 ends with a conclusion, implications, and recommendations for further studies. It also includes recommended practices for STEAM educators, administrators, museums with STEAM/Makerspaces, and any individuals who design curriculum for elementary-aged children.

Definition of Terms

For purposes of this study on STEAM education and student participation and motivation, the following terms are defined as follows:

Action Research: Practice-based research by an educator in the field of pedagogy aimed to improve student learning (Efron & Ravid, 2013).

Challenge-Based Learning: A problem presented by a teacher to the class, whereby, together students develop possible solutions and outcomes. Students are given time to collectively problem solve, test, and redesign solutions (Johnson et al., 2009).

Dual Coding Theory: Presenting information to learners using a variety of methods such as, verbal, visual, kinesthetic, or engaging senses (Driscoll, 2005).

Empowerment Theory: Study and explanation of oppression through the lens of status and power, and finding ways to combat the oppressive forces (Turner & Maschi, 2015).

Engagement: Student investment and participation to learn the content of a given lesson (Bender, 2017).

Feminist Theory: Study and explanation addressing the inequality and oppression between males and females, not limited to education, but also including the workforce, society, and voting (Hekman, 1997).

Gender Equity: Practices used to close the gender gap and ensure equal educational outcomes for both men and women (UNESCO, 2015).

Measures of Gender Equity in Education: Classification of measures of educational equity into five categories: Meritocracy, minimum standards, impartiality, equality of condition, and redistribution (UNESCO, 2018).

Mixed-Methods Research: Researchers using both quantitative and qualitative data collection methods in their study (Mertler, 2017).

STEAM-Minded: The disposition to be curious, ask questions, take educated risks, and enjoy experimenting and trying different solutions to problems (Lockwood, 2020).

Transdisciplinary Curriculum: An approach to ground the curriculum in real-life contexts, PBL, and engage students to ask questions and conduct research (Beane, 1993, 1997; Drake, 2012).

CHAPTER 2

LITERATURE REVIEW ON SCIENCE, STEM, & STEAM

Overview of Study

This action research study explored STEAM curriculum strategies to understand the impact on engagement and participation in these subjects. Studies have found successful curriculum design for gender-inclusion incorporate presenting students with challenges or problems to try to solve and provide students the opportunity to share their ideas and possible solutions (Bryk, 2014; Bulls, 2018; Casteel, 2018; Courey, 2016; Quigley et al., 2020; Snow, 2014; Weist, 2014; Yager, 2014). Therefore, this study combined these interventions into transdisciplinary STEAM curriculum design to increase engagement and achievement.

Many researchers focused on STEAM are working to understand the transdisciplinary nature of the approach and the ways it motivates girls (Casteel, 2018; Courey, 2016; Damour, 2019; Hand, 2017; Khazan, 2018; Noonan, 2017; Quigley et al., 2020; Venditto, 2018; Wiest, 2014; Wyss, Huelskamp, & Siebert, 2012). This study aimed to contribute to the body of research in STEAM education by developing curriculum and instruction that engages female students to pursue science, technology, engineering, art, and math education and related jobs as a result of early interventions of a STEAM program designed for young females. Data collected in this study were analyzed to determine the correlation between gender-specific STEAM-based transdisciplinary interventions and the effects on perceptions and engagement.

This chapter demonstrates the effects of STEAM integration into educational settings. The literature review explores existing research surrounding STEAM education as it relates to engaging students in learning science, technology, engineering, art, and math. Additionally, this research details the historical importance of closing the gender gap in science and what steps educators could take to advocate for equity and access using a gender-specific transdisciplinary STEAM curriculum design. Given these findings, the goal of this study was to understand the impact of instructional design on engagement and participation in STEAM.

Literature Review

This literature review examined the historical patterns of participation in science, technology, engineering, art, and math. To begin, the literature review applied the theories used in this study that explain gender and empowerment. A historical perspective was provided, including the development of educational standards and government policy. Also, data on women in STEAM education and the workforce were gathered and shared to understand the pattern and persistence of a gender gap. The movement from STEM to STEAM was detailed to demonstrate the importance of the preference for STEAM education when addressing gender-inclusive practices. The STEAM curriculum includes, CBL, project-based learning, PBL, and maker-centered learning (MCL). Finally, the literature review concluded with information about the importance of role models, early intervention, growth mindset, and gender questions (i.e., boys and STEAM, and gender as a spectrum versus binary).

Below is a list of the topics included in this theoretical framework:

1) Historical Significance
2) Standards and U.S. Government Policy
3) Education and Workforce Data
4) The Gender Equity Gap
5) Equity in Science and STEAM
6) STEM vs. STEAM: What is the Difference?
7) Why is STEAM Important?
8) STEAM Curriculum Design: Transdisciplinary CBL
9) CBL Integrated with Peer-to-Peer Learning
10) Project-Based Learning (PBL) and MCL
11) Gender-Specific Role Models
12) Early Intervention
13) Growth Mindset
14) Gender-Inclusivity: What About the Boys?
15) Nonbinary: Gender as a Spectrum

Historical Significance

Data on females in education and the workforce in STEM reveal that men continue to dominate these fields (Beede et al., 2011; Ignotofsky, 2016; Noonan, 2017). Year after year, the data show slow, incremental progress for women in science. Women who pursued careers in STEM fields continue to remain a minority in the workforce and educational settings, such as K-12+ schools (Beede et al., 2011; Ignotofsky, 2016; Marcus & Page, 2016; Noonan, 2017). At the same time, for the past 20 years, the United

States has scored mediocre on global science and math assessments. The National Assessment of Educational Progress reports that since 1990, the United States consistently scored below 20 other countries on science, math, and reading tests. The measurement used to gather this data is called the Programme for International Student Assessment (PISA) and is applied globally every three years to participating countries around the world. National policy and state policy in the United States began to address this achievement gap by providing funding for STEAM education (Allina, 2018; Cunningham & Berger, 2014; Harrell & Harrell, 2010). Based on these initiatives, school administrators in individual schools, entire districts, and some states began to implement STEAM-based practices in their schools versus science, or STEM (Cunningham & Berger, 2014).

Due to this creativity, these instructional strategies and design in student learning engaged more students, specifically females and minorities, to participate in class (Cimpian, 2018; Heinecke, 2018; Jamalian, 2018; Jolly, 2014; Quigley et al., 2020). Jolly (2014) described the A in STEAM as a focus on design, performing arts, and creative planning as it applies to solve a science problem or challenge. Jolly (2014) reported on the experience of Ruth Catchen, a STEAM teacher in Colorado, who found that when she incorporated the arts as a design approach for student communication of their ideas and iterations, she witnessed a growth in engagement from her underrepresented students (females). Ruth Catchen embodied empowerment theory as a curriculum by demonstrating to students their ability to attain education, access, and power through knowledge acquisition (Krajewski et al., 2010).

In order for underrepresented students to overcome such barriers, government policy began to change and incrementally, schools changed too (Carmichael, 2017; Holdren, 2013; Tanenbaum et al., 2016). Former President Barack Obama generated many initiatives to address the gender equity gap in the sciences. As the keynote speaker at the National Academy of Sciences on April 2013, President Obama said, We want to make sure that those who historically have not participated in the sciences as robustly – females, members of minority groups here in this country – that they are encouraged as well. Feminist theorists aim to understand gender inequality and promote women's rights and interests (Marcus & Page, 2018).

His efforts and policies were integrated into schools across the nation. Under the president's administration, Tanenbaum et al. (2016) listed initiatives that impacted science education, such as Race to the Top (RTTT), Change the Equation, Educate to Innovate, Committee on STEM Education (CoSTEM), Computer Science for All (CSA), Elementary and Secondary Education Act (ESEA), and Every Student Succeeds Act (ESSA). The Office of Science and Technology Policy issued a press release on December 4th, 2018 stating that the current president planned to spend $200 million dollars on STEAM education specifically, including the support of initiatives for women.

The past three presidents released major initiatives to increase science, technology, engineering, and math education in our nation, which resulted in 68% of states passing policy focused on STEAM and STEM education (Carmichael, 2017; Eger, 2010). *No Child Left Behind* (NCLB) under President George W. Bush declared math and reading were the subjects to be tested on standardized assessments (Lee, 2019). Science, STEM, and STEAM were not subjects federally mandated for standardized testing in elementary education. This distinction between subjects to be tested meant that teachers were given the freedom to design STEAM curriculum without worrying about standardized test results.

In 2009, Florida became the first state to acknowledge STEAM and the impact on elementary-aged students. Duval Elementary School in Florida implemented a STEAM program on limited resources and improved student achievement (FLDOE, 2009). Prior to the start of the program, the school ranked F and after 1 year of operating as an elementary STEAM school, the school ranked A (FLDOE, 2009). Duval Elementary School described their implementation of STEAM as "infusing the arts into math and science and technology to improve student learning" (Gainesville, FLDOE, 2009).

This study aimed to understand the impact of implementing a STEAM program similar to Duval Elementary School that fosters the arts into STEM as "a balanced curriculum that educates the whole child" (Gainesville, FLDOE, 2009). While STEAM curricula evolves, empowerment theory and feminist theory connect through educational practices that inspire marginalized students to participate, solve challenges, and reclaim power over their own education (Turner & Maschi, 2015).

Standards and U.S. Government Policy

According to the CCSS website, these standards only applied to ELA, Literacy (Reading), and Mathematics for students in grades K-12. The CCSS were developed as part of NCLB (2001) under President George W. Bush and implemented in schools to determine success and funding (Lee, 2019). O'Malley (2012) explained that the NCLB administered tests to schools to determine ranks for each student as basic, passing, proficient, or advanced. O'Connor (2014) shared that the CCSS did not include science, STEM, or STEAM in terms of outcomes or assessments but did emphasize writing as part of the science curriculum. When the CCSS were first published, 45 of the 50 states adopted the CCSS to receive additional funding for their schools (Turano, 2018).

While NCLB exempted science, STEM, or STEAM from being subject to standardized assessments, it acknowledged the importance of formative instruction in schools. Since schools, teachers, and districts did not have a nationwide assessment like math and English, many science teachers and programs experienced more freedom in developing curriculum and instruction. Payo and John (2016) shared that state-by-state policies on science standards were largely individualized until the development of *A Framework for K-12 Science Education* in 2011 and revised in 2012 and 2013. The framework was published by the NSTA. This framework included a conceptual guideline of science learning objectives and outcomes for teachers and schools.

According to the NGSS website (2019), the framework emphasized science, engineering, and technology education for students from kindergarten through high school. Next Generation Science Standards website (2019) re-released the NGSS Lead States (2013) to include engineering design for grades K-12 with direct links to the Common Core Standards in Math, Literacy, and supported the integration of STEAM-based, transdisciplinary curriculum into education.

The development of the NGSS stated the importance of integrating engineering into grades K-12. The NGSS published standards that encouraged schools to start teaching STEAM-based practices and curriculum in grades as young as kindergarten. Hand (2017) explained that the importance of early intervention of STEAM-based teaching strategies made a larger impact on student achievement and engagement. The historical significance of the NGSS update, was that it made engineering part of STEAM-based standards of instruction in schools K-12. These actions declared engineering under the umbrella of science education. The NGSS Lead States (2013) update provided teachers with a framework for teaching science and the STEAM curricula (Payo & John, 2016). The evolution of the standards in science education demonstrated an interconnection between policy and curriculum. Teaching standards changed when the government-mandated change through policy (Payo & John, 2016).

Another example of science and art integration and transition into STEAM developed out of a collaboration between the National Endowment for the Arts (NEA) and the National Science Foundation (NSF) and their work to understand the intersectionality between science, art, computer science, and engineering (Harrell & Harrell, 2010). The NEA and NSF findings supported the increasing use of STEAM in K-20 education through integration of the arts into science education. Additionally, they recommended the practice of iterative evaluation models for assessment in STEAM (Harrell & Harrell, 2010).

As states worked to develop and implement new policy, NSTA (2019) found the implementation of new programs and standards, such as the NGSS Lead States (2013), were slowly integrated into schools. According to the NSTA (2019), the NGSS Lead States (2013) was implemented in 20 of the United States. Turano (2018) explained that not all of the United States updated NGSS because of two main reasons that had nothing to do with the engineering, but that other updates in the standards deterred certain states: First, schools did not receive money to update their NGSS, unlike when the CCSS were implemented, and schools received funding for implementation. Second, controversial topics, such as evolution and climate change, kept certain states from adopting the new science standards. Researchers found that many states wrote their own version of the NGSS and updated their own version of science state standards (Turano, 2018).

Lambert (2019) described how the state of Maine adopted the NGSS Lead States (2013) and gave schools transition time and offered teachers the summer to adopt the new standards and curriculum. Additionally, the state of Maine offered professional development and online resources for teachers and schools to use while transitioning and continuing into the school year (Lambert, 2019). Maine explained one of the reasons they chose to implement the NGSS Lead States (2013) was because of the three-dimensional nature of the standards that promoted students doing science over passively listening to lectures (Lambert, 2019). The state of Maine set a precedent for states to adopt the NGSS. They allowed teachers and schools time and resources to transition. ESSA was updated in 2015 to include STEAM and the integration of arts into STEM, which resulted in states' ability to provide funding and resources for STEAM education (Tanenbaum et al., 2016). These were necessary action steps for schools to ensure the resources for implementing STEAM-based education.

The Race to the Top Initiative (RTTT, 2010) aimed to pair local businesses, museums, and institutions with schools to develop collaborative, localized learning opportunities for students. In order to help the government define STEAM education practices and policies, partnerships were formed between the DOE, the National Science Foundation (NSF), NEA, and the Smithsonian Institution (Harrell & Harrell, 2010; Holdren, 2013).

Agencies across the nation joined together to understand and develop STEAM education. Holdren (2013) called these back-and-forth between institutions, foundations, governments, and schools communities of practice (CoP). CoP was becoming increasingly important in STEAM education to provide mentors and examples for students to meet role models, specifically women, minorities, and those traditionally disenfranchised in the sciences (Tanenbaum et al., 2016). Casteel (2018) and Hmelo-Silver (2004) found that using female role models yielded a great amount of success to reinforce understanding through transdisciplinary STEAM curricula. Harrell and Harrell (2010) described STEAM as a gamechanger in the ability to provide access and participation for students to create innovations beyond rote classroom exercises. STEAM curricula used empowerment theory and feminist theory in educational practice as a means to inspire and engage marginalized students to participate, solve challenges, and reclaim power of their own education (Turner & Maschi, 2015).

Under President Obama's Administration and continuing on into the Trump administration, the success of women and minorities through STEAM programs, encouraged more states to integrate STEAM into curriculum. Florida, Ohio, and New York were among the first states to implement STEAM (FLDOE, 2009). Carmichael (2017) directly linked the government initiative RTTT (2010) with the increase of STEAM in public schools across the nation. Many states after RTTT began to implement this initiative with different teacher instructional methodologies that taught science, technology, engineering, and math with arts integration to create STEAM (FLDOE, 2009). Carmichael (2017) explained that Rhode Island passed legislation after their collaboration, research, and findings on STEAM. Together they defined the A in STEAM as art *and* design (Allina, 2018). Other states followed suit, such as Maryland, North Dakota, Washington State, and incrementally, K-20 education began to update their curriculum to include STEAM (Allina, 2018; Carmichael, 2017). As a state, North Dakota also defined STEAM in its educational policy documents as science, including creative problem solving, project-based learning, integrated curriculum, and student-centered learning (Carmichael, 2017). Historically, Florida, Rhode Island, and North Dakota were among the first states to legislate STEAM and mandate statewide change in science curriculum (Allina, 2018; Carmichael, 2017).

The state of South Carolina's DOE promoted STEM and STEAM, but did not distinguish between the two for educational purposes or implementation (Carmichael, 2017). At the time this study was conducted, states determined how to implement better quality elementary education, whether that meant adding STEAM or STEM through state policy; however, research studies on how to implement STEAM curricula are sparse (Quigley et al., 2020). National policy encouraged STEM or STEAM to update elementary education, but it was not nationally mandated (Carmichael, 2017). It was up to each state to decide how to improve their existing elementary education programs.

Negreiros (2017) explained that teachers in STEAM schools believed in policy reform, out-of-the-box curriculum, and transdisciplinary teaching. STEAM strayed from the traditional approaches to education that taught subjects in isolation (Harrell & Harrell, 2010). Concordia University (2017) published findings that the STEAM-based curriculum broke away from the traditional approaches in science education to foster innovative education and better prepare students for the real world. For a curriculum to be considered STEAM-based and integrated, Tanenbaum et al. (2016) explained that the curriculum should connect science, technology, engineering, art, and math through transdisciplinary learning.

Teachers implementing STEAM curriculum reported student gains in their ability to problem solve and collaborate (Casteel, 2018; Negreiros, 2017; Quigley et al., 2020). In order for schools to provide better quality STEAM education, Cornell and Hartmann (2007) recommended social change and advocacy work to implement a new plan of action in education. In support of this claim, Negreiros (2017) found that teachers working in STEAM schools began to promote policy reform and advocate for funding. They lived and experienced the positive side effects of teaching STEAM: higher quality science education through arts integration (Negreiros, 2017). Additional researchers found that STEAM education resulted in increased engagement, motivation, and hands-on learning (Casteel, 2018; Handelsman & Smith, 2016; Harrell & Harrell, 2010; Quigley et al., 2020; Yager, 2014).

Education and Workforce Data

Holdren (2013) reported research from a PISA study found 12 countries that scored higher than the United States in science, and 17 countries scored higher in math. Women overall were largely underrepresented in STEM education and the workforce. Women made up almost half of the overall workforce and less than 1 in 5 graduates (Holdren, 2013). Negreiros (2017) found that science and math teachers reported the lowest retention rate in K-12 schools. Further data gathered from Ignotofsky (2016) detailed the gender gap in science and STEM as follows:

1) 2011 total workforce by gender: 48% women, 52% men = 4% gender gap.

2) 2011 science and engineering graduates: 39% women, 61% men = 22% gender gap.
3) 2011 STEM workforce: 24% women, 76% men = 52% gender gap (p. 84).

The largest gain women made in the STEAM workforce between 2011-2019 was in the field of life, physical, and social sciences. The BLS (2019) reported that women comprised 46.7% of the workforce in these fields. However, the BLS (2019) found that jobs dominated by women were nursing, elementary and middle school educators, administrative assistants, and cashiers; none of which classify as part of the STEAM workforce.

Noonan (2017) explained that even when women graduated with a STEM degree, there was no guarantee that they would actively pursue a job in this field. Researchers reported that there was *no* change between 2011 and 2017 in the gender equity gap in traditional science education in the United States (Noonan, 2017). Educational policy in Florida, Rhode Island, and North Dakota explored the notion that STEAM education would directly impact the workforce and retention rate, but Beede et al. (2011) and Noonan (2017) pointed to data that reported a holding pattern in the gender equity gap (Allina, 2018; Carmichael, 2017). Rhode Island STEAM policy advocated for encouraging companies to employ artists and designers as a direct result of the governments' partnership with RISD (Allina, 2018). This is one reason why this study was designed: to determine the impact of the STEAM-based curriculum on student engagement and participation in order to understand the effects on the gender equity gap in elementary education.

The Gender Equity Gap

Ralph W. Tyler, researcher and teacher, found that designing and writing curriculum based on the learner helped to close achievement gaps (as cited in Flinders & Thornton, 2018). Tyler explained that education is a process of changing the behavior patterns of people (Flinders & Thornton, 2018). This notion of changing behavior held true during this study. Clewell and Ginorio (2002) reported that many science texts continued to portray a male-dominated curriculum. The practice of teaching about male scientists and the absence of female scientists continued in schools and curriculum across the nation (AAUW, 1997, 2017). Tyler argued that to improve schools and set educational objectives, behavior patterns that maintain a male-dominated scientific society had to change in order to close the gender equity gap in STEAM (Flinders & Thornton, 2018).

Beede et al. (2011) determined that gender stereotyping, combined with the lack of female role models resulted in a gender equity gap in science. Year after year, women continued to make up less than one-quarter of the STEM workforce (Beede et al., 2011; Noonan, 2017). Even when women graduate with STEM degrees, they were more likely to take jobs as educators and social scientists, which were not considered part of the STEM workforce in the U.S. Census Data reported (Beede et al., 2011; Noonan, 2017). Researchers explained that many women choose to leave the STEM workforce because of the lack of flexibility in the field for working mothers. Many women preferred to take jobs that offered them flexible hours and the ability to set their own schedules (Beede et al., 2011). Feminist theorists work to address inequality and oppression of women in the workforce (Hekman, 1997).

STEAM education encourages students to pursue innovative careers in this field (Allina, 2018; Harrell & Harrell, 2010). However, at a very young age, Anthony and Ogg (2019) found that female participation decreased in STEAM education beginning in elementary school. Advocates of gender equity practices argued that the introduction of a STEAM curriculum encouraged student participation and engagement for marginalized groups, such as females (Anthony & Ogg, 2019; DeJarnette, 2018; Hunter-Doniger, 2018).

Cimpian (2018) found numerous data on achievement gaps for females in science education. Government policies and initiatives attempted to impact the gender equity gap by implementing a STEAM-based curriculum in schools (Beghetto & Baxter, 2012). The AAUW (1992, 2017) explained that while policies ensure schools work towards closing the gender equity gap in male-dominated fields, such as science. Stearns et al. (2016) found that female teachers have the strongest impact on young females choosing to pursue STEAM education.

Tuner and Maschi (2015) defined feminist theory as a woman's experience within society and Stearns et al. (2015) demonstrated the power of feminist theory in relation to STEAM when the teacher is female. The researcher in this study was female and a led a group of elementary-aged females through a STEAM program in hopes to increase their engagement and participation in this field.

Venditto (2018) also discovered that starting as young as 6 years old, girls began to vocalize that boys were better in science and math. The research has repeatedly demonstrated how starting at an early age, young children internalized stereotypes and believed that males were better in science than females. One solution Venditto (2018), Fink (2015), and Tomlinson (2018) found to address stereotype threat was that early intervention allowed teachers to encourage excitement and creativity in students. Empowerment theory and feminist theory were applied in this study to understand the role of cultural, gender-specific role models in to address engagement and systemic oppression of women in STEAM (Turner & Maschi, 2015).

No data existed that demonstrated a gender equity gap in grades K-2; however, females began to develop a drop-in self-esteem around 2nd and 3rd grade, which impacted achievement and engagement in school (AAUW, 1992, 2017; Cimpian, 2018). Female students internalized stereotypes and implicit bias within society when science curriculum and textbooks deliver the message that their lives and contributions are less than men (AAUW, 1992, 2017). As young females transitioned through K-12th education and progress to college, at each sequential level, females participate less in STEAM education (Beede et al., 2011; Noonan, 2017; Venditto, 2018). Researchers explained that young women are more likely to choose fields where they did not have to combat stereotypes and implicit bias. Instead, they opted for jobs and education where female role models were primarily portrayed (Venditto, 2018). Feminist theorists would argue this is a systemic oppression of women in STEAM education and the workforce (Digiovanni & Liston, 2004).

Equity in Science and STEAM

Casteel (2018) and Berwick (2019) shared a study in the 60s and 70s, revealing that when students were asked to draw a scientist the majority of students drew pictures of male scientists (not a single boy drew a woman scientist). When the study was repeated in 2009, 35% of kids drew women (Casteel, 2018). The increase of students recognizing women as scientists were attributed to STEAM education that incorporated female role models, collaborative learning, and CBL transdisciplinary approach (Berwick, 2019; Casteel, 2018; Courey, 2016; Holdren, 2013; Quigley et al., 2020). This research stressed the need to address the gender equity gap in the sciences in order to increase the presence of women, and their recognition, in STEAM (Mace, 2018). Thornton Dill (1994) explained that feminist theorists advocate for all-inclusive practices in education, such as including women in the text.

Cameron, Daga, and Outhred (2018) authored a historical account of equity in education from around the globe on behalf of the United Nations Educational, Scientific, and Cultural Organization (UNESCO) and titled their work, *The Conceptual Framework for Measuring Equity in Education*. Overall, the goal of the report was to globally impact gender equity in both formal and/or informal educational settings. Researchers recommended that measures of educational equity can be classified into five categories: meritocracy, minimum standards, impartiality, equality of condition, and redistribution (Cameron et al., 2018). The report described inequity from varying standpoints: input, process, outcome, and context. Cameron et al. (2018) expanded the idea of the curriculum from what was taught to include the outcome of *how* students applied *what* was being learned in school. This action was relevant to ensure that females and males were afforded equal opportunities in education; in other words, the *why* equity of opportunities was a necessity in education. As it applied to this study, UNESCO's equity defined an educational curriculum as the *how*, the *what*, the *why,* and the effects of the curriculum to aid in the development of closing the gender gap in the sciences.

Dangelmaier and Hermann (2017) argued that the language around science as a male-dominated field should change to demonstrate that science without women was more dangerous. “If we wish to advance our evolutionary journey as a species, a shift from feeling sorry for the disadvantaged to STEAM without their perspective is imperative,” (Dangelmaier & Hermann, 2017, p. 1). One such example of an invention without the input of a female perspective was the invention of the airbag. Automotive engineers were predominantly male and the invention of the airbag did not take into account the size of a female or a child when first created, tested, and put into use in cars across the world (Nietner, 2017). As a result, females were injured 47-71% more than males in the same type of car accident (Nietner, 2017).

It took 20 years after the airbag was invented before female crash test dummies were instituted as policy mandated usage to test cars in the United States (Nietner, 2017). Asked by ABC News why car makers did not take the female physiology into account when testing vehicles, Dr. David Lawrence, director of the Center for Injury Prevention Policy and Practice at San Diego State University, replied, “Manufacturers and designers used to be all men. It did not occur to them that they should design for people, unlike themselves,” (Nietner, 2017). The lack of a female perspective in automotive engineering resulted in the injury of many women and children over 2 decades until policy mandated the testing with female crash test dummies. This anecdote demonstrates the importance of taking into account the perspective of women in STEAM as significant to the creation of new inventions that benefit all individuals in society, and not just males. The lack of a female presence in the field of engineering revealed what happens when women were not present in the design process.

Dangelmaier and Hermann (2017) explained the discourse from keeping up with the boys needed to change to "What happens to our society when the voices of women and girls are absent?" The former statement placed females in a position of the oppressed and the disenfranchised, whereas the latter statement placed women in an empowered stance. This study used empowerment and feminist theory to address the discourse in STEAM and argued for the inclusion of equitable teaching practices as a means to address systemic oppression of those marginalized in the workforce (Quigley & Herro, 2019).

STEM vs. STEAM: What is the Difference?

STEM stands for Science, Technology, Engineering, and Math, and STEAM includes the arts, creativity, design, and the performing arts (Jolly, 2014). Since states are slowly introducing STEAM policies, many schools are taking independent action to implement programs and curriculum. Heinecke (2018) explained that the way teachers used art in STEAM varies based on the interpretation of each teacher. The interpretation is varied and vague because the NGSS Lead States (2013) detail *what* students are to achieve, but do not detail *how*. As schools transition from science and STEM to STEAM, many teachers are encouraged to use hands-on activities, CBL, arts integration, and collaborative learning opportunities for all students (Harrell & Harrell, 2010; Quigley et al., 2020). The curriculum designed in this study aimed to inspire females in STEAM grounding this work in feminist and empowerment theory (Digiovanni & Liston, 2005; Parker, 2018).

Jamalian (2018) explained that many educators choose to implement STEAM because it fostered arts-based pedagogy to teach science, which engaged more females and minorities in science. STEAM pedagogy taught students problem-solving skills in collaborative settings. Introducing a STEAM-based curriculum encourages meaningful learning and fosters students to make connections to the world around them (Quigley & Herro, 2019). When schools change the type of science curriculum provided to students by integrating STEAM education, teachers report improvements in student engagement and achievement (Gopal & Pastor, 2015). The AAUW (2017) stated the effects of increasing student collaboration time with other classmates and allowing them time to build connections to resulted in an increase in empathy towards one another. The benefits of shifting from science to STEM to STEAM result in an increase in engagement and empathy.

Why is STEAM Important?

Long and Davis (2017) found that STEAM education was important in society because of the innovation and creative problem-solving skills it promoted in students. Anthony and Ogg (2019) demonstrated that STEAM fostered understanding of science in terms of real-world applications. The use of A in STEM, including the arts, creates empowerment for the learner through the act of problem solving and creativity (Jamalian, 2018). Additionally, research that suggested STEAM encourages collaboration, a broad interpretation of the arts, and an increase in female participation and engagement (Mace, 2018). STEAM education incrementally impacted the gender equity gap in the STEM workforce by changing the way women perceive subjects such as science, technology, engineering, art, and math (Mace, 2018). An outcome of the RISD implementing STEAM at the college level resulted in graduates that excelled in traditional arts practices or in nontraditional fields applying their artist perspective (Allina, 2018). The RISD

STEAM curriculum fostered innovation through use of an empowerment curriculum that taught learners skills to recognize and use choice, ownership of ideas, and accountability for their education (Allina, 2018; Collins, 1991).

Collins (1991) explained that oppression was an interlocking system, or a matrix, whereby people moved in and out of roles and, in some situations, individuals were in the dominant role and at other times, they were the subordinates. The fluidity of the roles created a matrix. Collins (1991) framed empowerment theory as an inclusive model because of the opportunity to switch roles. Additionally, Collins (1991) described the fluidity as an opening for empowerment. The RISD example fostered agency within each individual to recognize their own creative and critical thinking perspective (Allina, 2018).

STEAM Curriculum Design: Transdisciplinary Challenge-Based Learning

Jamalian (2018) explained that the STEAM-based curriculum included learning through play and risk and providing students with opportunities to test the designs they created. STEAM-based curriculum encouraged teachers to challenge students to solve science-based problems (Tanenbaum et al., 2016). Drake (2012) defined this type of PBL as CBL, which included introducing students to a big idea, asking an essential question (EQ) on the topic, and presenting students with a challenge. Based on findings from this literature, the STEAM-based curriculum interventions developed in this study followed a CBL framework. Challenged-based learning encouraged young females to problem solve, test out ideas, brainstorm solutions, and share findings with one another (Berwick, 2019; Drake, 2012; Jamalian, 2018).

Inclusive CBL STEAM curriculum included both transdisciplinary and interdisciplinary pedagogical approaches. Each subject in STEAM was integrated into hands-on challenges for the participants in solve using STEAM skills in this online learning platform. John Dewey in 1929 described interdisciplinary education as he wrote about progressive education, integrated curriculum, and learner-centered approaches to teaching and learning (as cited in Flinders and Thornton, 2017). For almost 100 years, U.S. education researchers encouraged interdisciplinary curricula, yet schools continued to subjects in silos (Harrell & Harrell, 2010). Education researchers continued to argue for interdisciplinary curriculum to improve student learning and understanding (Casteel, 2018; Drake, 2012). STEAM-based curricula fostered transdisciplinary learning and developing student problem-solving skills (Harrell & Harrell, 2010; Quigley et al., 2020). Participants demonstrated success through iterations of ideas and proving there was more than one way to solve challenges by offering many right answers (Tanenbaum et al., 2016).

Teachers using STEAM-based pedagogy incorporated problem solving and application of skills into real-world, meaningful learning experiences—even through an online learning environment (Courey, 2016; Drake, 2012; Weist, 2014). The research demonstrated that flexibility offered in CBL and curriculum design motivated more of the students since there was more than one way to solve the problems posed in the challenges.

This study, therefore, was designed to inform teachers, administrators, school districts, and policy advocates about teacher instructional STEAM curriculum and to evaluate and assess progress in online STEAM education. The need to better understand ways to implement a STEAM-based curriculum came to exist because standardized testing did not evaluate science or STEAM-based education. Standardized testing measures were linked to CCS in English language arts and mathematics (Turano, 2018). However, the NGSS Lead States (2013, 2017) were written as performance standards, not assessment standards like CCSS, where students demonstrate the use of their knowledge learned in science class. Since standardized assessment measures did not apply to STEAM curricula, so researchers recommended gathering formative assessments based on performative or collective active use of student knowledge, such as documenting student learning with demonstrations, journals, portfolios, plays, presentations, and rubrics (Berwick, 2019; Drake, 2012; Quigley et al., 2020; Tanenbaum et al., 2016). These assessments asked students to demonstrate their understanding of STEAM principles and share their knowledge on the concept.

STEAM-based curriculum encouraged transdisciplinary learning that fostered innovation, creativity, and empathy in students (Long & Davis, 2017). As schools and educational policy began to change to incorporate the NGSS and STEAM programs, Catterall (2017) and Quigley et al. (2020) found that many teachers did not know what instructional strategies were recommended for STEAM education yet worked in schools where STEAM education was required. The NGSS (2013/2017) encouraged science educators to incorporate engineering into STEAM but did not include *how* or the methods teachers could use to implement these new science standards. Other researchers recommended the importance of early interventions and beginning programs as early as kindergarten (Holdren, 2013; Jamalian, 2018; Tanenbaum et al., 2016).

Researchers found that early intervention was key to engaging and motivating students to participate in STEAM education (Holdren, 2013; Jamalian, 2018; Tanenbaum et al., 2016; Venditto, 2018). Early intervention means integrating programs beginning in pre-kindergarten and kindergarten programs. Exposing children to STEAM in elementary school sets a foundation for learning that lasts throughout a learning career. Venditto (2018) explained that early intervention enabled teachers to spread excitement in students and foster creativity. The material becomes increasingly more difficult as students progress through K-12 education. They were more likely to stay involved in STEAM educational programming, if they had a foundation and were presented with the opportunity to problem solve in creative ways (Cunningham & Berger, 2014; Tanenbaum et al., 2016; Venditto, 2018).

Cunningham and Berger (2014) developed and tested a curriculum integrating engineering in the elementary classroom. The curriculum included physical, life, and earth science for grades K-5 grade levels. In their research, they found that at first many students were unclear about the role of an engineer in society, but, with the implementation of their curriculum, students gained a better understanding by solving problems together. Additionally, students increased the number of communication skills used in the classroom and improved collaboration and sharing skills (Cunningham & Berger, 2014). The use of a STEAM-based curriculum, like the example above, encouraged student participation, hands-on learning, and collaborative small group learning, which fostered student engagement and motivation (Berwick, 2019; Drake, 2012; Jamalian, 2018; Quigley et al., 2020).

Challenge-Based Learning Integrated with Peer-to-Peer Learning

When students were introduced to role models and provided with the opportunity to collaborate with their peers, Weist (2014) found that students increased engagement. Quigley and Herro (2019) recommended teachers design a STEAM-based curriculum that presents students with challenges to solve. When students used CBL, they collectively worked to determine and test possibilities. Group problem solving is a recommended practice for STEAM educators (Harrell & Harrell, 2010).

This collaboration fostered peer-to-peer interactions, even in an online educational setting, and an overall shared collaborative learning experience. Teachers reported that they found a STEAM curriculum motivating to students (Cifaldi, 2018; DeJarnette, 2018). In a study by Johnson, Smith, Smythe, and Varon (2009), peer-to-peer interactions and CBL curriculum allowed the students to learn from one another and teach each other simultaneously.

Additional findings included students reporting increased positive attitudes and practice using a growth mindset. Peer-to-peer learning and CBL were implemented as teacher instructional strategies to understand the impact on engagement and participation in STEAM. The program was designed to use peer-to-peer cooperative learning and CBL to promote student empowerment.

Project-Based Learning and MCL

The emergence of curricula like STEAM, project-based learning, and MCL were changing the notion that academic subjects were taught in isolation and instead were developing curricula that blended subjects in schools. Rather than teaching subjects as individual concepts, teachers engaged students in transdisciplinary lessons. Solis, Larmer, and Olabuenaga (2017) and Clapp, Ross, Ryan, and Tishman (2017) explained that project-based learning and MCL were two interdisciplinary theories for an educational curriculum that blends core academic subjects. Project-based learning curriculum asked students to work on a project for a long period of time using interdisciplinary subjects and share their findings with the community as the conclusion for their work (Solis et al., 2017).

Formal education was beginning to change in order to reach underrepresented and marginalized learners, and this was not limited to students of color or females. It also included students with learning disabilities like attention deficit disorder. Project-based learning, MCL, and STEAM-based curriculum encouraged out-of-the-box thinking. Nentwig (2019) found that varying from traditional education practices and towards curriculum, like STEAM, better prepared a wide variety of learners for the future.

One example of a STEAM and MCL curriculum designed for an informal learning environment at Braithwaite Fine Arts Gallery and Garth and Jerri Frehner Museum of Natural History. Grant and Patterson (2016) described the partnership between the two informal education settings with the help of Southern Utah University students implementing the curriculum. The goal was to increase middle and high school participation through an art-science integration curriculum using MCL with the aim to increase student participation (Grant & Patterson, 2016). The result of the program yielded higher student participation, engagement, and creativity (Grant & Patterson, 2016). Other researchers agreed that arts integration into science curriculum empowered learners through the act of problem solving, collaboration, and creativity. Empowerment theory as curriculum taught students to persist through shared group goals and group success through an interdisciplinary arts, science, and MCL STEAM curriculum (Grant & Patterson, 2016; Turner & Maschi, 2015).

Gender-Specific Role Models

Researchers argued that there is a lack of a female presence in the science curriculum perpetuated the gender equity gap (AAUW, 1992, 2017; Berwick, 2019; Fink, 2015). Kohli and Burbules (2012) explained that feminist theory explores themes of dominance, oppression, and works to find ways to address these inequities. The AAUW stressed that the curriculum can strengthen or decrease student motivation for engagement, effort, growth, and development through the messages it delivers to students about themselves and the world (AAUW, 1992, 2017). Noonan (2017) explained that females were less likely to go into male-dominated fields when they faced stereotypes and bias. While textbook publishers have established guidelines ensuring nonsexist language, these guidelines were oftentimes not enforced (AAUW, 1992, 2017). Teachers recalled their own education and stated the lack of females present in the science classes, and many reported only remembering Marie Curie (AAUW, 1992, 2017). Students internalized the lack of a female presence in the sciences as a message that their lives count for less than men (AAUW, 1992, 2017).

Children developed an understanding of stereotypes and self-identity in school (Tomlinson, 2018). Additionally, parents, media, and society influenced stereotypes and self-identity development as well (Fink, 2015; Tomlinson, 2018). Researchers argued that in order to reimagine identities and stereotypes, the learning needs to begin in schools, specifically with a gender inclusive curriculum (Berwick, 2019; Fink, 2015; Jamalian, 2018; Tomlinson, 2018). They also suggested using role models as examples of successful women in science to combat stereotypes (Berwick, 2019; Casteel, 2018;

Courey, 2016; Espy, 2016; Fink, 2015; Halper, Aronson, Relmer, Simpkins, Star & Wentzel, 2007; Jamalian, 2018; Tomlinson, 2018; Weist, 2014).

Books such as *Little Feminist: Celebrating 25 Amazing Women Throughout History, STEM Gems: 44 Women in Science, Technology, Engineering and Mathematics, And How You Can Too!,* and *Women in Science: 50 Fearless Pioneers Who Changed the World* were published featuring successful women in the STEAM field (Alpert, 2019; Espy, 2016; Ignotofsky, 2016). This literature provides teachers and parents with literature to make role models tangible and to invite female scientists, artists, astronauts, activists, artists, mathematicians, and more into the classroom through literature to engage students with stories, foster discussion, and learn about women in STEAM (Alpert, 2019; Courey, 2016; Espy, 2016; Weist, 2014).

If young students became aware of STEAM professionals in male-dominated careers, then culture would begin to change and the younger generation would be inspired by role models (Casteel, 2018). Through identifying with a role model, female students were more likely to pursue a degree in STEAM, see an increase in their grades, and feel a sense of belonging in a traditionally male-dominated field (Espy, 2016; Gilbert, 2015). Women who participated in STEAM associations and role model programs in school or the workplace were more likely to succeed (Casteel 2018; Courey, 2016; Espy, 2016; Gilbert, 2015; Weist, 2014). Feminist theory impacts policy as it calls for a transformation in society to improve and make the world a better place for women to exist within (Kohli & Burbules, 2012).

Educators that engaged students with STEAM literature featuring female, cultural professionals in the field, formed a back-and-forth relationship from school to the workforce, and female students began to see the possibility of becoming part of the field. This relates back to Collins (1991) who described empowerment theory as the ability to unlock from the matrix of stereotype threat and switch roles. Through collaborative partnerships with community members, mentors, and real-life role models in literature, the gender equity gap increasingly closes as more young females participate and engage in STEAM.

Early Intervention

Researchers across the board published findings of the importance of early intervention to engage and motivate elementary-aged students to participate in STEAM education (Holdren, 2013; Jamalian, 2018; Tanenbaum et al., 2016; Venditto, 2018). Holdren, the CoSTEM, and the National Science and Technology Council (2013) found that exposing children to STEAM-based curriculum elementary schools set a foundation for learning. The importance of early intervention allowed teachers to encourage excitement in students and to foster their creativity (Venditto, 2018). As students advanced through school and curriculum content became increasingly difficult, students continued to stay engaged in STEAM with a foundation from their early learning years when they were presented with the opportunity to problem solve in creative ways (Cunningham & Berger, 2014; Tanenbaum et al., 2016; Venditto, 2018). Similarly based on empowerment theory and that instead of learning to survive in school, students were encouraged to thrive (Collins, 1991).

Growth Mindset

Traditional STEM subject education gave praise to students based on the correct outcomes of being able to perform a given science experiment. This practice leads many females to shy away from the field of science, including STEAM, because it promoted right and wrong answers (Weist, 2014). Instead, researchers found that when teachers praised students based on effort and logical reasoning, females performed better in STEAM education (Casteel, 2018; Courey, 2016; Jamalian, 2018; Quigley et al., 2020; Weist, 2014). The work of Dweck (2010) established this practice in education as teaching students to develop a growth mindset. The application of a growth mindset teaches students that with hard work and dedication, they could learn anything and this practice connected to empowerment theory and an individual's ownership over their own learning (Collins, 1991; Dweck, 2010; Jamalian, 2018).

Quinton (2014) suggested interventions for STEAM educators to close the gender equity gap focus on teaching students to develop a growth mindset to work past existing stereotype threats. The researcher explained how a growth mindset gave students the ability to reflect on their own learning so that students cultivate a growth mindset that they can learn difficult concepts, and they can overcome challenges. Dweck (2010) recommended that teachers place the emphasis on the challenge, or the process, rather than the outcome.

Many young girls in education believed that what they learn in school was based on luck, while boys felt in control of their learning and attributed skills to natural ability (AAUW, 2017, 1992). At a very young age, females experienced *learned helplessness* in schools and were dropping out of subjects where perseverance was required (AAUW, 2017, 1992; Berwick, 2019; Noonan, 2017). The research demonstrated that more females than males expected to fail in school, which resulted in a lower sense of self-confidence (AAUW, 1992, 2017). As a result, increasingly, more female students dropped out of subjects where failure was likely to occur (AAUW, 1992, 2017). Feminist theorists seek to address the preconceived gender stereotypes that exist within society (Quinton, 2014).

Gretchen Brinza (2019), a fifth- and sixth-grade teacher in Chicago Public Schools, explained that without failure, her students would have missed a learning opportunity and the chance to write their own success stories. Failure and iteration became a natural part of STEAM-mindsets and growth mindsets allowed students to understand their own ability to overcome obstacles (Weist, 2014). Therefore, Brinza's STEAM curriculum empowered students to take agency over their own learning (Turner & Maschi, 2015; Weist, 2014).

In early elementary school, young females scored higher on tests, but they still shied away from subjects like science as the content became increasingly difficult and failure was a norm (AAUW, 1992, 2017; Beede et al., 2011, Brinza, 2019; Damour, 2019; Noonan, 2017). As they began to pursue STEAM education, a growth mindset helped young females combat gender bias and understand that school was about ability and not luck (AAUW, 1992, 2017; Weist, 2014). Buoncristiani and Buoncristiani (2012) encouraged educators to provide students with the opportunity to be risk-takers and occasionally fail. This taught students grit, determination, and perseverance to stick with subjects like STEAM where failure often occurred (Buoncristiani & Buoncristiani, 2012; Quinton, 2014). This action research study developed a STEAM curriculum focused on presenting participants with CBL, where there were no right answers to the problems. This curriculum design moved away from the traditional structure of STEM education with a scripted lab report and right answers, to a STEAM model, which fostered student empowerment, creativity, engagement, and motivation (Allina, 2018; Weist, 2014). The research found that this change in curriculum, combined with a growth mindset, resulted in more females in male-dominated fields (Barack, 2018).

Gender-Inclusivity: What About the Boys?

The STEAM-based curriculum was integrated into schools because it strove to encourage all students to learn in engaging ways and to become creative risk-takers (Barack, 2018; Bulls, 2018; Jamalian, 2018; Mukherjee, 2018; Quigley et al., 2020). Supporting females in STEAM was not at the expense of the males. Rather, the movement to close the gender equity gap in STEAM education was to benefit all learners (Bulls, 2018). STEAM-based curriculum fostered a level playing field for students of all genders and backgrounds (Bulls, 2018; Venditto, 2018). The misconception that helping the females meant the males were being ignored was a myth that needed to be debunked. Educating all students about gender equity benefits all sexes (Grant & Patterson, 2016).

Damour (2019) argued that schools, even now, are set up to benefit males even when they put in less effort than females in the same classes. Boys were more likely to feel confident, see, and read about male role models in all fields, and put in the minimal effort with maximum gain (AAUW, 1992, 2017; Courey, 2016; Damour, 2019). Young boys were oftentimes taught that they would succeed, while females continued to feel pressured, less confident, and underrepresented (AAUW, 1992, 2017; Beede et al., 2011; Damour, 2019; Holdren, 2013; Noonan, 2017; Tanenbaum et al., 2016). Feminist theory applied in this study aimed to equip the females in the program with the confident skillset demonstrated by boys. When educators worked to provide strategies to support and engage females in STEAM, males benefited too (Bulls, 2018; Weist, 2014). Bulls (2018) argued that the STEM gender gap was not just a women problem, but rather a societal problem that requires the work of the collective.

Nonbinary: Gender as a Spectrum

Sam Killerman, author of *A Guide to Gender: The Social Justice Advocates' Handbook* (2017), explained that gender no longer was binary, but rather thought of as a spectrum. This spectrum included males on one end and females at the other, which allowed for individuals to self-identify as somewhere in between (Killerman, 2017). From transgender students to boys that played football and liked theater or females that associated with societal attributions of masculine identities, the spectrum of gendered identity became one that educators, administrators, parents, and children needed to take into account (Killerman, 2017; Venditto, 2018). Advocates of gender-fluid practices encouraged teachers to share role models of professionals in non-stereotypical roles and to use gender-neutral materials and language in the classroom (Killerman, 2017; Venditto, 2018; Weist, 2014).

For instance, instead of using the pronoun he or she, use they. This was true even when it refers to a singular person, because it allowed students to focus on the message of the lesson being delivered versus the gender of the message. Developing gender-free speech in the classroom and in curriculum materials allowed students the freedom to express their gender identity in their own time. The unconscious gender bias in STEAM played a role in the gender equity gap, but culture became increasingly diverse in terms of gender, it became important to create a supportive learning environment that was welcoming to all students, of all genders, and everything on the spectrum in between (Bulls, 2018; Killerman, 2017; Venditto, 2018; Weist, 2014).

Summary

This literature review presented an investigation on policy and science, STEM, and STEAM standards and policy that resulted in the development of STEAM programs and curriculum in schools across the United States. Additionally, it detailed a historical account of the development of STEM and the subsequent development of STEAM. This review found studies that demonstrated a gender gap in science, technology, engineering, art, and math education and the workforce. The engagement of females using STEAM increases, which is why the researcher designed a STEAM online summer camp for this study (Quigley et al., 2020).

Empowerment and feminist theories focused on teaching students to trust their ideas and test them out while encouraging all learners to succeed. STEAM-based curriculum engaged females in the fields of science, technology, engineering, art, and math by presenting them with challenges to solve. This study used CBL as an instructional instrument to increase engagement and participation in a STEAM program. The general goal of this research project was to assess the CBL, gender-inclusive STEAM curriculum impact on participation and engagement in STEAM education when students are presented with the opportunity to share their ideas and iterations of solutions (Byrk, 2014; Casteel, 2018; Courey, 2016; Snow, 2014; Weist, 2014; Yager, 2014). Therefore, this study combined these interventions into a transdisciplinary STEAM curriculum design aimed to increase young females' engagement and achievement.

Many researchers have found that the gender gap in science, technology, engineering, and math persists year after year and affects females starting in elementary school and continuing through their education and into the workforce (Casteel, 2018;

Courey, 2016; Damour, 2019; Hand, 2017; Khazan, 2018; Noonan, 2017; Venditto, 2018; Wiest, 2014; Wyss, Huelskamp, & Siebert, 2012). The aim of this study was to contribute of the body of research in STEAM education by developing curriculum and instruction that engaged female students to pursue science, technology, engineering, art, and math education as a result of early interventions of a STEAM program integrated using a transdisciplinary approach by an elementary science teacher turned action researcher.

This chapter demonstrates the effects of STEAM integration. The literature review explored existing research surrounding STEAM education as it relates to engage students in learning, science, technology, engineering, art, and math. Additionally, this research detailed the historical importance of closing the gender gap in science, STEM, and STEAM and what steps educators could take to advocate for equity and access using gender-specific transdisciplinary STEAM curriculum design. Given these findings, the goal of this study was to understand the impact of instructional design on females' engagement and participation in STEAM.

CHAPTER 3

METHODOLOGY

Elementary programs in schools across the United States have started to incorporate STEAM as a means to create further student engagement in this field (DeJarnette, 2018; Perignat & Katz-Buonincontro, 2019; Quigley et al., 2020). This action research study was designed to understand how the STEAM curriculum impacts student engagement and participation. The research design included interventions using transdisciplinary STEAM curricula, CBL, and gender-specific, cultural role models designed to engage students by presenting them with problems to solve related to science, technology, math, art, and engineering. All of the transdisciplinary CBL units were aligned with the 5E instructional model (5Es), which stands for engage, explore, explain, elaborate, & evaluate (Kahn, 2019). Additionally, participants in this study were introduced to empowerment theory as curriculum as an intervention using cultural, gender-specific role models in the STEAM workforce. In DEI work, empowerment curriculum is implemented to explore privilege, oppression, and diversity (Lo, 2005).

STEAM curriculum was believed to foster creativity and hands-on learning in students (Handelsman & Smith, 2016). The question remained to many teachers *how*. This study aimed to combine interventions featuring transdisciplinary STEAM curricula, gender-inclusive, cultural role models, the 5Es, and CBL. This study was constructed to evaluate how the abovementioned interventions impact elementary-aged females' participation and engagement in a STEAM program.

Problem of Practice

The PoP identified arose from the lack of research related to young females in STEAM and the researcher's personal experience as an elementary educator working with young children for the past 14 years as a STEAM, science, Pre-K, and 4th grade teacher. Oftentimes, many female students around third and fourth grade self-reported to the researcher that they were unsuccessful in STEAM. Harding (2012) determined that action research and feminist research often began with personal experience and then moved to study other groups experiencing the same problem or issue.

The literature review in Chapter 2 demonstrated the systemic issue of women's oppression and marginalization in science, STEM, and STEAM education and the workforce. When empowerment theory was integrated into STEAM curriculum, students were presented with opportunities to fail, iterate, and try again. Researchers found that providing opportunities for students to test and practice multiple ideas in a supportive environment leads to succeed in the future—especially for females, when they were presented with gender inequities and stereotype threats in school in the workforce, they were more likely to overcome obstacles (Huhman, 2012; Parker, 2018; Quigley et al., 2020).

According to Huhman (2012), the majority of females begin to lose interest in science-related fields beginning in elementary school. Earlier research has shown that this problem frequently emerged for females in third grade and then again in the eighth and 12th grade (Clewell & Ginorio, 2002). Additional researchers reported that females in elementary school feel invisible by the time they enter fourth grade (Digiovanni & Liston, 2004). Further research concurs that the gender gap begins in elementary school and continues into secondary and postsecondary education in STEAM-related subjects (Anthony & Ogg, 2019). The data for the past 20 years continued to prove the consistent gender inequity in STEAM subjects and the workforce.

The lack of participation and engagement of underrepresented groups of people, specifically females and minorities, plays a major role in the decrease of females in STEAM (Pollack & Zirkel, 2013). Researchers Funk and Parker (2018) explained the problem began with access to quality science, math, technology, and engineering educational programming. They found that many disenfranchised students have limited access and, therefore, incrementally became less engaged in STEAM subjects during their education. The research supported the necessity for this STEAM study and to address the issue of participation and engagement in STEAM and the effects of the proposed interventions.

Positive research about STEAM-related curriculum found that if young females believed in their own ability to succeed, they were linked to higher achievement and engagement (Beghetto & Baxter, 2012). A belief in oneself resulted in greater academic achievement and engagement (Beghetto & Baxter, 2012). Empowerment theory as a curriculum design in practice encouraged active learning among students and the individual perspective that success was a result of effort and not luck (Turner & Maschi, 2015). The literature on empowerment theory applies to educators working to change a culture. Cornbleth (2010) described this work as the *hidden curriculum*. This action research study was designed by an educator working to change the culture, stereotype, and mindset of young females and empower students to learn the value of their own efforts.

Further studies found that female teachers produce higher academic performing females in elementary school because of the verbal reassurance they offer to students and this was especially true in STEAM subjects (Stearns et al., 2016). Young female students proved to succeed and persist in learning difficult material with positive words of encouragement from female teachers (Stearns et al., 2016). Elementary-age females respond to words of encouragement from their teachers and adversely, without positivity, many young females disengage in STEAM education (Weist, 2014). Feminist research in practice focuses on the female perspective and their life experience (Harding, 2007). This study sought to understand the experience of females in a STEAM program with a researcher that reinforced trial-and-error combined with positive words of reinforcement.

Females disengage in STEAM education between the ages of 7 to 10 and, oftentimes, researchers suggested engagement would increase if interventions were implemented early, such as in an elementary school setting (Anthony & Ogg, 2019). The participants in this study were limited to females only to target this age group and determine the effectiveness of the program's design. When elementary educators designed interdisciplinary and transdisciplinary curriculum around integrated subjects in STEAM, the results were enhanced student engagement and interest for all genders (DeJarnette, 2018; Hunter-Doniger, 2018; Quigley et al., 2020).

One STEAM curriculum that teachers reported as successful was presenting students with challenges to solve (DeJarnette, 2018). This teaching methodology is known as CBL or PBL, which is one of the interventions developed for this study. In one

STEAM CBL study, students worked in small groups and used inexpensive materials and everyday recyclables to design and test prototypes of their solutions (DeJarnette, 2018). The STEAM CBL design found that students using found materials thrived in creativity, curiosity, and exploration (DeJarnette, 2018). Additionally, students increased working collaboratively to improve iterations of their designs (DeJarnette, 2018). The researcher applied a STEAM CBL methodology and asked participants to gather everyday items found around the house, which aided in the researcher's ability to conduct this study during a pandemic. The goal was to understand the impact of these interventions on young females' engagement and participation in STEAM.

Once the PoP was identified as a systemic issue that young females faced starting in elementary school, the STEAM interventions were designed and implemented to foster engagement and participation using a transdisciplinary curriculum. The researcher identified instructional strategies, such as transdisciplinary instruction, CBL, empowerment, and the 5Es, in hopes of engaging females in STEAM. The aim was to develop interventions to address the problem of females losing interest in STEAM at a very young age and internalizing implicit bias and stereotypes in society (Bryk, 2014; Bulls, 2018).

Research Question

The literature and the research informed the action research study and the following question was designed to understand:

1) What impact did an empowerment curriculum, utilizing transdisciplinary curriculum, Challenge-Based Learning and cultural, gender-specific role

models have on elementary-aged females' participation and engagement in STEAM education?

Purpose of the Study

As demonstrated by the literature review, the PoP resulted in an overarching theme in STEAM education and identifying ways to engage more females in this field. The lack of research on STEAM curriculum, programs, and the impact on elementary-aged females in informal settings necessitated this study (Grant & Patterson, 2016; Quigley et al., 2020). Researchers demonstrated that the age range from 7 to 10 years old was when the majority of young females stop participating in STEAM subject classes; however, few studies have been published on the *effectiveness* of the specific interventions outlined in this study (Anthony & Ogg, 2019). Grant and Patterson (2016) researched STEAM programs and interventions and concluded that more research is needed in this field. They urged others to contribute to this emerging field in education.

This action research study was designed to address gender inequity in STEAM beginning in elementary education and understand the impact of transdisciplinary curriculum, CBL, empowerment, and the 5Es as interventions to motivate young females through a summer camp program. Concurrently, this study took place during a worldwide pandemic, which resulted in the necessity of online learning as the medium for student engagement. The researcher designed the study to take place online using the web application Zoom. The result was this action research study, which, specifically, was an online STEAM summer camp program for elementary-aged females.

Research Design

Action research was selected as the method for research since it offers teachers an opportunity to take on the role of a researcher in hopes of generating meaningful, professional contributions to their field (Mertler, 2017). Herr and Anderson (2015) found teachers conducting action research aim to solve problems within their own schools. The literature review in Chapter 2 demonstrated the need to improve the outcome for young females in elementary education, and resulted in this action research study for females between the ages of 7 to 10. As a result, this study was designed to address the question: how are the interventions designed impacting participation and engagement in STEAM education?

This action research study was designed using a mixed-methods research design and included parent observations, participant surveys, researcher reflections, and video transcriptions. Silverman (2013) explained a mixed-methods methodology offers researchers an overall picture to answer the research question guiding the study. The benefits of using a mixed-methods approach offered a more complete understanding of a research problem than either quantitative or qualitative data alone (Creswell & Creswell, 2018).

Throughout the 2-week long action research study, the researcher collected parent observations, participant surveys, researcher reflections, and video transcriptions. The research included both qualitative and quantitative data. Quantitative methods used to analyze the data include numerical formulated graphs representing the amounts of responses to linear and Likert-scale questions on parent observations and participant surveys. Qualitative analysis was applied to open response questions on parent observations, participant surveys, researcher reflections, and videotape transcriptions during the study.

The qualitative data were analyzed using Tetra Insights and NVivo Software to identify patterns and themes that emerged. Initially, the researcher used Tetra Insights software to watch the video recordings alongside the transcripts and self-code the data for common themes. Next the researcher uploaded the qualitative data into NVivo Software to run a word search query, so the software could identify the most commonly used words. Lastly the researcher, applied codes from the Tetra Insights software into the NVivo Software to identify the emerging themes.

The software programs helped to apply open coding qualitative methods to find and highlight similar words, phrases, and sentences to develop emerging themes. Burnard (1991) described open coding as a research strategy to read through data repeatedly and group together common themes. The researcher took the themes from the qualitative data and compared them to the quantitative results.

A mixed-methods research design uses both quantitative and qualitative data together to provide a better understanding of the research problem (Creswell & Creswell, 2018). Results were analyzed and triangulated for comparative purposes (Efron & Ravid, 2013). The researcher applied a mixed-methodology to ground the study in data and reported the findings of STEAM education and the impact on elementary-aged females. This action research study used a mixed-methods approach to validate the findings in the data.

Interventions

The interventions designed for this study were implemented through a STEAM program for females ages 7-10. The interventions used for this study were a transdisciplinary STEAM curriculum, empowerment, CBL, and the 5Es (Drake, 2012; Harrell & Harrell, 2010; Kahn, 2019; Turner & Maschi, 2015). Education policy makers, NSF, and NEA postulated the best curriculum design for STEAM and whether it should be implemented as transdisciplinary or interdisciplinary. Harrell and Harrell (2010) documented findings from the NSF and NEA joint collaboration to explore STEAM curriculum and program design. The committee described the emphasis on the process rather than the project itself and found that both interdisciplinary (teaching more than one discipline together) and transdisciplinary (components from multiple disciplines) practices were used in the application of STEAM.

Grant and Patterson (2016) documented their work to create innovative STEAM programming and found that integrating all 5 disciplines to be a "tall order" (p. 150). They recommend that others starting STEAM programs collaborate with others in the field, survey participants on their experience, and share findings with others to help influence further research in this emerging educational field. The program in this DiP focused on a transdisciplinary STEAM curriculum. The researcher brought in an expert in the field who published a children's book on STEAM, titled *More than a Princess*, and works in the technology sector. She shared her experience as a mother, author, and technology specialist, and encouraged the participants in the program to focus on multiple strengths and talents in the STEAM field. The transdisciplinary curriculum focused on teaching students about science, technology, engineering, art, and math.

Components from these disciplines were used to write a transdisciplinary curriculum. Appendix K features the standards from the STEAM fields used to engage students in STEAM.

Empowerment theory was developed into an empowerment curriculum by educating participants about female, cultural role models in the current STEAM workforce. This strategy was used to reduce the stereotype threat of women in STEAM (Lo, 2005; Parker, 2018). To empower young females in STEAM, the researcher aimed to educate students about women in the workforce that already succeeded and shared their stories of how they got to where they are today. The program featured 22 role models and 12 were Black, Indigenous, People of Color (BIPoC). Nine of the role models were children in STEAM. The women and girls presented were mathematicians, artists, graphic designers, marketing and media content creators, makers, engineers (chemical, electrical, and aerospace), computer coders, scientists (in a lab, in the field, two ichthyologists), inventors, entrepreneurs (CEOs, COOs, founders of companies supporting women), astronauts, social justice advocates, explorers (of jungles, the deep ocean, outer space, cyberspace, mixed media art), computer coders, and network scientists. Similar to Long and Davis (2017) who implemented a STEAM program to increase engagement, literacy across the disciplines, and apply a holistic approach in education, this program used a transdisciplinary approach to educate students about females in STEAM and the multitude of possibilities for future careers through interdisciplinary applications. Many of the role models featured demonstrated how as a STEAM professional they used their passions in one field and applied their knowledge to another.

During this action research study, the role models that were introduced to the participants in the program were predominately female (22) and additionally, many of them BIPoC (12). The role models were an intervention designed to feature a gender-inclusive, cultural STEAM curriculum and represent the voices so often left out of the textbooks—women. Every lesson included a read aloud that the researcher read to the participants daily. Additionally, the researcher recorded the read alouds and uploaded them to YouTube for students to access repeatedly. Role models were also featured through a woman in the STEAM workforce video where each role model spoke about their experience, education, and current job. This strategy aimed to teach female participants about female role models, their experience in the field, and their educational path towards becoming a STEAM professional. Concomitantly, participants learned the interdisciplinary nature of STEAM professionals and digital literacy skills to safely navigate YouTube.

The application of a transdisciplinary CBL curriculum fostered student creativity, the ability to fail forward and collaborate with classmates to problem solve (Johnson et al., 2009; Quigley et al., 2020). Oftentimes, experiments are conducted in hopes of finding answers to a problem, which is also referred to as inquiry-based learning. The program featured role models in science labs, makerspaces, office buildings, design studios, and of course, due to the pandemic, their own home. The role models demonstrated how many times they did not find answers to their questions or problems on the first try. They took time, failure, iterations of ideas, collaboration, confirmation from others (peer review), and many more steps.

The experiments in the study were based on CBL to offer students the opportunity to work towards solving a STEAM-based challenge, apply the skills, and mindsets demonstrated by the role models in the curriculum (Drake, 2012). Each lesson included a challenge phrased in the form of a question. In order to find the answer, participants had to first find the supplies from around their house by going on a scavenger hunt. DeJarnette (2018) found that students were more creative when using found materials and recyclables. Next, participants conducted multiple iterations of their solutions in a synchronous environment alongside a group of peers.

The 5Es instructional model stands for engage, explore, explain, elaborate, & evaluate and consists of a five-step process based in many science curricula (Kahn, 2019). The 5Es model provided the structure for the transdisciplinary CBL component of the program. As students engaged, explored, explained, evaluated, and went back to elaborate on their designs, a peer-to-peer learning environment was encouraged from the researcher. Rather than providing answers to participants, she encouraged the others in the group to offer suggestions for improvement. Harrell and Harrell (2010) described this practice in STEAM as group problem solving through communication and was based on networking technologies. Cooperative learning, communication, and group problem solving was demonstrated by students volunteering to help one another through Zoom as they explained tips for success. Empowerment theory offers students opportunities to collaborate and create a shared knowledge (Digiovanni & Liston, 2005).

Clapp (2017) coined the phrase participatory creativity. When applied in an educational setting, participatory creativity results in collaborative efforts by a group of learners, so each student sees that there is a role for everyone to play in the creative classroom, and that creativity can look like them too (p. 85). The STEAM curriculum in this program was designed to encourage all students to participate, share their voices, and solve problems collectively and creatively—even with the limitation of distance learning.

The interventions featured an introduction to women in STEAM and BIPoC role models. This ensured that every student in the study saw a role model that looked like them. This was by design. The researcher gathered information from parents about race and gender prior to the study to include role models representative of the participants in the study. As empowerment theory developed into curriculum, students learned the about challenges and obstacles females in STEAM faced. The role models featured taught participants the importance of trusting their voice and using it as a tool in their educational toolkit. Empowerment theory as curriculum encouraged students to develop an awareness of what they can do instead of focusing on what they cannot do (Digiovanni & Liston, 2005).

The program lasted for 2-weeks for a total of 16 hours. It included 10 lessons on STEAM. Eight of the lessons were synchronous and 2 were offered to the parents and participants to complete asynchronous. The curriculum design aimed to teach participants about females and BIPoC STEAM, using transdisciplinary curriculum, CBL, the 5Es, and empowerment. The researcher introduced the interventions on the first day of the program and each consecutive day. Additionally, the participants also learned digital literacy skills. For example, participants were taught how to use the Seesaw application, YouTube, and Google forms to complete the surveys and contribute to the understanding of the impact of the transdisciplinary STEAM curriculum designed for this program. Participants completed the surveys to explain their understanding, beliefs, and perceptions about women in STEAM and learning about STEAM as experienced through the transdisciplinary curriculum in the program.

Intervention summary:

1) Transdisciplinary curriculum - grounds the curriculum in real-life contexts, PBL, and engages students to ask questions and conduct research (Beane, 1993, 1997; Drake, 2012).
2) Challenge-based learning - presenting students with a STEAM-based challenge where they conduct an experiment to problem solve and discover answers (Drake, 2012).
3) Empowerment theory as empowerment curriculum featuring women and BIPoC role models in STEM (Lo, 2005; Parker, 2018).
4) The 5Es instructional model: engage, explore, explain, elaborate, & evaluate (Kahn, 2019).

The goal of this action research study's interventions were to understand the impact of a transdisciplinary curriculum using CBL, empowerment, and the 5Es on young females ages 7 to 10 explore STEAM concepts in an informal educational setting. The researcher sought to understand how the designed interventions above impacted engagement and participation of elementary-aged females in STEAM.

Research Context and Setting of Study

The participating students came from elementary schools all over the southern United States. Students logged into Zoom to join class, which allowed the researcher to teach students from a wider geographic range of states. Originally, this program was designed to be implemented in the researcher's school. All of the participants in the program attend elementary school in-person throughout the year, but with the outbreak of COVID-19, educational settings converted to digital learning formats. Thus, creating a pivot for the researcher from localized study in one school to a study that reached children in more states. Students were rising second to fifth graders enrolled in public, private, and charter elementary schools. In order to protect the identity of the students, pseudonyms are used throughout the study. For example, students are referred to as Participant A or Participant B.

When the researcher collected initial data to determine participant eligibility, parents were asked to help create a place for their daughter to work inside the house. Parents and students were sent on a “scavenger hunt” around the house for materials and asked to purchase any missing items (total under $25 with most items already existing in the average household). Sample scavenger hunt items included containers with or without lids, plastic cups, toilet paper tubes, and tin cans. Examples of items families purchased were vinegar, baking soda, and aluminum foil. The STEAM program was provided free to students and their families.

Participants

This action research study focused on females in elementary school, specifically ages 7 to 10 years old. The program served 15 students and the sample size for the program was 10 students. This sample of 10 was selected based on attendance and completion of surveys. The students in this STEAM program were in Grades 3 to 5. Four students were Black, three students were classified as two or more races, one was White, one was Asian American, and one student was Latina. Figure 3.1 summarizes the demographics of the participants.

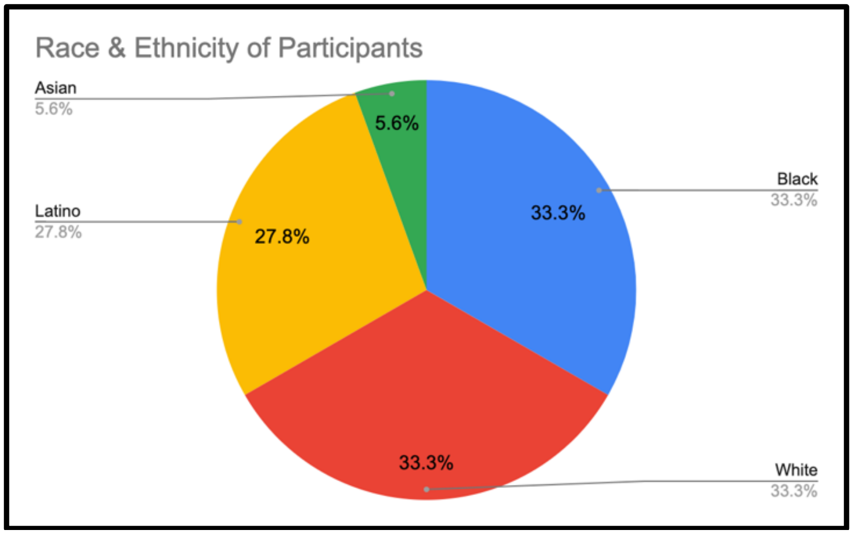

Figure 3.1. Race & Ethnicity of Participants.

When determining which students to sample, the researcher reviewed parent observations and participant surveys (see Appendices A – F). The researcher identified which 10 students were able to attend camp consistently and consented to participate in data collection. Approximately, 10 to 15 students attended the program each day. However, for the purposes of the study, 10 were identified to as data points, and this sample is displayed in Table 3.1.

Table 3.1 Demographic Characteristics and Identification of Participants Interviewed

Participant	Gender	Age	Race	Interviewed	Location
Student A	F	8 years old	White, Latino	Initial & Follow-up	TX
Student B	F	10 years old	White	Initial & Follow-up	GA
Student C	F	8 years old	White, Latino	Initial & Follow-up	TX
Student D	F	10 years old	Black	Initial & Follow-up	FL
Student E	F	10 years old	Latino	Initial & Follow-up	GA
Student F	F	8 years old	White, Latino	Initial & Follow-up	TX
Student G	F	8 years old	Asian	Initial & Follow-up	GA

Participant	Gender	Age	Race	Interviewed	Location
Student H	F	9 years old	Black	Initial & Follow-up	GA
Student I	F	9 years old	Black	Initial & Follow-up	SC
Student J	F	7 years old	Black	Initial & Follow-up	SC

Ethical Considerations

The procedure for the study began with permission from the dissertation chair, the USC School of Education and the IRB (Creswell & Creswell, 2018). Once all the approval was given, outreach to determine participants and eligibility began. Any names of participants, including students, parents, and teachers, in this study, have been changed to protect their anonymity. The sensitivity of participants (children) and respect their stories, experiences, and sharing of these with the researcher (Creswell & Creswell, 2018). Sensitivity was paid to cultural differences in gender norms and expectations (Creswell & Creswell, 2018). These safety precautions were built into the study to confirm and protect the identity of research participants.

Role of the Researcher

The role of the researcher was from a feminist action research approach, which Herr and Anderson (2015) supported for feminists and critical theorists. Both have critiqued the social engineering tendencies of turning action research into a codified and packaged professional and organizational development strategy (p. 33). A feminist action research approach was designed to explore dominant structures that exist in society, which perpetuate male-dominated STEAM workforce and educational settings.

Feminist action researchers seek to apply a methodology to better understand patriarchy and dominant constraints within the field. Leckenby and Hesse-Biber (2007) explained that researchers using a feminist lens produce research that may provide space for social change (p. 250). The role of the researcher working from a feminist action research lens aimed to first understand dominant paradigms and the effects on young elementary-aged females. Additionally, the researcher aimed to create modifications to traditional science curriculum by implementing and collecting data on the impact of transdisciplinary STEAM curriculum designed with CBL, empowerment theory, and the 5Es specifically for young females. Turner and Maschi (2015) posited that feminist researchers look at societal gender in relation to status, power, and development.

Research Methods and Data Collection Instruments

This STEAM program in this action research study used a transdisciplinary curriculum, CBL, the 5Es, and empowerment through the introduction of cultural, gender-specific role models. The 5Es stand for engage, explore, explain, elaborate, and evaluate (Bybee, 2015; Kahn, 2019; NGSS, 2014). The 5Es instructional model encourages students to use inquiry-based learning instead of traditional science step-by-step instruction, which aligns with the CBL curriculum developed for this STEAM program (Kahn, 2019).

The researcher used various instruments to gather both qualitative and quantitative data for a mixed-methods study. The specific instruments used for data collection were: (a) parent observations, (b) participant surveys, and (b) researcher reflections and video transcriptions (see Figure 3.2). The results of the responses and data are analyzed and explained in Chapter 4.

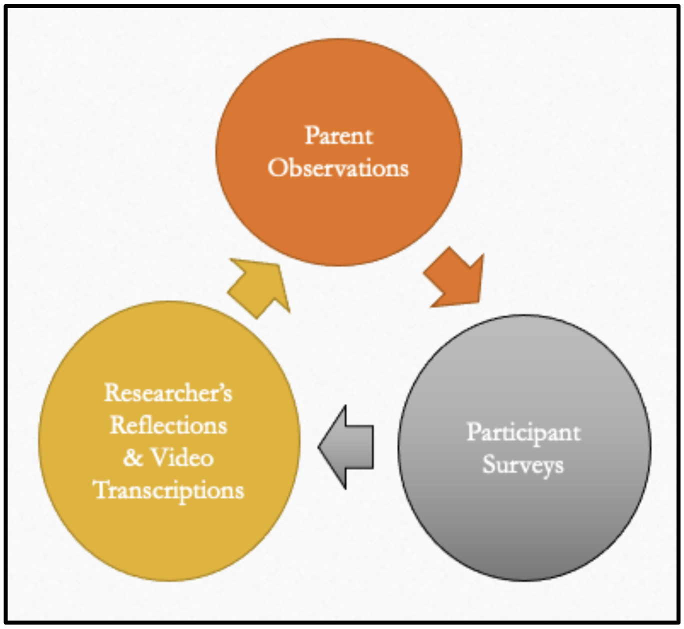

Figure 3.2. Illustration depicting the triangulation of data.

The parent observations and participant surveys were Google forms surveys distributed via email and/or in class for participants and parents. The questions were formatted as multiple-choice, Likert-scale, and open response. The data collection instruments were purposefully designed with a variety of questions, "For the reluctant, shy, or less verbal respondent, they offer an easy way out," and to gather both quantitative and qualitative data (Merriam & Tisdell, 2016, p. 122). Researchers recommended when working with young students, such as the elementary-aged females in this study, to keep the questions in short-and-easy-to-answer formats (Efron & Ravid, 2013; Merriam & Tisdell, 2016). Parent observations and participant surveys provided the researcher with a large number of responses in a short amount of time.

Quantitative Data

The parent observations and participant surveys provided numerical data that informed growth patterns witnessed by parents and students and the overall impact of the

STEAM interventions on females ages 7 to 10. The parent observations were used to gather data on the experience their daughters were having in camp and reflections on a change in their behavior at home (see Appendix C, D, & E). The participant surveys were used to gather data for the study to understand basic understanding, perceptions, and participation in STEAM (see Appendix A & B). The researcher analyzed participant data for overall opinions, perceptions, and feedback about their experience.

To gather quantitative data, statements were provided to allow participants and parents to complete the statement. For the participant and parent surveys, identifying statements were used to collect data specific to participation, engagement, and impact of the program. Table 3.2 features the following key statements for participants and Table 3.3 includes key statements on the parent observations.

Table 3.2 Key Quantitative Statements on Participant Survey

Measure	Statement
Participation & Engagement	I share things I learn about Science & STEAM with my family.
Participation & Engagement	I convince my parents to let me do science and STEAM experiments at home (either with them, friends, siblings, other family members, or alone).
Impact	I feel confident about my abilities to tackle STEAM Challenges & Experiments.
Impact	I think of myself as STEAM-minded, meaning someone who is curious, asks questions, takes educated risks, and likes to experiment and try different solutions to problems.

Table 3.3 Key Quantitative Statements on Parent Observations

Measure	Statement
Participation & Engagement	My daughter talks more about STEAM now than before camp.
Impact	The educational programming made a big impact on my daughter.

The parent observation forms were completed three times throughout the duration of the program. The researcher gathered forms from the parents on the first day, midway through the program, and on the concluding day of the program.

Qualitative Data

Qualitative data was gathered from open-ended questions on the participant and parent surveys, researcher reflections, and transcriptions of the videos. The researcher's reflections were gathered daily as a means to keep track of data and understand how to improve delivery, understanding, and any potential improvements in instruction and learning (see Appendix H). The open-ended survey responses, researcher's reflections, video transcriptions were uploaded and analyzed into Tetra Insights and NVivo Software (see Appendix J).

Initially, the researcher worked with Tetra Insights Software to code the data using the playback feature to watch videotapes of lessons alongside transcriptions repeatedly and color code similar word groupings. Next, the researcher loaded the transcripts into NVivo software, which allowed the researcher to run a word frequency query that autogenerated a list of the most frequently used words from the parent observations, participant surveys, researcher reflections, and the video transcriptions. The researcher classified words, sentences, and phrases into similar groupings based on word frequencies to develop emerging themes.

The researcher applied open coding to define the emerging themes and patterns between the different sources. Burnard (1991) explained that open coding is when a researcher reads through their material repeatedly and groups together common themes. Finally, the qualitative data were compared to the quantitative data and triangulated to further understand parent, participant, and researcher perceptions and experiences from this action research STEAM study. The use of multiple data collection methods provided data to triangulate, which increases the accuracy of the findings (Efron & Ravid, 2013).

For the open-ended questions on the participant and parent surveys, statements were provided to allow students and parents to complete. The identifying statements were used along with the key quantitative statements outlined above in Table 3.4 (participants) and Table 3.5 (parents). In addition to the identifiers on each survey, the following key qualitative statements were included:

Table 3.4 Key Qualitative Statements on Participant Surveys

Measure	Statement
Impact	I want my teacher to know…
Impact	The #1 reason I like camp is…
Impact	This camp has changed my opinion about…

Table 3.5 Key Qualitative Statements on Parent Observations

Measure	Statement
Impact	Other kids could benefit from this program because…
Impact	This program has taught my child…
Impact	I wanted to tell Diana…

Research Procedure

The following steps by Efron and Ravid (2013) were used to develop this action research study:

- Step 1: Identify the problem. The problem was identified as a systemic issue starting in elementary-aged females.
- Step 2: Gather background information. Researchers have found in elementary school females articulate that boys were better in STEAM- related subjects, and as a direct result, young females increasingly participate less and less as they progress through school, such as PK-university educational settings (Bryk, 2014; Bulls, 2018; Tomlinson, 2018; Venditto, 2018; Wiest, 2014).
- Step 3: Design the study. This is an action research study aimed to address the impact of a STEAM curriculum on participation and engagement.
- Step 4: Collect data. Both qualitative and quantitative data were collected to create a clearer understanding of the impact of the interventions.
- Step 5: Analyze and interpret data. Data was triangulated between parent observations, participant surveys, and researcher reflections.
- Step 6: Implement and share the findings. Findings were shared with the USC Graduate School of Education (p. 8).

This action research study occurred sequentially with first, a parent application and consent for their daughter to participate in this action research study. Participants were identified and selected to join based on their age (7 to 10), gender (female), access to technology (i.e., internet and Zoom), and the ability to attend. Upon the start of the 2-week action research study, parents completed an initial observation form, and participants filled out a survey. These two instruments provided data about parent and participant opinions, mindsets, and participation in science and STEAM.

The timeline for the action research project was as follows:

- Prior to the start of the study – Identified 15 females ages 7 to 10 years old with parent support, collaboration, and consent. Interested parents submit applications (see Appendix C).
- Day 1 – Parents completed the first observation (see Appendix D). Participants completed an initial survey (see Appendix A). Researcher recorded reflections and video transcriptions (see Appendix H & I).
- Day 2 – Researcher recorded reflections and video transcriptions (see Appendix H & I).
- Day 3 – Researcher recorded reflections and video transcriptions (see Appendix H & I).
- Day 4 – Parents completed second observation (see Appendix E). Researcher recorded reflections and video transcriptions (see Appendix H & I).
- Day 5 – Researcher recorded reflections and video transcriptions (see Appendix H & I).

- Day 6 – Researcher recorded reflections and video transcriptions (see Appendix H & I).
- Day 7 – Researcher recorded reflections and video transcriptions (see Appendix H & I).
- Day 8 – Parents completed third observation (see Appendix F). Researcher's recorded reflections and video transcriptions (see Appendix H & I).
- Upon completion of the study – the researcher compared surveys for quantitative data, and used Tetra Insights and NVivo Insights software to analyze qualitative data.
- Approximately 1 month later – Participants completed follow-up surveys (see Appendix B).

Data Analysis

This action research study used a mixed-methods methodology, where the researcher collected qualitative and quantitative data including parent observations, participant surveys, and researcher reflections. Efron and Ravid (2013) posited that action research studies involve gathering data before and after the intervention was introduced. The quantitative data gathered from parent observations and participant surveys were analyzed to determine the likelihood that the sample population was representative of a larger population of females in the same age range (Mertler, 2017). Numerical data were included to help the researcher maintain objectivity (Efron & Ravid, 2013).

The quantitative and qualitative data from parent observations and participant surveys included Likert-type scales to capture numerical data on participation and perceptions on STEAM and science education. The Likert scale follows a 5-point scale:

(5) Strongly Agree, (4) Agree, (3) Neutral, (2) Disagree, (1) Strongly Disagree. The researcher organized and analyzed the data from the surveys with Google forms, Tetra Insights, and NVivo Software.

The qualitative data were collected from open response questions on parent observations and participant surveys. Additionally, the researcher reflections and videotape transcriptions also contributed to the qualitative data. Tetra Insights and NVivo Software was used to code the qualitative data for emerging themes using a method called open coding, which allowed the researcher to identify similar words, phrases, and sentences to develop patterns (Burnard, 1991). The researcher organized the qualitative data and compared it to the quantitative data to understand the impact of the program from the perspective of the parents, participants, and the researcher.

Triangulation was applied to qualitative and quantitative data sources. Triangulation was a method that allowed for responses to be compared side-by-side (Efron & Ravid, 2013). The goal was to analyze the data to determine the impact of the STEAM program interventions on the females in this action research study.

Summary

This chapter reviewed the research design, methodology, procedures, and data analysis measures applied in this study. The study occurred over the course of 2 weeks using the web application Zoom (16 hours = 16-week semester). The action research study was designed to understand the impact of a STEAM program and interventions on elementary-aged females. The researcher applied a mixed-methods methodology to illustrate the effects of these specific interventions: a transdisciplinary STEAM curriculum, empowerment, CBL, and the 5Es. The goal was to understand the interventions and their effectiveness on student engagement and participation in STEAM.

The researcher used a mixed-methods methodology research design to analyze quantitative data first and then evaluated qualitative data to compare the two subsets of data. Parents completed three observations throughout the study, and participants completed four surveys. Additionally, the researcher recorded reflections and uploaded video transcriptions into Tetra Insights and NVivo software. The researcher used open coding to define similar patterns and develop emerging themes among the sets of data.

Specifically, the researcher focused on data that described participant engagement, thoughts, and perceptions about STEAM and science. During the 2-week study, participants experienced interventions designed using transdisciplinary curriculum, CBL, empowerment, and the 5Es. The findings from the data analysis will be discussed in Chapter 4.

CHAPTER 4

PRESENTATION AND ANALYSIS OF DATA

The following chapter is a presentation of the study's findings and an analysis of the data in this action research study. The goal was to understand how the interventions developed impacted young females studying STEAM. This study was designed to address the loss of participation and engagement of young females experience in elementary education. This chapter presents an analysis of the effectiveness of a STEAM program on engagement and participation in these subjects. The researcher applied a mixed-methodology methods approach to analyze data from parents, participants, the researcher, and video transcriptions during the program.

Problem of Practice

In this action research study, students ages 7 to 10 participated in a program to engage in STEAM education. Participants learned about gender-specific role models in STEAM, their struggles, success, mindsets, and skillsets used to achieve their goals and then solved challenge-based questions working synchronously with peers from across the southern United States to practice dispositions exhibited by the role models. Researchers found that the average female begins losing interest in STEAM subjects around 7 to 10 years old (Courey, 2016; Huhman, 2012). This chapter addresses the impact of a transdisciplinary STEAM curriculum to learn which interventions empower young females to participate and engage in the sciences, technology, engineering, art, and mathematics

Research Question

The action research study aimed to understand how a curriculum designed around STEAM would impact young females ages 7 to 10. Specifically, the research sought to understand:

1) What impact did an empowerment curriculum, utilizing transdisciplinary curriculum, challenge-based learning and cultural, gender-specific role models have on elementary-aged females' participation and engagement in STEAM education?

Significance of the Study

This action research study was significant for a few different reasons. Firstly, an empowerment curriculum is a framework that teachers could use to structure the STEAM curriculum to engage learners in the classroom, which originates from DEI curricula (Lo, 2005). Secondly, this study took place specifically for females ages 7 to 10, which is when females begin to drop out of STEAM-based subjects in school. The information in this chapter addresses the use of these interventions. The findings are not limited to this age group or to females alone, but rather sought to address the inequities in STEM subject education through the implementation of STEAM programs. The researcher found that by adding the arts into STEM, and, therefore, teaching STEAM to elementary-aged females' participation and engagement of the subjects in STEAM increased.

Students Zoomed in from Texas, Georgia, South Carolina, and Florida. The participants attend charter, private, and public elementary schools. Regardless of geographic location and/or educational background, parents encouraged their daughters to participate in STEAM education through this program and others. Parents explained that they desired to expose their daughter to STEAM to help motivate their child to enjoy science, technology, engineering, art, and math.

Data Collection Methods

This mixed-methods action research study used parent observations, participant surveys, researcher reflections, and video transcriptions of the program. The combination of these different instruments allowed the researcher to triangulate the data and identify emerging themes.

Initial Data

To understand where each participant was starting in terms of their participation and engagement in science, STEM, and STEAM preliminary surveys were completed by participants at the beginning of the program (see Appendix A). Additionally, parents completed an observation on their daughters about the impact on the first day (see Appendix D). Lastly, the researcher wrote reflections and video recorded each day to gather data on the effectiveness of the interventions and participant reactions (see Appendix H & I).

The parent observations and participant surveys contained statements using a Likert-scale from Strongly Disagree (1) to Strongly Agree (5) and True and False statements. These instruments formed the quantitative data. Other questions and statements posed to participants were in an open-response format to contribute to the qualitative data, which was in addition to the researcher's reflections and video recordings.

During the Study

Data collected midway was in the form of parents' observations (see Appendix E). Throughout the study, researcher reflections were written daily, and transcriptions of the recordings were uploaded into NVivo software (see Appendix H & I).

Concluding the Study

Upon completion of the program, parents completed their final observation form (see Appendix F). Researcher reflections and videos were completed (see Appendix H & I). The researcher took the following weeks to analyze the data using Google forms, Tetra Insights, and NVivo software. The outcomes were coded and compared to one another to identify emerging themes. Approximately 1 month after the completion of the STEAM program, participants completed a follow-up survey (see Appendix B).

General Findings and Data Analysis

The program occurred in the form of 8 online synchronous lessons for 2 hours per day, totaling 16 hours of STEAM classes for females ages 7 to 10 years old. The researcher provided 2 additional asynchronous lessons for parents and participants. This synchronous component of the program is the equivalent to a 16-week study during the school year. Traditionally, students attend a STEAM class for 45 minutes per week. However, the closing of schools presented the researcher with the opportunity to provide STEAM education as a 2-week program online. The entire study was conducted using the web application Zoom.

The researcher used Google forms to gather quantitative and qualitative data from participants and parents. Researcher reflections and transcriptions of videos contributed to the qualitative data. Below the researcher presents first the quantitative data, which is presented as percentages and organized into tables. The researcher compares and analyzes the quantitative data in sets by reviewing participant results and directly following with the parent observations.

Secondly, the qualitative data is presented in themes with the inclusion of the perspectives of the participants, parents, and the researcher. To understand the perspectives of all three groups, the data were uploaded into Tetra Insights and NVivo software and coded for emerging themes. The researcher used open coding qualitative methodology to identify what patterns in words, phrases, and sentences emerged from the participants, parents, and the researcher herself. The researcher read the data again and again to self-code the data, and used computer software to organize large volumes of text into common themes and patterns (Burnard, 1991). The program allowed the researcher to compare the commonalities between the different data sources. This mixed-methodology approach used quantitative and qualitative data to understand the outcome of the applied interventions (Creswell & Creswell, 2018).

Lastly, the qualitative data were reviewed to understand the impact of the interventions applied. The interventions used transdisciplinary curriculum to teach participants about STEAM through cultural, gender-specific role models, and then presented students with a challenge in the form of a question. The CBL design led students through the 5Es instructional framework as students worked to engage, explore, explain, elaborate, and evaluate (Kahn, 2019). The young girls to persisted alongside one another in a synchronous environment and began to act as a group. They developed shared goals with peers and self-efficacy through group success. Turner and Maschi

(2015) reported increased retention in STEAM education when students feel empowered to solve challenges.

As the program educated participants about women in STEAM, they explored new roles as scientists, engineers, artists, architects, inventors, social justice advocates, and graphic designers as they worked to collectively problem solve the daily challenge. Empowerment theory builds connections among the oppressed and marginalized to come together to reclaim power and equity (Turner & Maschi, 2015). The data presented below began with participants followed by parents and concluded with emerging themes from participants, parents, and the researcher.

Participant Surveys

The data below is presented in percentages of students that answered on the initial survey, which is represented below as "initial." Consequently, the follow-up survey results are reported as "follow-up." Participants completed a survey recording their initial reactions to the program and completed a follow-up survey after the program. The surveys gathered quantitative data to understand the direct impact of the program on participants' participation and engagement with STEAM. Results are first shown by measures of participation and engagement and followed by measures of impact.

Measures of participation and engagement. The first statement presented in Figure 4.1 asked participants to share if they talked about things they learn in science and STEAM with their family as a measure of engagement and participation. Initial reactions included 20% of participants "Strongly Agree" that they shared with their families. After the program ended, 80% of participants "Strongly Agree" that they shared what they were learning in science and STEAM with their families. Researchers explained how a learning outcome of engaging STEAM-based lessons results in students spending time developing their ideas and investigating answers (Milto, Portsmore, Watkins, McCormick, & Hynes, 2020). When participants share what they learn with parents and engage in conversations around STEAM concepts outside of class, it creates authentic, real-world connections to scientific phenomena and values students' individual ideas (Milto et al., 2020).

Figure 4.2 demonstrates the results when participants were asked to reflect on a statement about the amount of time students spend on science and STEAM experiments outside of class was included as a measure to understand participant application of concepts learned in class. Perkins (2014) argued that lifeworthy learning includes understanding as applying. The data above showed that the amount of time students spent on science and STEAM outside of program hours increased. Initially, 30% of participants strongly agreed that they conducted experiments at home; however, by the end of the program, 100% of participants strongly agreed that they convinced their parents to let them conduct science and STEAM experiments at home. The interventions provided students with the skillset to ask questions, create their own challenges, and conduct investigations and experiments in their very own home.

When participants were presented with a learning opportunity in the form of a challenge, they learned a set of skills to work independently, and they increased the amount of time spent engaging and participating in STEAM. Kahn (2019) explained the importance of including modeling skills for students so they understand how to logically approach and solve challenges.

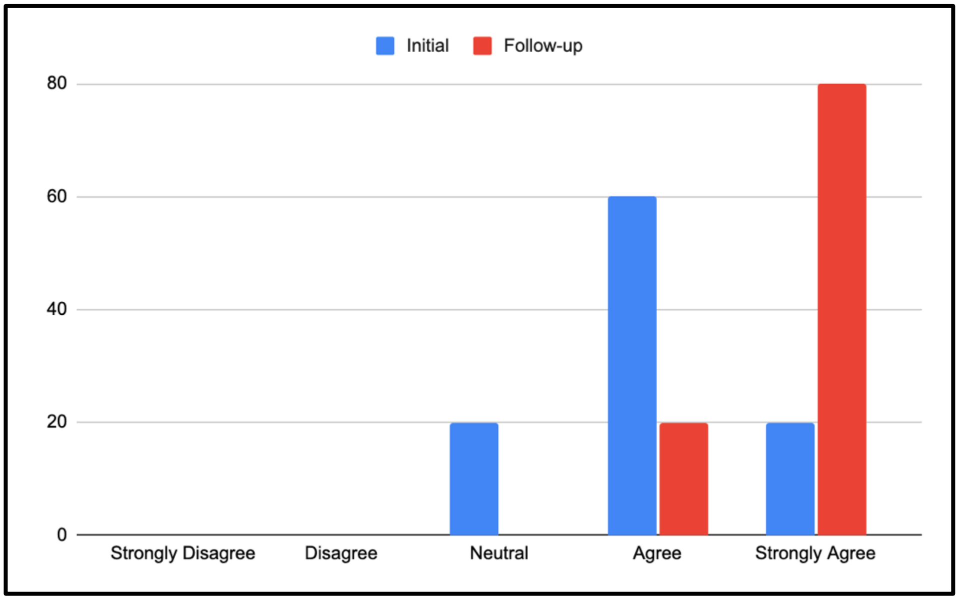

Figure 4.1. I share things I learn about Science & STEAM with my family.

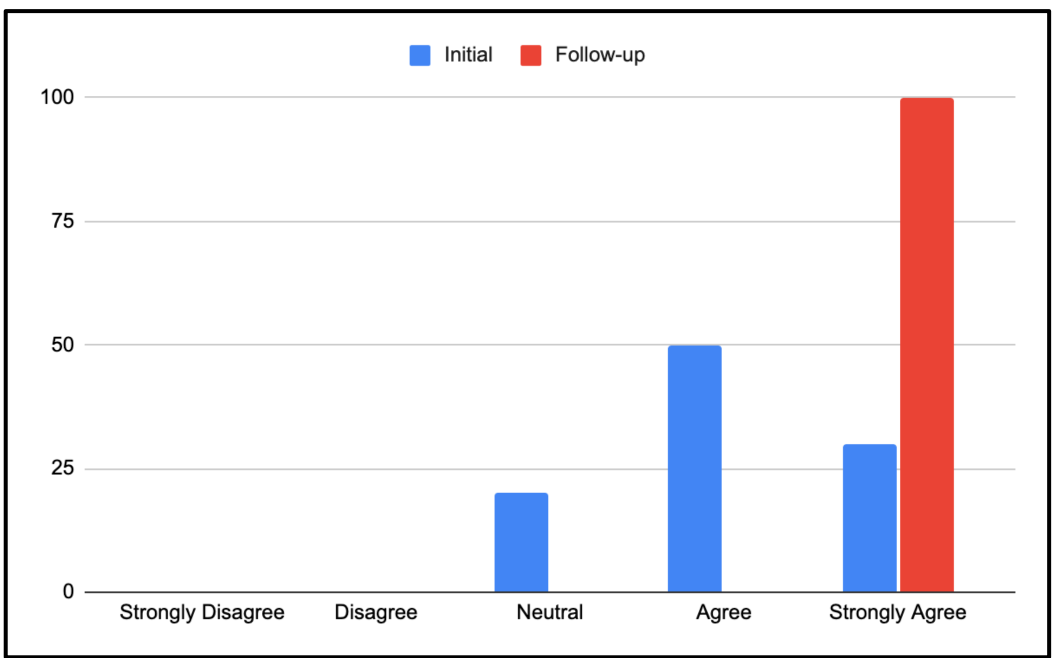

Figure 4.2. I convince my parents to let me do science and STEAM experiments at home (either with them, friends, siblings, other family members, or alone).

Measures of impact. Figures 4.3 to 4.5 demonstrate the results of the impact of the program on females ages 7 to 10. The first statement addressed participants' feeling of confidence about their ability to tackle STEAM challenges and experiments in the program. Originally, only 20% of participants Strongly Agree that they were confident about their abilities to tackle STEAM challenges and experiments. After completing the program, 70% of students marked "Strongly Agree" in terms of feeling confident in their abilities to solve STEAM challenges and experiments. This is a 50% increase in students' confidence and abilities to problem-solve (see Figure 4.3). Research from Espy (2016) concurred that effective role models and teachers inspire students to believe in themselves, and results in an increased student confidence and ability to problem solve.

The second statement addressed participants' ability to see themselves as a STEAM-minded individual. Initially, only 10% of participants thought of themselves as STEAM-minded, and upon conclusion of the program, 100% of participants considered themselves STEAM-minded (see Figure 4.4). Heinecke (2018) posited that STEAM does not require you to be an expert. The definition of a STEAM-minded individual encourages curiosity, experimenting, and trying out different solutions. The intervention of presenting students with a transdisciplinary STEAM curriculum introducing them to role models and CBL that encouraged students to think of *all* the possibilities and to test them *all* out. This encouraged a multitude of answers, group problem solving, and engaged more students in STEAM (DeJarnette, 2018; Harrell & Harrell, 2010).

Finally, the increase of students that thought about pursuing a job in a STEAM-related field increased. Initially, 50% of participants reported Neutral when prompted with the statement, "When I grow up, I want to work in a STEAM-related field." After completion of the program, 50% of participants Strongly Agreed and Agreed that they wanted to go into the STEAM workforce (see Figure 4.5). Espy (2016) and Catterall

(2017) emphasized the importance of using role-models to teach young females about STEAM to increase their engagement and participation in the field.

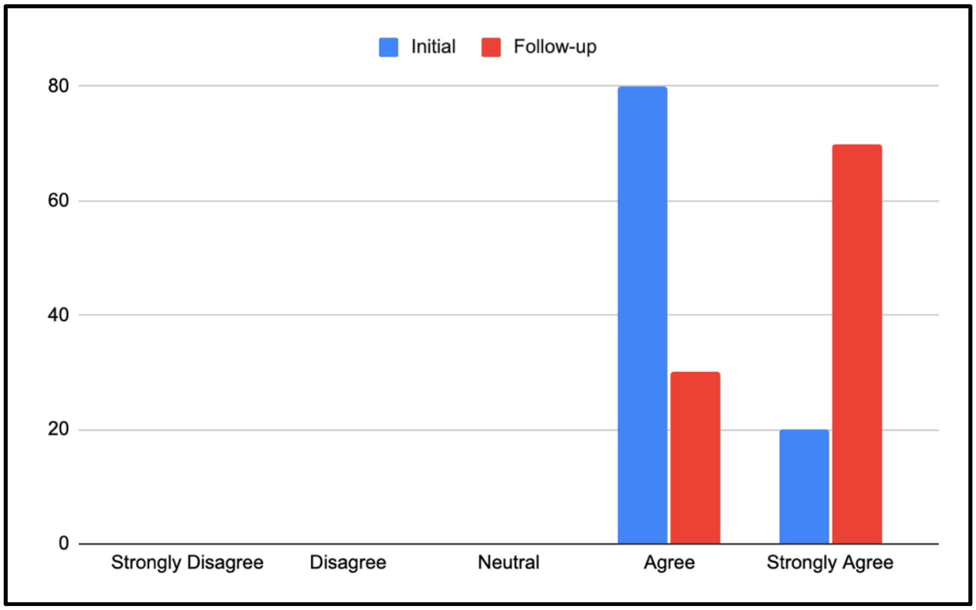

Figure 4.3. I feel confident about my abilities to tackle STEAM Challenges & Experiments.

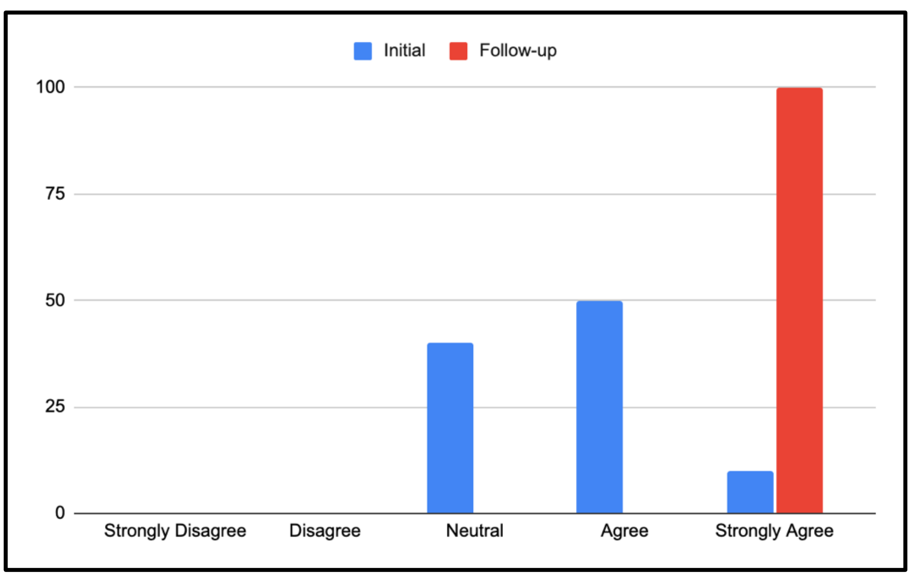

Figure 4.4. I think of myself as STEAM-minded, meaning someone who is curious, asks questions, takes educated risks, and likes to experiment and try different solutions to problems.

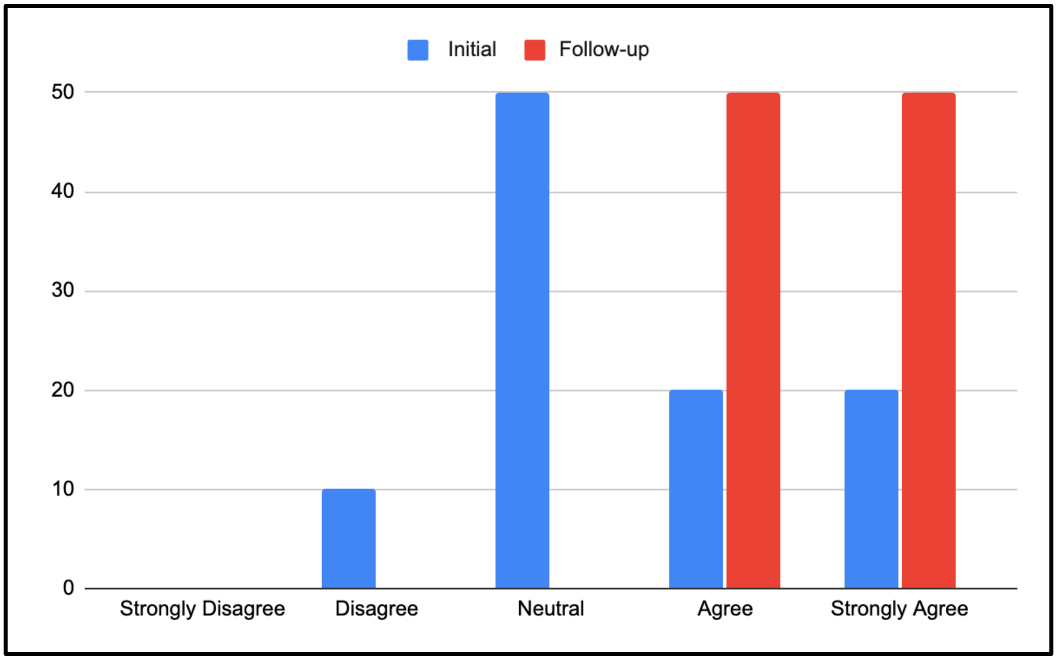

Figure 4.5. When I grow up, I want to work in a STEAM-related field.

Parents' Observations

Parents recorded observations three times throughout the program. Observations occurred on day one, midway through the program, and upon completion of the program. This information informed the researcher on the impact of the STEAM program from the perspective of the parents. The results of the quantitative findings are first shown by measures of participation and engagement and followed by measures of impact.

Measures of participation and engagement. The results show that 90% of parents responded true when prompted by my daughter talks more about STEAM now than before camp (see Figure 4.6). Parent C was the only one to reply no, but her child attends a STEAM program during the school year at a charter school. The conversations around STEAM between parents and their children occurred as a direct result of participation in this program. Catterall (2017) found that encouraging children to have discussions sharing STEAM concepts prepares leads to further innovation and better prepares them for the future. Heinecke (2018) explained that STEAM education encourages enthusiasm and possibility. The data in this study demonstrated an increase in student engagement and participation in STEAM through conversations with family members.

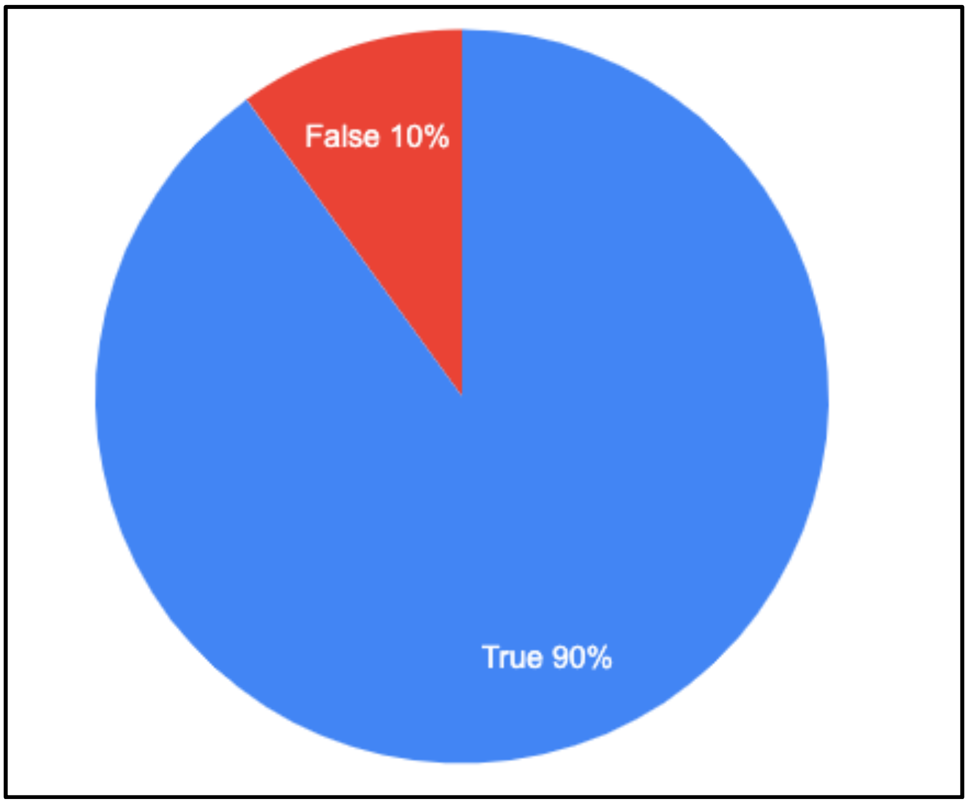

Figure 4.6. My daughter talks more about STEAM now than before camp.

Measure of impact. Figure 4.7 displays that 100% of parents would recommend this program to other families. The results demonstrate the overall satisfaction of parents and participants. Depicted in Figure 4.8, when asked if this program made a big impact on their daughter, 90% of parents responded Strongly Agree. Parent C was the only Neutral response and is the parent of a child enrolled in a STEAM charter school program. Espy (2016) explained that women in succeed when they surround themselves with peers that have similar interests. The parent data supported that the interventions increased females' passion for STEAM as a result of this program.

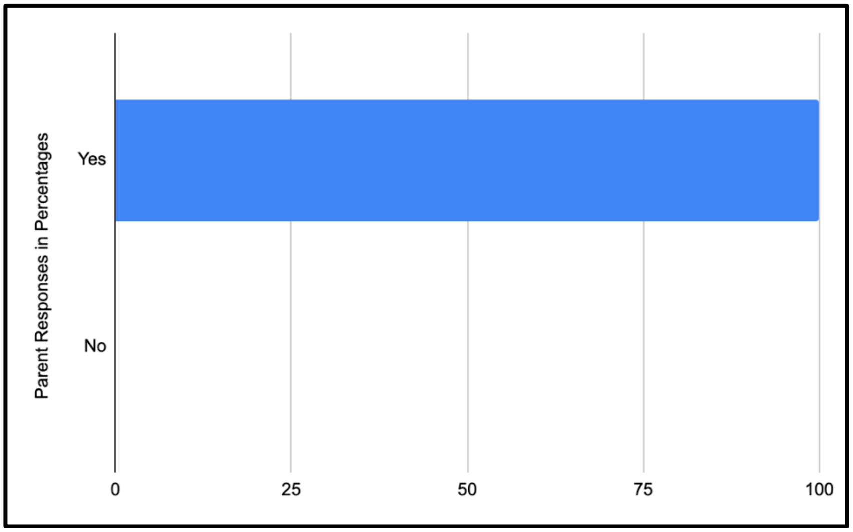

Figure 4.7. I would recommend this camp to other families.

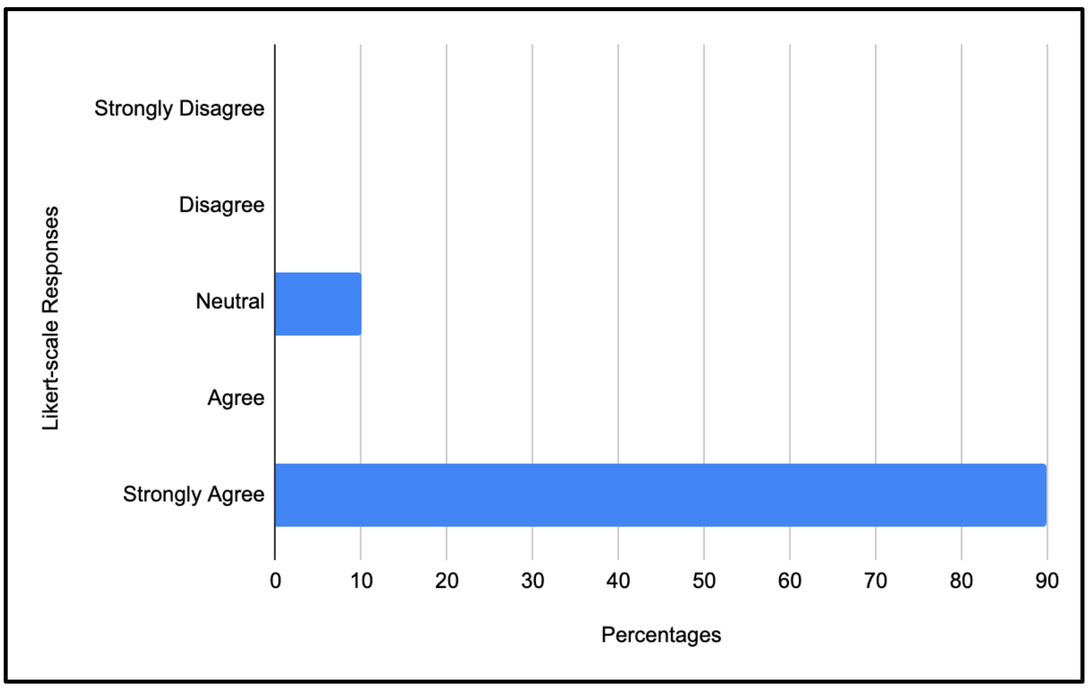

Figure 4.8. The educational programming made a big impact on my daughter.

Emerging Themes

The qualitative data were analyzed using Tetra Insights and NVivo software to identify patterns in the parent observations, participant surveys, researcher reflections, and video transcripts. The researcher open coded the qualitative data using word frequency query to identify emerging themes from the different data sources (Burnard, 1991). Terms added to the coding schema include impact, engagement, participation, role model, girl, and female. Tetra Insights software had a feature where the researcher could watch the videos alongside the transcripts to color code words that appeared over and over again. NVivo Software featured a word frequency query and auto-generated the words most frequently used between the different sets of data. The software made it possible for the researcher to code large amounts of data and compare the impact of the interventions between the parents, participants, and the researcher.

The word frequency query in NVivo Software for the parents revealed the top five words used were science, girls, fun, program, and STEAM. Participants word frequency query resulted in science, camp, love, STEAM, and experiments. The researcher's reflections and the video transcriptions resulted in kids, learning, work, differently, and 2020. The software allowed the researcher to highlight the commonalities between the data.

Both the parents and the participants mentioned science and STEAM. The parents and the participants also demonstrated that the program was fun and how they loved learning. The researcher's reflections captured the limitations of the study and the pivot to an informal instructional setting as a result of the pandemic. The researcher took the codes from the three groups and added in additional coding to answer the research coding. The words used in the search were impact, engagement, participation, role model, girl, female, science, girls, fun, program, STEAM, camp, love, experiments, kids, learning, work, differently, and 2020. These themes were highlighted to allow the reader to identify the patterns in the text and to develop the emerging themes.

Theme 1: Increased Engagement, Participation, and Understanding of Science and STEAM

This was a program designed to engage females in STEAM through transdisciplinary, CBL, empowering students using female role models. The qualitative data described a STEAM program that taught students scientific concepts, problem-solving skills, and yielded confident, curious learners.

The quantitative data from participants shown in Figure 4.2 demonstrated how students increased their amount of time spent practicing STEAM skills independently. Participant G explained the top reason she liked camp was because “I learned a lot of different experiments.” An outcome of the camp was that participants learned how to set up, conduct, and clean up experiments in their own. DeJarnette (2018) found that educating students in STEAM using design challenges led to an increase in student engagement and motivation.

The researcher’s reflections on the first day included the comment that kids are really good at adapting to the new learning environment. In the following lesson, the researcher commented that the participants started to think independently about materials they can use to design their own inventions. The program was designed to empower participants to solve challenges, conduct experiments, and design inventions self-sufficiently. Part of this design was out of necessity. Many parents were also working from home and children attended this remote program from their bedrooms, the kitchen, or the basement. This theme of independent exploration carried over into their playtime, so solving STEAM challenges and conducting experiments became part of play. Parent I said, "This program is extremely fun for kids while they learn, so it's super engaging."

The quantitative data in Figure 4.8 demonstrated that 90% of parents reported this program made an impact on their daughter. Themes that emerged in the data were that the program provided fun, meaningful experiences with connections to role models in STEAM fields. Parent E shared, "It brings science to life through fun experiments and makes connections to female scientists." The researcher's interventions included introducing participants to cultural, gender-specific role models. Example of professions in the STEAM field included engineers, scientists, astronauts, inventors, architects, businesswomen, mathematicians, artists, makers, computer coders, and social justice advocates. Participant B said the top reason she liked the program was because of learning about the role models.

Participants gained an understanding of how possible career paths widened to include the STEAM fields. The quantitative data in Figure 4.5 asked the students to rate on a Likert-scale their response to the statement, "When I grow up, I want to work in a STEAM-related field." Initially, 50% of participants reported Neutral. However, when the program ended, 50% of participants Strongly Agreed and Agreed that they wanted to go into the STEAM-related field. Throughout the program participants solved STEAM-based challenges where they role-played additional identities such as scientist, inventor, architect, mathematician, artist, and engineer.

On the final observation of the program, parents reported what STEAM professionals their daughters talked about at home. Figure 4.9 displays the data from the parents' perspective. The top two professions mentioned in discussions between parents and participants were scientists and inventors. The third most mentioned occupations were engineer and artist.

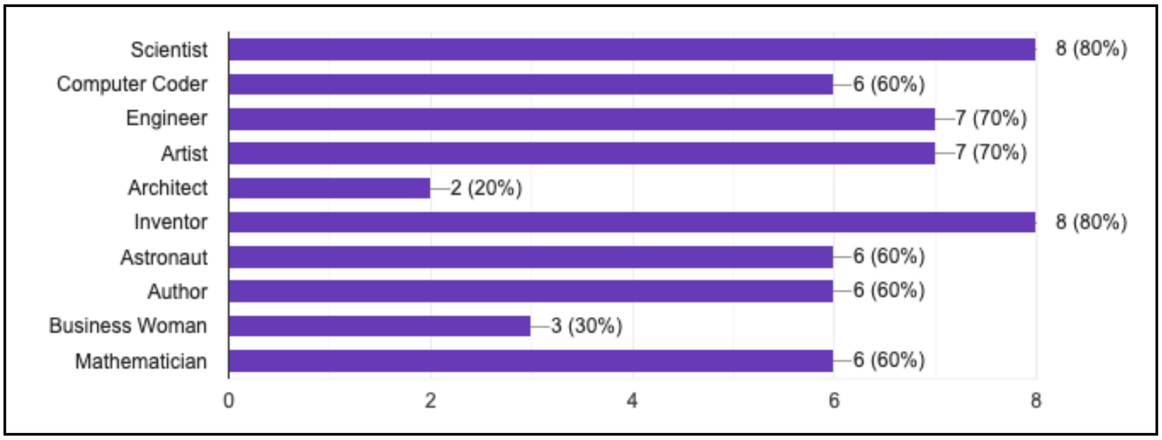

Figure 4.9. My child talks about the following (check all that apply).

Participants expressed a clearer understanding of STEAM, and relation to jobs in the STEAM workforce. When students were exposed to cultural, gender-specific role models in the STEAM field, they were more inclined to test drive, play, or become a STEAM professional. The participants increased their understanding of what types of jobs exist in STEAM based on those displayed in Figure 4.9.

An increased understanding of science and STEAM in the real-world led to further engagement and participation. When asked how this camp has changed their opinion, Participant B said, "being something STEAM when I grow up." In response to the prompt, "the #1 reason I like camp," Participant J said, "I like camp because it is filled with new things that I will learn." Students shared their engagement in STEAM resulted in wanting to continue to pursue in the present and the future.

The RISD also implemented a STEAM program for low-to-no cost to "justify creativity" to provide students with a breadth of opportunities in education and resulted in better preparing students for an "increasingly complex world" (Allina, 2018, pp. 77-78). Similarly, this STEAM program better prepared students to understand the integrated nature of subjects from varying role models' perspective through a sampling of educational activities designed to empower students to design their own challenges, ask questions, problem-solve, and ideate.

Theme 2: Importance of a Female Perspective

The data from the participants demonstrated that this generation of young females believes that females can do anything boys can do. Figure 4.10 displays the participant's reaction to the statement, "Boys are better than girls at (check all that apply)." The possible answers included science, technology, engineering, art, math, or none of the above.

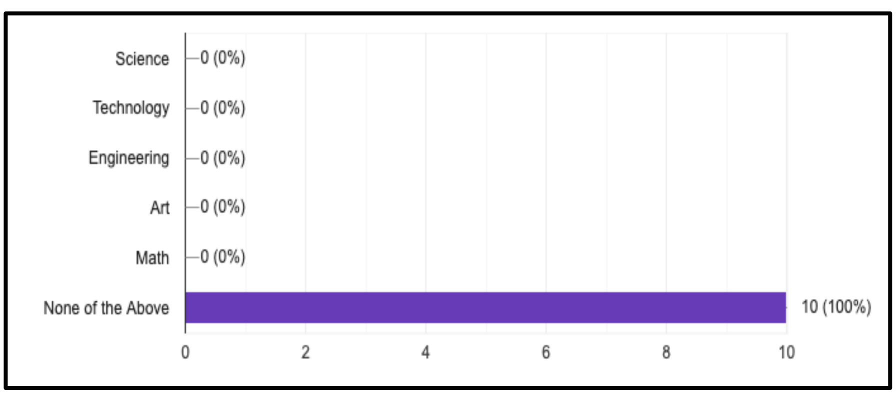

Figure 4.10. Boys are better than girls at…

100% of participants replied none of the above. The findings were unanimous on the initial and follow-up survey. At one point, Participant A wrote the instructor a note in the chat, "You know girls can do anything that boys can do." Parent A shared that the impact of the program on her daughter was an understanding that, "STEAM is fun...not just a school thing...and not just for boys (who might be more dominating in the classroom environment)." From the beginning of the study, the participants and parents explained how they all believed in the equality of females and males to succeed in STEAM.

During the study, the participants were asked to draw a scientist; 100% of the females in this study drew female scientists. All of them drew pictures of themselves dressed up as a scientist, except for one student who drew the researcher. The researcher also asked the participants to draw inventors, engineers, explorers, astronauts, and artists. Every drawing was female. One of the astronauts had a ponytail coming out of her helmet. The data demonstrates that this group of elementary-aged girls believes that the future is female and that the future of STEAM professionals includes females. From the beginning of the study and carrying on after the program, the participants believed that girls and boys were equal. This data further suggested that there was no negative gender effect from the start of the study.

Instead, the female role models were used to impact participants understanding of STEAM and what real-world application of jobs in this field looked like. The most commonly used phrase from participants to describe the female role models in STEAM was that they seemed energetic and fun. The researcher's reflections purposefully shared female role models that worked for National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA) after students requested to learn about women in space. The researcher shared a quote from Christina Koch, "Focus on what you do have instead of focusing on what you don't." Participant C recognized the application of using what you do have and referenced a role model featured in the curriculum. Participant C shared, "It rocked when one of the role models used tweezers from her purse to solve a computer bug problem. She had a tool that none of the men had and used it."

The intervention of using cultural, gender-specific role models led to the development of parents and participants seeing the female gender as an attribute and a quality that made them special. Participants shared how female role models followed their passions—even when other people judged them for it. Participant F explained, "In order to succeed, women in STEAM were role models that wanted to make a positive change in the lives of others." In the follow-up survey, Participant H shared, "You inspired me to follow my heart after learning about role models who followed their passions in STEAM to make a difference in the lives of others."

Parents reported that the STEAM program resulted in a marked growth in their daughter's confidence. FLDOE (2009) emphasized that STEAM instruction includes hands-on learning and that a balanced curriculum includes active learning to better prepare students for with skills for the 21st century. Additionally, Beilock (2019) found that when girls were introduced to females in the field, they become more engaged and interested. The findings in this study support STEAM policy that includes hands-on learning to engage students. The findings also reinforce findings from researchers like Beilock (2019), Catterall (2017), and Espy (2016) about the importance of gender-specific, cultural role models in STEAM and the positive impact on children. This study takes it one step further to support the outcome also increases a female's confidence in their own abilities to do science, technology, engineering, art, and math.

Theme 3: Science and STEAM are Fun

Parents and participants used the words fun and love as one of their most frequently used words to describe this program. Both participants, parents, and the researcher all commented about the role fun played as part of the learning process about STEAM. In the follow-up surveys, when prompted with "I want my teacher to know," Participant D shared, "I love this camp, the camp in general is so fun and I love the experiments." Participant A said, "This camp was really nice and it teaches me new things. And it's fun." The theme of fun emerged and left a lasting impression on the participants.

Similarly, the parents made the same comments about the impact of the program and the researcher on the participants. Parent I said, "You made STEAM fun for my daughter and this intensive, all-girls format was exactly what she needed." Parent H said, "The combination of science, STEAM, and investigations was a format that engaged the participants and created an environment that was fun."

The researcher's reflections and video transcripts include a quote from the researcher where she said, "I hope you continue to be curious and remember that is our theme as we play the game. Let's be curious and have fun." Kahn (2019) shared that the 5Es include engage, explore, explain, elaborate, and evaluate. The STEAM program presented participants with challenges to complete synchronously with a group of their peers and worked through the process of being curious, making mistakes, trying again, and, most of all, having fun. Participant D shared that the #1 reason she liked camp was, "To have fun with my friends."

The researcher's instructions during the program directed participants to enjoy themselves while in the process of problem-solving and the students did just that. The parents and the participants' qualitative data shared that this message was received and performed. Fun generated as a theme within this STEAM program.

Theme 4: Increased Participants' Confidence and Curiosity

Participants applied the 5Es through the exploration of STEAM concepts by conducting experiments. In each lesson, the researcher presented participants with a STEAM-based challenge phrased in the form of a question. The students attempted to solve the challenge by conducting experiments in their own homes while Zooming together synchronously with a group of their peers and the researcher. The curriculum encouraged low stakes trial-and-error, participant design, and reiterating their ideas until they were successful.

Figure 4.11 is an example of one transdisciplinary CBL STEAM lesson designed for this DiP. There were 10 total lessons created for this program. The lesson plan displayed in Figure 4.11 represents the connection between STEAM and CBL and how the researcher wrote planned, applied, and assessed the curriculum and student work.

STEAM CBL LESSON PLAN DESIGN
Standards-Based – What standards are used to this lesson?
NGSS (Science)
2-PS1-1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties. 2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose. 2-5-PS1-3. Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.

ISTE (Technology)
Knowledge Constructor 3a-3d. Students critically curate a variety of resources using digital tools to construct knowledge, produce creative artifacts and make meaningful learning experiences for themselves and others. Creative Communicator 6a-6d. Students communicate clearly and express themselves creatively for a variety of purposes using the platforms, tools, styles, formats and digital media appropriate to their goals. Global Collaborator 7a-7d. Students use digital tools to broaden their perspectives and enrich their learning by collaborating with others and working effectively in teams locally and globally.
NGSS (Engineering)
3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
NCCAS (Art)
VA:Cr1.1.5&6aCombine concepts collaboratively to generate innovative ideas for creating art. VA:Cr2.2.K-5a When making works of art, utilize and care for materials, tools, and equipment in a manner that prevents danger to oneself and others. VA:Cr2.3.2a Repurpose objects to make something new. VA:Cr3.1.2a Discuss and reflect with peers about choices made in creating artwork.
CCMS (Math)
K-4.MD.A.1 Describe measurable attributes of objects, 4.MD.A.1 Know relative sizes of measurement units within one system of units K-3.MD.A.2 Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference.
CCELA (Literacy)
RI.2.3 Describe the connection between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text. SL.K.3 Ask and answer questions in order to seek help, get information, or clarify something that is not understood. SL.K.5 Add drawings or other visual displays to descriptions as desired to provide additional detail. SL.4.5 Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes. *optional asynchronous activity in Seesaw
Reverse Engineer the Lesson using CBL
Challenge Question: What do you want the students to find out? How? Who? Why?
What happens when you stick a dried out marker in water? What do you create? How does the level of water effect your outcome?
Supplies Needed
water/water bottle, clear cup, measuring cup/ruler, markers that can be ruined (preference for dried out markers to include sustainable practices), paper, paint brushes

Learning Goal
Student(s) will be able to... Make predictions, share hypothesis, make, share, and communicate observations, measure the amount of liquid used, recording findings, compare with peers, discover that students recycled an old marker by turning it into paint, use the paint to produce a picture, perform the problem-solving activity Possible problems or challenges that may arise… Possible solutions… Some students will want darker paint Use less water, try fresh marker Some students will more than one color Put more markers in diff. H2O
Vocabulary
Cohesion – the scientific process used to explain why the water changes color. Cohesion – sticking together, apply this principle to us and the peers in the group EX: We are a cohesive group that sticks together and helps one another out when we get stuck.
Teacher Reminders
Leave enough time to do the painting. Ask students to work on paintings while listening to the role model in the lesson to save enough time for the game and today's message journal activity. Remind students to share their work on Seesaw application. If you run out of time for students to share paintings with one another, share their Seesaw pictures with classmates the following day. *Criteria – demonstrate an understanding of what is happening inside the cup, how to measure, what works best, have fun *Constraints – real-world applications, such as, supplies, technology, ability to problem-solve
Assessment Tools/Student Work Samples
SHARE OUT DEMO GLOW/GROW PORTFOLIO JOURNAL RUBRIC PRESENTATION *highlighted text represents assessment tools used in this lesson

Figure 4.11. Sample STEAM CBL Lesson.

The impact of the curriculum design presented itself from their comments in the video transcriptions as they worked to solve the challenge. Student M talked about the importance of asking lots of question and brainstorming with others. Student H explained that one role model taught her how not to be intimidated by a problem and that she broke down problems into pieces. When faced with a CBL question and given the tools to find the answers, participants worked, ideated, and collaborated with one another to brainstorm and test out multiple solutions.

The researcher's reflections and video transcripts revealed that when Student I struggled to successfully solve a challenge, she said outwardly to the entire group, "I cannot get this to work." The researcher resisted from sharing an idea, Participant G jumped in and offered a suggestion with the phrase, "Try this." The transcripts were filled with supportive language where the students' shared solutions and ideas with one another as a way to be kind and helpful. The outcome was a group of females working collaboratively to help one another find success.

The curriculum empowered the females to use their voice as a tool to collaborate. The web application Zoom offered learners a variety of ways to express themselves. Some students typed comments into the chat to share ideas with other participants, while other students raised a physical hand and waited to be called on to share their thoughts. When the internet was choppy, students wrote down ideas on paper and held up the paper to the screen. Together the participants discovered a variety of ways to express themselves, but one thing was certain, they made sure their voice was heard.

The researcher's reflections included comments, "They all shared. Everyone tried out ideas and gave it their best." When prompted with, "This program has taught my child," Parent B replied, "Confidence, being creative, thinking about STEAM concepts, reasoning skills." Fink (2015) found that "Students who believe their abilities can grow with practice are much more likely to persist than those who believe they possess the limited ability." The data in this study support this growth mindset by actively teaching students that openly asking for help, persist, try again, and work through iterations of their designs becomes part of the routine in a STEAM class. Therefore, all the participants began to see themselves as someone who was capable of success.

Research Question Analysis

The data from parent observations and participant surveys were combined with researcher reflections and transcriptions. The data were coded and analyzed to determine emerging themes. Specifically, the mixed-methods design was used to understand the impact of the STEAM program's interventions: a transdisciplinary approach, CBL, empowerment curriculum, and the 5Es.

The researcher asked the following question to guide the action research study:

1) What impact did an empowerment curriculum, utilizing transdisciplinary curriculum, Challenge-Based Learning and cultural, gender-specific role models have on elementary-aged females' participation and engagement in STEAM education?

The impact of teaching elementary-aged students about STEAM resulted in an increased understanding of real-world application of role models in this field, qualities and mindsets of those who succeed, and the important trait of persisting even after failing. The participants practiced being STEAM-minded, curious individuals by conducting experiments to solve challenges. They worked synchronously with a group of their peers during program hours and data gathered demonstrated that they worked asynchronously solving their own STEAM challenges on their own. All of the parents and participants reported an increase in the time spent practicing STEAM skills, mindsets, and challenges outside of program hours. The CBL intervention prompted participants to practice strategies to problem-solve through asking questions, problem solving, and group collaboration.

Several participants discovered that STEAM role models failed, persisted, and created multiple iterations of their ideas. Student A observed that role models often failed a couple of times, and that they tested many ideas. During the experiment time in the program, the researcher reflections revealed that participants would get stuck while trying to solve the challenge. This was intentional by the researcher. The instructional design used empowerment through educating participants about traits of role models, and then presenting them with CBL & the 5Es opportunities to develop participants' ability to persevere. Along the way, participants began to group work and they encouraged one another to test out other ideas so they could all achieve success.

Frequently, when a participant was stuck, peers offered advice to one another with strategies on how to improve, and the researcher modeled instructions for students as well. Participants increasingly shared what worked and also began to cheer on failure and iterations of ideas as part of the learning process in STEAM. Researcher reflections cited how participants contributed instructions, questions, ideas, and advice to other participants on how to achieve success at solving STEAM-based challenges. Parent A shared, "This program has taught my child confidence and persistence."

Many students felt empowered by the all-female setting, which included a female researcher. Participants listed the researcher as a role model for women in STEAM. In addition to gender-specific role models (22), participants were also introduced to culturally diverse females in the STEAM fields (12). Role models included children in STEAM (9) and references to their own childhood (7). The wide range of role models enhanced the participants' understanding of what a STEAM professional looks like and their understanding of who has the ability to succeed in science, technology, engineering, art, and math.

Another gain the families reported was a positive impact on their daughter's ability to try out being a maker, inventor, scientist, mathematician, engineer, and more. Specifically, Parent H commented, "The main impact of camp on her daughter was taking on the identity of a scientist." Parent C shared, "Learning about positive role models who are all interested in STEAM made a big impact on her daughter." Parent F explained how, "This program increased her [daughter's] desire to be a risk taker." Participants increased their willingness to fail, ask for help from peers, iterate, and persist using different strategies to problem-solve. Comments from Participant J suggested that, "In order to overcome obstacles, many times, the role models demonstrated bravery."

The participants observed how the role models frequently experienced failure and produced many ideas when attempting to solve a problem. STEAM role models demonstrated the necessity to test out different iterations of their ideas and modeled persistence when faced with failure. Student L shared how, "One STEAM role model had people make fun of her and her ideas." Participant E wondered, "Why people didn't believe in her ideas?" Regardless of why others did not believe in the STEAM role model, Participant J observed that, "She wasn't scared to state her opinions and test out ideas."

An underlying theme that emerged was a determination and a growth mindset by the female role models in STEAM. The researcher taught participants the importance of not giving up and that iterating many times before succeeding is part of STEAM. Student B explained, "I saw that the role model never gave up and then this participant went on to emulate this behavior in the experiment that day." The researcher's reflections included that, "Students learned to take risks, try again, and fail forward."

Parent J shared, "The experiments are fun, the discussion is engaging and meaningful. Our girls need to see and discuss women in less traditional roles." Parents reported that this program made a big impact on their daughter. The qualitative and quantitative data demonstrated an increase in participant's confidence and abilities in STEAM. Parent C said, "She feels empowered and so encouraged by your classes."

The interventions encouraged the process of tinkering and designing answers to the STEAM-based challenges, which is part of MCL. When this hands-on approach is paired with CBL and the 5Es in a transdisciplinary curriculum, the outcome was female empowerment. At the end of the STEAM program, the researcher specifically prompted students with, "This camp has changed my opinion about…" Participant I shared, "I learned I can do anything as long as I put my mind to it." Student H wrote, "How girls can do anything." The data in this study confirm the findings of other researchers who describe similar outcomes. Specifically, when STEAM, MCL, and CBL were combined, the outcome was authentic learning experiences for participants who felt confident in their own abilities to tackle challenges in school and the real-world (Allina, 2018; DeJarnette, 2018; Farland-Smith & Thomas, 2017).

Online Learning for Elementary-Aged Students

While not the intended focus of this action research study, the entire study was conducted using Zoom, taught 100% online, and all interactions were included in distance education. Data in this study offers information about the efficacy of learning online for elementary-aged students. In 1987, Keller, an educational curriculum designer, wrote, “How many times have you heard a teacher or designer say, I know my subject, but I’m not really an entertainer?” (p. 2). Online education and distance learning transitioned many parents and educators into subject matter experts *and* entertainers that worked together to bring education into each child’s home.

The role model read alouds and videos of experts in the field were presented by the instructor in a catchy way using YouTube to create pre-recorded videos. The medium of using YouTube to teach gained and sustained student interest and engagement. Reneau (2020) reported in a study that during quarantine many people, parents, and children, were feeling the increased desire to go into shutdown mode. The STEAM program gave students the opportunity to engage with their peers and learn about STEAM subjects in a synchronous setting. If participants wanted to work more on activities in the program, the researcher provided asynchronous activities in the Seesaw application and students also had access to the researcher’s YouTube channel to watch role model read alouds and speeches from experts again and again.

This action research study pivoted from a 16-hour, in-person classroom study (1 hour/week for 16 weeks) to a 16-hour summer camp STEAM program. The option to move to an online format for class instead of an in-person classroom experience was made out of necessity due to the pandemic. This action research study was presented to parents and participants as Inventor’s Camp – STEAM Themed (see Appendix H).

One effect of converting to an online program versus an in-person program was a wider range of participants’ geographic location. Students were located in Texas, Florida, Georgia, and South Carolina. Additionally, the researcher was able to use digital tools to gather data, such as, video recordings of sessions and Google Forms. Furthermore, the digital instruction allowed the researcher to incorporate digital instruction tools such as YouTube, Seesaw, and Zoom. An online program made the STEAM program possible and received IRB approval during a pandemic.

As a result, this study's findings inform parents, educators, and administrators about possible digital tools and transdisciplinary STEAM curriculum designed to engage elementary-aged girls. The study demonstrated the possibility to bring STEAM into each child's household through interactive, teacher-facilitated synchronous instruction. Parents and participants shared their motivation to participate in STEAM education. The online medium for instruction fostered students to build connections to a group of peers around the topic of STEAM and provided a safe environment to practice newly learned skills and mindsets.

Diversity, Equity, Inclusion

The demographics of the camp were females from racially diverse backgrounds between the ages of 7 to 10. The participants attended private, public, and charter school programs across the southern United States. The participants demographics range across diverse populations, background in educational settings, and access to STEAM programming. All of the parents commented that they enrolled their daughter in this program, because they wanted their child to have exposure to the emerging educational field of STEAM.

To encourage the participants to feel represented in STEAM, the researcher matched the role models from the workforce and the protagonists in the read-alouds to the racial backgrounds of the students. The role models were Black, LatinX, Asian, Biracial, and White, just like the girls in the program. The female role models demonstrated how they overcame obstacles and what actions they took when faced with adversity. The researcher purposefully featured role models that demonstrated STEAM mindsets and skills. Additionally, the STEAM curriculum was aligned with the NGSS, International Society for Technology in Education (ISTE) Standards, Engineering Design Standards (NGSS), National Core Art Standards (NCCAS), Common Core Math Standards (CCMS), and Common Core ELA/Literacy Standards (CCELA, see Appendix K for a complete list of standards).

100% of the read-alouds selected for inclusion in the STEAM program were authored by female authors and featured female main characters. Researchers state the historical importance of closing the gender gap in STEAM education by exposure to cultural, gender-specific role models in the fields of science, technology, engineering, art, and math (Catterall, 2017; Espy, 2016; Gilbert, 2015; Mace, 2018). The curriculum predominately featured women's role models to depict a wider range of understanding and depth for what a scientist, programmer, engineer, artist, and mathematician look like. Additionally, this action research study expanded from to include role models, such as, astronauts, pilots, computer coders, chemists, graphic designers, authors, and businesswomen. The STEAM program taught participants the importance of empowerment and how to actively engage in breaking down barriers of stereotype threat based on gender and race.

The opportunity gap for women still lags far behind men in STEAM education and the workforce (Anthony & Ogg, 2019; Bulls, 2018; Cimpian, 2018). This action research study demonstrated the benefits of early interventions to educate elementary females about cultural, gender-specific role models in STEAM. Muhammad (2019), author of *Cultivating Genius: An Equity Framework for Culturally and Historically Responsive Literacy*, recently said in a webinar on abolitionist teaching and the future of our schools, “The pandemic taught us the power of our teachers. We need to teach kids how to navigate racism, actively speak up, and teach more than just skills.” The empowerment curriculum designed for this study offered students a chance to connect to cultural, gender-specific females in STEAM and shared the struggles these women faced to become who they are today.

Summary

This chapter explored the findings of the research question: What impact did an empowerment curriculum, using transdisciplinary CBL curriculum, and cultural, gender-specific role models have on elementary-aged females’ participation and engagement in STEAM education? It sought to answer how the interventions designed, would impact females in STEAM. The study had a mixed-methods methodology design, and the researcher collected data through parent observations, participant surveys, researcher reflections, and video transcriptions of each lesson. The researcher analyzed the data using comparative analysis to identify emerging themes in the data from the different sources.

The results from the findings suggest that the students’ participation in the STEAM program led to an increase in their self-confidence, participation, and engagement in STEAM. Additionally, the researcher’s reflection emphasized the ability of the students to collaborate with one another by sharing ideas, asking for help, and learning the power of their voice as a tool in their educational toolkit. Additional findings, conclusions, and recommendations for further research are detailed in Chapter 5.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Despite recent efforts to increase the number of females in STEAM, gender inequities in education and the workforce persist (Beghetto & Baxter, 2012; Carmichael, 2017; Clewell & Ginorio, 2002). The PoP developed out of the lack of data on the effectiveness of STEAM curriculum and the effectiveness of interventions on the engagement of young female students in elementary school. The PoP that emerged out of systemic issue where young girls begin to lose interest in academics beginning in elementary school, therefore, a STEAM program was developed for this action research study to encourage females to participate in these fields (AAUW, 2017; Long & Davis, 2017).

This study examined the impact of a STEAM program on young females' engagement and participation in STEAM education. STEAM over STEM was selected because the arts in STEAM adds another lens to learning and engages a wider variety of students, specifically, females and students of color (Jamalian, 2018; Quigley et al., 2020). Additionally, STEAM curriculum teaches problem-solving skills, encourages collaborative learning, and facilitates deeper understanding of concepts with connections to the real world (Ignotofsky, 2016; Kirschner, 2020; Quinton, 2014). This action research study was designed to introduce STEAM to young females through an interactive program.

The goal was to understand if their outlook on STEAM education changed as a result of interventions designed to challenge and engage females in these subjects. Researchers found that the first noticeable gender-based differences in STEAM subjects begin to appear in elementary school (Beede et al., 2011; Cifaldi, 2018; Ignotofsky, 2016). Increasingly, more females lose interest in STEAM subjects as they advance through the educational school system (Anthony & Ogg, 2019; Cifaldi, 2018; Clewell & Ginorio, 2002). This action research study was designed to address ways to engage young elementary-aged females to participate in STEAM.

The targeted interventions included transdisciplinary STEAM curriculum using cultural, gender-specific role models, CBL, and the 5Es. To define cultural, gender-specific role models and what is intended by this statement in this study, the researcher matched the cultural identity of the participants and made sure that every female in the program was exposed to a role model that looked like them and came from a similar cultural background. This practice was developed from empowerment theory and turned into curricula where students read books, watched videos, met and interviewed a role model in the STEAM workforce (Lo, 2005; Quigley et al. 2020). Throughout the program, participants shared their reactions to learning about these women in STEAM. Stories about the role models included the educational path they took to get to where they are today. Other information about the role models included what they were like as a kid and the skills and mindsets they recommended to be successful in STEAM.

The literature review in this study explored the existing research surrounding STEAM curriculum, legislation, research, education standards, and existing stereotypes in this field. From 1992 to 2020, researchers have reported that textbooks mainly portray

White males as the role model for success (AAUW, 1992, 2017; Clewell & Ginorio, 2002; Kirschner, 2020). The practice of teaching about males over females continues (AAUW, 1992, 2017; Kirschner, 2020). Female students, and the students of color, internalize the portrayal of successful White male role models to mean that people like them do not study into STEAM (Beilock, 2019; Fink, 2015). The stereotype threat of this is that people who are female or a minority do not grow up to work in STEAM fields (Cimpian, 2018).

Cimpian (2018) argued that as soon as girls enter school, they are underestimated. As young as 6 years old, females began to vocalize that boys are better in science and math (Venditto, 2018). The research has demonstrated repeatedly how starting at an early age, young children of both sexes internalize STEAM stereotypes (Tomlinson, 2018). In recent years, researchers have encouraged educators and parents to introduce children to STEAM education at an early age and an introduction to role models to build excitement about science, technology, engineering, art, and math (Anthony & Ogg, 2019; Grant & Patterson, 2016; Tomlinson, 2018). These actions create a foundation for developing an interest, the skills, and a mindset necessary to succeed in the STEAM workforce (Allina, 2018; Beilock, 2019; Fink, 2015; Harrell & Harrell, 2010).

This action research study aimed to address the PoP and understand ways to engage young females in STEAM education. The interventions were designed to empower young females to believe in themselves as able to learn the skills and mindsets necessary to succeed in the STEAM and educate them about women who have achieved in this field.

Research Question

This study aimed to understand how a STEAM program grounded in empowerment theory would impact young females' interest in these subjects. Specifically, the researcher sought to understand:

> 1) What impact did an empowerment curriculum, utilizing transdisciplinary curriculum, Challenge-Based Learning and cultural, gender-specific role models have on elementary-aged females' participation and engagement in STEAM education?

Purpose of the Study

The purpose of this study was to provide a STEAM program for females ages 7 to 10 to engage in activities to learn about these subjects. The STEAM program was offered as a summer camp titled Inventor's Camp - STEAM Themed. It took place for 2 hours a day for 8 days total over the course of 2 weeks. This program was equivalent to a 16-week program designed to be implemented in a STEAM class for students in grades 3 to 5. At the time the researcher applied for IRB approval, only online studies were being approved. This led the researcher to pivot and implement the STEAM program as an online summer camp that was equivalent to one semester of educational programming (totaling 16 hours of educational time).

The transdisciplinary STEAM curriculum used empowerment, CBL, and the 5Es as the main components for instructional design. Subsets of other theories applied include MCL and PBL. Empowerment and feminist theory were applied to increase females' awareness of their own ability to learn by introducing them to successful female role models in STEAM that demonstrated active struggle and shared experiences from when they were a child. The framework of the instructional design encouraged participants to actively engage in their own learning.

Results Related to Existing Literature

The research demonstrated young females initially participate less and less in STEAM subjects in elementary school, nevertheless, this study demonstrated the impact early interventions on the females in this program as a successful example (Anthony & Ogg, 2019; Davis, 2017). While much of the academic research mainly focused on STEM interventions on women at the college, high school, and middle school level, this study sought to inform STEAM educators focused on elementary-aged learners in an informal educational setting.

STEAM programs, such as the one in this action research study, play a key component in gender equity in elementary education. This study found that exposure to gender-specific, cultural role models for students in the program, resulted in a confidence boost. Yet, at a very young age, females' participation decreases in STEAM education beginning in elementary school due to gendered stereotyping experiences (Berwick, 2019). Existing literature reported that women who pursue careers in STEAM continue to remain a minority in the workforce (Beede et al., 2011, 2017; BLS, 2019; Funk & Parker, 2018; Ignotofsky, 2016).

This study presented findings to support the effectiveness of a STEAM program for young females and the direct impact on their engagement and participation. This participants in this study shared that when early interventions were introduced to elementary-aged females, their ability to understand, participate, and engage in the STEAM field increased. The students learned the importance of their own efforts, collaboration, practicing failure, and sharing ideas with classmates. The empowerment curriculum developed for this program taught learners the tools and mindsets needed to become successful in STEAM. Examples of those tools include, a growth mindset, a STEAM-mindset, the power of their own voice, and the importance of collaboration.

Change-Based Learning and a Growth Mindset

The literature stated that when educators integrated STEAM into curricula, the outcome was enhanced student engagement and interest (DeJarnette, 2018; Hunter-Doniger, 2018; Long & Davis, 2017). Consequently, standards in education, such as the NGSS Lead States (2013, 2017), ISTE (2020), NCCAS (2014), CCMS (2020) were updated to encourage educators to design engaging curriculum that fostered creativity, hands-on learning, and opportunities for transdisciplinary learning for elementary-aged students (Cunningham & Berger, 2014; Drake, 2012). This study demonstrated the impact of using standards-based instructional frameworks, such as the 5Es and CBL, within a transdisciplinary STEAM curriculum. The outcome for the participants in this study was increased engagement and participation for elementary-aged females. Furthermore, the curriculum in this study also increased participants' understanding of the STEAM workforce and what women in this field look like.

The students demonstrated eagerness and enjoyment from transdisciplinary CBL, hands-on learning opportunities. The data in Chapter 4 also demonstrated how majority of participants commented on their enjoyment from CBL structured learning, a synchronous, supportive environment with a group of their peers, and learning about female role models. CBL was as a framework for STEAM hands-on opportunities to increase student engagement by providing multiple right answers. Researchers in support of CBL explained that students' engagement increases because of their curiosity to solve the challenge (Bender, 2017; Casteel, 2018; Drake, 2012).

The curriculum methodology of teaching students by asking a guiding question in the form of a challenge (CBL) leads to individualized processing, understanding and memory of science, technology, engineering, art, and math educational standards and skills (Ertmer & Newby, 2013; Harasim, 2012; Tebes, 2018). The data in this study demonstrated what researchers in other studies have found: when STEAM curriculum includes transdisciplinary approach combined with CBL students collaborated on iterations of their ideas, it increased student engagement and participation in STEAM (Bulls, 2018; Bryk, 2014; Casteel, 2018; Courey, 2016; Snow, 2014; Weist, 2014). This action research study supports these findings: engaged, hands-on learning—even remotely—proved to be an effective approach to participation and engagement of elementary-aged females in STEAM.

Additional findings exhibited in the data included students reporting increased positive attitudes and practice using growth mindset when applied to STEAM subjects. Existing research demonstrated the importance of peer-to-peer collaboration and CBL strategies in educational settings for purposes of furthering a transdisciplinary approach in education, specifically, the need for educators to present students with real-world challenges to solve in the form of experiments so students are presented with the opportunity to practice problem solving, iterating, and applying critical thinking skills (Drake, 2012; Dweck, 2010; Johnson et al., 2009; Tebes, 2018; Weist, 2014).

Researchers stated that when students learn that with hard work and dedication they are capable of learning anything, this practice is commonly referred to as a growth mindset (Buoncristiani & Buoncristiani, 2012). The curriculum in this study provided participants with the opportunity to take educated risks and fail often before attaining success. This transdisciplinary curriculum design used CBL, the 5Es, and role models to educate students about the importance of developing a growth mindset and STEAM-minded way of thinking. The data in this study demonstrated that transdisciplinary CBL, and role models incorporated into a curriculum taught participants perseverance, which is needed in the STEAM field where failure occurs (Buoncristiani & Buoncristiani, 2012; Quinton, 2014).

The STEAM program offered participants challenges to solve and modeled how to use a growth mindset with peers in a supportive environment. The effectiveness of transdisciplinary curriculum, CBL, and role models in a curriculum designed for this STEAM program resulted in increased student participation, collaboration, and practice of a growth mindset.

Major Points of the Study

As a result of the STEAM program, participants experienced a growth in self-confidence and further understanding of STEAM subjects. Participants learned to use their voice as a tool to collaborate, ask for help, and advocate against the unfair treatment of females. Finally, participants identified STEAM mindsets and skillsets necessary to achieve in this field.

While the stereotype threat that boys are better than girls in STEAM subjects still endures in schools and society today, participants in this program disagreed (AAUW, 1992, 2017; Bender, 2017; Berwick, 2019; Bulls, 2018; Kirschner, 2020; Quinton, 2014; Venditto, 2018). The data in Chapter 4 illustrated in Figure 4.10 revealed that the females in this program believed girls and boys are equal in the STEAM field. As illustrated by the data, 100% of participants collectively believed in gender equity and achievement in the STEAM.

Other findings demonstrated by the data in Chapter 4, Figure 4.5 concluded that participants' perspective of who works in the STEAM field widened as they gained a real-world understanding through purposeful education about women in the workforce. Their overall understanding about STEAM and inventors widened because of the direct teaching about cultural, gender-specific role models featured in the program. The STEAM empowerment curriculum was designed to share examples with participants about successful women in STEAM and offered students an idea of what it was like to work in the field and the importance of developing skills and mindsets necessary to succeed.

As a result of STEAM interventions in this study, students practiced sharing success, failure, and iterations of ideas with one another, which supported learning together, practicing growth mindsets, and the importance of testing multiple solutions. The research gathered in this study demonstrated that when participants were given the opportunity to practice STEAM-minded skills, the amount of time spent engaged in this area increased. The exposure to the STEAM program taught participants the skillset and mindset needed to participate in these subjects. When solving STEAM challenges, participants practiced failing numerous times before succeeding.

In conclusion, the study drew awareness to the females' ability to succeed in STEAM through practice, failure, collaboration, and learning about women in STEAM. Elementary-aged females in this study believed that girls can do anything boys can do.

The STEAM Program designed for this action research study taught the participants the skills and mindsets necessary to achieve success in STEAM education and the workforce.

Action Plan for Implementation

If we wish to advance our evolutionary journey as a species, a shift from feeling sorry for the disadvantaged to fearing STEAM without females is essential (Dangelmaier & Hermann, 2017). The action plan is described in two parts. First, the necessary steps to implement a program like the one described in this study are listed in detail for others wishing to establish STEAM programs in their elementary schools to engage females and BIPoC students. Secondly, the researcher describes the action plan for herself as a result of the findings from the data in this study.

The goals for implementing a STEAM program in an elementary school:

1) Early intervention – start the program at the earliest level of learners, pre-kindergarten or kindergarten (elementary-aged students).
2) Write STEAM curriculum that includes a transdisciplinary approach, CBL and the 5Es framework. Align curriculum with national standards (see Appendix K).
3) Empowerment curriculum – Find books, videos, speakers that feature gender-specific, cultural role models. Encourage students to develop their voice, identity, and mindsets as tools in the STEAM toolkit.

In order to accomplish these suggestions, many schools are recommended to convert from the traditional siloed science education methods to an interdisciplinary STEAM-based approach. The outcome of taking these action steps generates STEAM programs where students collaborate and problem-solve real issues in science, technology, engineering, art, and math (Harrell & Harrell, 2010; Tanner, 1991, 2017).

This STEAM action plan calls for educators to design curriculum that fosters students' agency. In education, agency is when students develop a sense of independence in their own learning, the ability to problem solve, and a mindset to practice taking educated risks (Clapp et al., 2017). DeJarnette (2018) found that STEAM programs fostered student agency among elementary-aged learners, which was exhibited by the participants and the data in this study. Through transdisciplinary CBL, and empowerment curriculum, participants practiced active problem solving and struggle.

Another key component of this action plan is to ensure STEAM educators design curricula that are representative of all the students in their classrooms. The existing literature states that showing students examples of role models in the field also influences a child's likelihood to study that topic (Beilock, 2019). The action plan asks educators to teach students about role models in STEAM that are representative of their entire student population. An outcome from the study demonstrated that the participants wanted to participate in the STEAM workforce when they grow up (see Figure 4.5).

The action plan specific to this researcher is that she started STEAM Kids, LLC. This business is dedicated to bringing the curriculum designed for this program to elementary-aged students around the United States. She is currently working on her first book titled, *The STEAM Girls Guide 2 Awesome!* that includes a workbook for students to complete. The workbook includes interactive, hands-on CBL experiments with QR code video links to tutorials and instructions for parents and students. Additional information in the book focuses on women in STEAM and sharing gender-specific experiences of role models in the field. Lastly, the book includes five games developed to practice STEAM-minded thinking and encourage kids to develop a STEAM mindset.

In Spring 2021, the researcher plans to host her first cohort of females in an enrichment mentoring program where each participant receives a copy of *The STEAM Girls Guide 2 Awesome!* along with mentorship from Scientist Diana (the researcher's teacher name), and meets with a group of peers to share and discuss STEAM. The researcher hopes to develop the mentoring program into a cyclical format where students eventually become mentors for younger students.

Additionally, the researcher is a practicing science and STEAM educator at the Paideia School in Atlanta, GA where she designed, developed, and implemented the elementary STEAM program. The curriculum in this program is taught to students in grades K-6 once a week as 45-minute class periods.

Moreover, the researcher also consults for companies that are interested in developing STEAM materials. She purchased a license for software that allows her to offer her materials to larger STEAM box companies. They hire her on as a consultant to produce PDFs or high-resolution PNGs of STEAM activities to teach elementary students about STEAM. See Appendix J for an example.

Lastly, the researcher started a YouTube channel dedicated to conducting STEAM-based challenges with kids, reading books, and sharing stories about cultural, gender-specific role models in science, technology, engineering, art, and math.

Recommendations for Practice & Policy

Researchers across the board published findings about the importance of early intervention to engage and motivate students to participate in STEAM subjects (Holdren, 2013; Jamalian, 2018; Tanenbaum et al., 2016; Venditto, 2018). The CoSTEM and the National Science and Technology Council (2013) found that early exposure to a STEAM education established a foundation for learning and helps to close the gender gap. This action research study supports these findings. Females that attended this program between the ages of 7 to 10 developed growth mindsets and STEAM skills. One further reason to support STEAM education versus traditional siloed elementary education is that it creates critical thinkers, innovators, and workers needed for the survival of the U.S. economy (Allina, 2018; Beede et al., 2017; Oberoi, 2016).

The recommendations are for states, schools, and their districts to adopt policy that promotes STEAM education. Most states and schools are focusing in STEM. The U.S. government also places an emphasis on STEM, which provided funding for STEAM programming in PK-20 schools (Allina, 2018). The STEAM educational practices in this study were designed to bring females and students of color's voices to the table. The researcher in this study is an educator first. From an educator's lens, the goal is to teach *all* the students in the room. In order to foster a society of STEAM students that are *all* encouraged to participate and learn, the emphasis should be on transdisciplinary STEAM education.

Secondly, recommendations for practice stress the importance of early intervention. When STEAM programs start in elementary school, or younger, student engagement increases and fosters student creativity. Again, the recommendations are to start early to develop STEAM skills and mindsets that build a foundation for females and students of color to succeed in STEAM. As students advance through school, and the curriculum in STEAM subjects becomes increasingly difficult. Researchers in this field argue that students stay engaged when explicitly taught STEAM skills in their formative years (Cunningham & Berger, 2014; Tanenbaum et al., 2016; Venditto, 2018).

Another recommendation is to re-write traditional elementary siloed curricula. The existing research stated in this study recommends that STEAM instructors provide students with transdisciplinary CBL, empowerment instruction that offers praise based on effort, and share role models from different backgrounds to engage a wider variety of students (Casteel, 2018; Courey, 2016; Drake, 2012; Jamalian, 2018; Weist, 2014). The step-by-step, siloed approach to education needs to be rewritten to include access and entry points for *all* the children in the classroom to succeed.

Traditional elementary education praises students based on the correct yes-or-no answers and the ability to follow step-by-step instructions (Barack, 2018; Weist, 2014). These traditional practices in elementary education disengage many females and students of color from the fields of science, technology, engineering, art, and math (Catterall, 2017; Johnson et al., 2009; Noonan, 2017). The recommendation is for elementary educators in this field to focus on praising students based on effort. This is a pedagogical technique recommended to develop a student's growth mindset.

This practice is recommended so that students develop a growth mindset understand that with hard work and dedication, they are capable of learning anything (Buoncristiani & Buoncristiani, 2012; Dweck, 2010; Jamalian, 2018). Education practice recommendations include teaching students about a growth mindset to encourage children to practice being educated risk takers, failing forward, building grit, and becoming determined to accomplish goals. Growth mindset practiced in STEAM allows students to practice skills needed in the real world.

In conclusion, based on the outcomes of this study, recommendations are made to update traditional siloed elementary educational programming into transdisciplinary STEAM-based integrated approach. Specifically, the recommendation includes STEAM curricula designed to incorporate CBL and cultural, gender-specific role models. This study demonstrates how these practices combined with a STEAM curriculum improve student engagement and achievement.

The recommendations for schools, administrators, educators, and parents include taking action and advocating for:

1) Early intervention – Elementary-aged Students or younger.
2) Updating traditional elementary programs with transdisciplinary STEAM curriculum that includes CBL, the 5Es, and role models.
3) Include an empowerment curriculum that focuses on gender-specific, cultural role models, and development of student voice and a growth mindset.

Recommendations for Future Research

This study demonstrated that the future is female for the participants in this study. Female participants saw themselves as equal to the boys and capable of doing the same work. The researcher used the draw a scientist experiment and the results found that 100% of participants drew female scientists. This pattern also occurred when participants drew artists, inventors, and mathematicians. The researcher recommends future, more rigorous research in this area and asks researchers to repeat this study with their own students.

The practice of asking kids to draw what a scientist looks like is a study that has been conducted by many scientists, teachers, and researchers beginning in the 1960s

(Berwick, 2019; Casteel, 2018). This is a simple activity where the teacher/researcher/parent/babysitter asks the participants to draw a scientist. Students share what they drew after having time to work independently on drawings. Older students may have time to add written descriptions to their pictures. Since this is a STEAM study, the researcher extended this activity to include draw an inventor, engineer, mathematician, author, explorer, artist, and more. When leading this activity, recommendations are made for facilitators to discuss similarities and differences in the drawings and breakdown the barriers by naming what the students see.

Another recommendation for future research is to conduct a study specifically designed around the efficacy of online education. This study pivoted to include an online component as a result of a pandemic; however, the study was initially designed for an in-person, classroom setting. To validate results of effective online teaching practices, a specific study is recommended for the purposes of online education. The goal of this research study was to understand the impact of a STEAM program on young females' engagement and participation. The online component allowed the study to take place. Repetition and specific focus on online learning are recommended for researchers wishing to understanding the impact of online learning on elementary-aged students.

The final recommendation is to repeat the study for boys of color. This program focused on females. Future researchers wishing to apply these results to both genders and the spectrum of gender are recommended to repeat the study for elementary-aged boys with cultural-specific role models to see if the outcome of results are the same.

Resources for Educators

Additional resources for educators, administrators, and parents in STEAM education:

- The *STEAM Journal: Integrated Perspectives* is a research journal that offers up-to-date research in the STEAM field from practitioners and researchers. This journal is produced on behalf of Claremont Colleges & Consortium.
- Agency by Design is a research branch based in Harvard's Graduate School of Education that studies and produces engaging MCL, CBL, and Thinking Routines. They offer free downloadable handouts and instructions for educators across the globe. Information available includes lesson plans, tools for teachers, and thinking routines are available for free through their research center.

Conclusion

In conclusion, the literature demonstrated that the first noticeable gender differences in STEAM subjects appear in elementary school and that progressively more females lose interest as they advance through school and into the workforce (Anthony & Ogg, 2019; BLS, 2019; Cifaldi, 2018; Clewell & Ginorio, 2002). This study found that early intervention makes a difference. When elementary-aged females were exposed to an empowerment curriculum, focused on cultural, gender-specific role models and CBL, they improved their mindset, engagement, and participation in STEAM.

In 2020, the females in this study demonstrated that 100% of them believed that girls can do anything boys can do. The practice of teaching predominately about White males is a practice that continues to dominant in educational settings across the nation

(AAUW, 1992, 2017). Young female students internalize these stereotypes and implicit bias within society as increasingly exposed to the same message over and over again. The literature continues to find that when the majority of role models pictured are White men, females increasingly believe that women's lives count less than male's (AAUW, 1992, 2017).

The current female workforce in STEAM paved the way for the upcoming generation. This females in this study did not believe the stereotypes. This study demonstrated the impact of a transdisciplinary STEAM empowerment curriculum. When young females are taught about women in STEAM who look like them, their desire to pursue STEAM education and the possibility of a STEAM job in the future increased. In other words, this study demonstrated that interventions introduced at an early age increased participants likelihood of pursing work in the STEAM field when they grow up.

While the research reports that the current number of females in STEAM education and the workforce is on the decline, this study demonstrates that the participants in the program were willing to pursue futures in STEAM. The solution to increased engagement and participation is early intervention of STEAM education combined with an empowerment framework. The research demonstrated the impact of an introductory STEAM programs on young females in an informal setting. The curriculum designed for this action research study taught the female participants that *because* they were female, they had an advantage in STEAM. Empowerment curriculum taught the participants to embrace who they are and to cherish all the parts of their identity, including their culture and their gender.

STEAM education leads to innovation, creativity, design, and the creation of new technologies and inventions (Nietner, 2017). When females join the STEAM workforce, it promotes diversity in ideation, creation, and innovation. Different perspectives are needed in STEAM to solve problems and create new tools for the future. The recommendations made in this study are to implement STEAM education early with a transdisciplinary approach and an empowerment framework. Closing the gender gap and equity gap in STEAM is possible with early intervention and access (Quigley et al., 2020). Many schools are transitioning to learning online and/or creating hybrid models for education, which presents the opportunity to incorporate a STEAM curriculum in schools that is representative of ALL the students in the classroom.

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APPENDIX A

PARTICIPANT INITIAL SURVEY

In collaboration with The University of South Carolina Graduate School of Education
Doctoral Dissertation Study by Diana K. Lockwood
(Answers are private a.k.a. This survey is private and will only be viewed by Diana)

1. My name is (please type REAL first and last name/what you go by in class).

   _____________ (Short answer).

2. I am _____ years old (check one answer).

   a. 8 years old

   b. 9 years old

   c. 10 years old

   d. 11 years old

3. My school offers & I have been to (select all that apply).

a. A STEAM Class

b. A Science Class

c. A Computer Coding Class

d. None of the Above

4. I have gone to (select all that apply)

   a. An afterschool/enrichment Science club

   b. An afterschool/enrichment STEAM club

   c. An afterschool/enrichment STEM club

d. An afterschool//enrichment Technology club

e. An afterschool/enrichment Math Club

f. None of the Above

5. During the summer, my parents have sent me to...(select all that apply).

a. Science Camp

b. STEAM Camp

c. STEM Camp

d. Computer Camp

e. None of the Above

6. I share things I learn about Science and STEAM with my family.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

7. I convince my parents to let me do science and STEAM experiments at home (either with them, friends, siblings, other family members, or alone).

Linear Scale 1:5 Strongly Agree to Strongly Disagree

8. I feel confident about my abilities to tackle STEAM Challenges & Experiments.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

9. I have met a scientist.

a. Yes

b. No

10. I have met an engineer.

a. Yes

b. No

11. Boys are better than girls at (check all that apply)

- ☐ Science
- ☐ Math
- ☐ Technology
- ☐ Engineering
- ☐ Art
- ☐ None of the above

12. When I grow up, I want to work in a STEAM-related field.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

13. I think of myself as STEAM-minded, meaning someone who is curious, asks questions, takes educated risks, and likes to experiment and try different solutions to problems.

14. I prefer to solve STEAM challenges instead of being given traditional science experiments with a series of steps.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

15. In class, I zoom on (check all that apply).

- ☐ iPad
- ☐ Laptop
- ☐ Desktop
- ☐ Phone
- ☐ Other

16. I know how to use this technology (check all that apply).

- ☐ YouTube
- ☐ Seesaw
- ☐ Zoom

17. I want my teacher to know...

_____________ (Long Answer Text)

18. The #1 reason I like camp is…

_____________ (Long Answer Text)

19. This camp has changed my opinion about…

_____________ (Long Answer Text)

APPENDIX B

PARTICIPANT FOLLOW-UP SURVEY

In collaboration with The University of South Carolina Graduate School of Education
Doctoral Dissertation Study by Diana K. Lockwood
(Answers are private a.k.a. This survey is private and will only be viewed by Diana)

1. My name is (please type REAL first and last name/what you go by in class).

   _____________ (Short answer).

2. I am _____ years old (check one answer).

   a. 8 years old

   b. 9 years old

   c. 10 years old

   d. 11 years old

3. My school offers & I have been to (select all that apply).

a. A STEAM Class

b. A Science Class

c. A Computer Coding Class

d. None of the Above

4. I have gone to (select all that apply)

   g. An afterschool/enrichment Science club

   h. An afterschool/enrichment STEAM club

   i. An afterschool/enrichment STEM club

j. An afterschool//enrichment Technology club

k. An afterschool/enrichment Math Club

l. None of the Above

5. During the summer, my parents have sent me to...(select all that apply).

f. Science Camp

g. STEAM Camp

h. STEM Camp

i. Computer Camp

j. None of the Above

6. I share things I learn about Science and STEAM with my family.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

7. I convince my parents to let me do science and STEAM experiments at home (either with them, friends, siblings, other family members, or alone).

Linear Scale 1:5 Strongly Agree to Strongly Disagree

8. I feel confident about my abilities to tackle STEAM Challenges & Experiments.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

9. I have met a scientist.

c. Yes

d. No

10. I have met an engineer.

c. Yes

d. No

11. Boys are better than girls at (check all that apply)

- ☐ Science
- ☐ Math
- ☐ Technology
- ☐ Engineering
- ☐ Art
- ☐ None of the above

12. When I grow up, I want to work in a STEAM-related field.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

13. I think of myself as STEAM-minded, meaning someone who is curious, asks questions, takes educated risks, and likes to experiment and try different solutions to problems.

14. I prefer to solve STEAM challenges instead of being given traditional science experiments with a series of steps.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

15. In class, I zoom on (check all that apply).

- ☐ iPad
- ☐ Laptop
- ☐ Desktop
- ☐ Phone
- ☐ Other

16. I know how to use this technology (check all that apply).

- ☐ YouTube
- ☐ Seesaw
- ☐ Zoom

17. I want my teacher to know...

_____________ (Long Answer Text)

18. The #1 reason I like camp is…

_____________ (Long Answer Text)

19. This camp has changed my opinion about…

_____________ (Long Answer Text)

APPENDIX C

PARENT APPLICATION AND CONSENT FORM

In collaboration with The University of South Carolina Graduate School of Education
Doctoral Dissertation Study by Diana K. Lockwood

Email address - To submit form user must have a valid email address

1. First and Last Name of Parent (s)

_____________ (Short Answer)

2. Child's First and Last Name

_____________ (Short Answer)

3. Age of My Child

a. 8 years old

b. 9 years old

c. 10 years old

d. 11 years old

4. My child will be in grade ___ next year

a. 3

b. 4

c. 5

d. 6

5. Our child's race & ethnicity is (check all that apply)

- White
- Black
- Latino
- Asian
- Native American
- Native Hawaiian or Pacific Islander

6. By participating in this program, I agree my child will attend camp M-Th from 10 am - 12 pm the week of 6/15-6/18 & 6/22-6-25.

- Yes
- No

7. By participating in this FREE program, I agree to save items from the recycling bin to use in experiments. For example toilet paper and paper towel tubes, Kleenex box, Tupperware or take out containers. A list will be provided by Diana.

- Yes
- No

8. By participating in this FREE program, I agree to order supplies. For example baking soda, vinegar, a notebook, and rubber bands. The average cost of supplies is approximately $25.

- Yes
- No

10. I understand the goal of this online summer camp program is to empower young girls to participate in STEAM projects, foster positive science-minded identity, and introduce role models in the STEAM field.

- Yes
- No

11. I agree to fill out a Google Form "Parent Observation Form" on 6/15, 6/18 & 6/25. (FYI - Diana will email us links to complete the Google Form on those dates).

- Yes
- No

12. I understand that Diana is a doctoral student at The University of South Carolina and collecting observations from Parent & Child Google Forms, Zoom observations & videos, and select participant interviews in July for her study. I agree and consent to my child and myself (if applicable, and my spouse) to participate in this study.

- Yes
- No

13. I understand that this research study has been approved by the University of South Carolina and the Institutional Review Board for research studies.

- Yes
- No

14. I understand the anonymity of participants (parents and children) will be protected and all names will be changed for Diana's doctoral dissertation.

- Yes
- No

15. My preferred email address Diana contact me through is

_____________ (Short Answer)

16. I allow Diana to ask my child follow up questions via FaceTime or Zoom in July about the impact of this program.

- Yes
- No
- Maybe

17. Any questions, comments or concerns I have for Diana are

_____________ (Short Answer)

APPENDIX D

PARENT OBSERVATION FORM #1

Inventor's Camp for Girls, STEAM Themed
In collaboration with The University of South Carolina Graduate School of Education
Doctoral Dissertation Study by Diana K. Lockwood

1. My first and last name is...

_____________ (Short Answer)

2. My child participating in the program is...(list first and last name)

_____________ (Short Answer)

3. My Child is ___ years old

a. 8 years old

b. 9 years old

c. 10 years old

d. 11 years old

4. My student has shared what she is learning in Inventor's Camp.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

5. Specifically, she has shared the following...(please describe the information, facts, science or STEAM content that she talks about at home)

_____________ (Long Answer)

6. My child wants to conduct her own science experiments at home.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

7. I have noticed a change in my child's confidence and abilities towards STEAM activities and education.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

8. My child talks about wanting to become a STEAM professional when they grow up.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

9. I consider my child STEAM-minded, meaning someone who is curious, asks questions, takes educated risks, and likes to experiment and try different solutions to problems.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

10. My child prefers to solve STEAM challenges instead of being given traditional science experiments with a series of steps.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

11. What can you share with Diana about STEAM classes, camps, lessons, videos, etc. is...(a.k.a. What do you want me to know the most?)

_____________ (Long Answer)

12. How has distance & digital education impacted your child's learning about Science & STEAM?

- Decrease
- Increase
- The same
- Nonexistent during virtual schooling

13. How has distance & digital education impacted your child's Science & STEAM learning and/or mindset?

_____________ (Long Answer)

14. I understand that all answers are private and any data used will include anonymity measures to protect the identity of families and students in order to remain private. Please sign your name below.

_____________ (Short Answer)

APPENDIX E

PARENT OBSERVATION FORM #2

Inventor's Camp for Girls, STEAM Themed
In collaboration with The University of South Carolina Graduate School of Education
Doctoral Dissertation Study by Diana K. Lockwood

1. My first and last name is...

_____________ (Short Answer)

2. My child participating in the program is...(list first and last name)

_____________ (Short Answer)

3. My Child is ___ years old

a. 8 years old

b. 9 years old

c. 10 years old

d. 11 years old

4. My student has shared what she is learning in Inventor's Camp.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

5. Specifically, she has shared the following...(please describe the information, facts, science or STEAM content that she talks about at home)

_____________ (Long Answer)

6. My child wants to conduct her own science experiments at home.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

7. I have noticed a change in my child's confidence and abilities towards STEAM activities and education.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

8. My child talks about wanting to become a STEAM professional when they grow up.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

9. I consider my child STEAM-minded, meaning someone who is curious, asks questions, takes educated risks, and likes to experiment and try different solutions to problems.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

10. My child prefers to solve STEAM challenges instead of being given traditional science experiments with a series of steps.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

11. The main impact inventor's camp has had on my child is...

_____________ (Long Answer)

12. How has distance & digital education impacted your child's learning about Science & STEAM?

- ○ Decrease
- ○ Increase
- ○ The same
- ○ Nonexistent during virtual schooling

13. The best method to communicate with me is (check all that apply)

- ☐ Email
- ☐ Text
- ☐ Phone call
- ☐ Facebook
- ☐ Facebook messenger
- ☐ Other

14. Questions or concerns? Ideas? Other information for my child's teacher?

_____________ (Short Answer)

15. My child works on virtual camp (check one)

- ○ Independently
- ○ With minimal help from an adult
- ○ Somewhat dependent on adults
- ○ Needs an adult present the majority of the time

APPENDIX F

PARENT OBSERVATION FORM #3

Inventor's Camp for Girls, STEAM Themed
In collaboration with The University of South Carolina Graduate School of Education
Doctoral Dissertation Study by Diana K. Lockwood

1. My first and last name is...

______________ (Short Answer)

2. My child's name is...(first and last)

______________ (Short Answer)

3. This time of day worked well for us.

- True
- False

4. A better time of day would be…

- 9:00-11:00 (2hr)
- 12:00-2:00 (2hr)
- 2:00-4:00 (2hr)
- 1 hour AM option
- 1 hour PM option

5. I would recommend this camp to other families.

- Yes
- No

6. Other kids could benefit from this program because...

_____________ (Short Answer)

7. I think the following improvements or changes could enhance this program...

_____________ (Long Answer)

8. My child used the experiment materials she received in the mail.

- o Yes
- o No

9. The educational programming made a big impact on my daughter.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

10. If my child had a paper workbook with the written activities it would greatly enhance the English Language Arts and Visual Arts component of the program (writing & drawing).

Linear Scale 1:5 Strongly Agree to Strongly Disagree

11. Meeting Delanda Coleman, author & STEM professional, impacted her because...

_____________ (Short Answer)

12. My child talks about the following (check all that apply)

- ☐ Scientist
- ☐ Computer Coder
- ☐ Engineer
- ☐ Artist
- ☐ Architect
- ☐ Inventor
- ☐ Astronaut
- ☐ Author
- ☐ Business Woman
- ☐ Mathematician

13. This program has taught my child…

____________ (Short Answer)

14. An ALL GIRLS setting benefitted my child's learning, sharing, and participation in STEAM.

Linear Scale 1:5 Strongly Agree to Strongly Disagree

15. My daughter talks more about STEAM now than before camp.

- True
- False

16. I wanted to tell Diana…

_____________ (Short Answer)

APPENDIX G

STEAM PROGRAM ADVERTISING FLYER

Figure G.1. Inventor's camp for girls - STEAM themed.

APPENDIX H

RESEARCHER'S REFLECTIONS

INVENTOR'S CAMP
RESEARCHER REFLECTIONS
Adaption of The Inquiry Cycle Tool by Agency by Design
http://www.agencybydesign.org/sites/default/files/AbD%20Inquiry%20Cycle%20Tool%20.pdf

Monday
June 15, 2020
1. What was your learning objective?
Students will be able to...
-Demystify typical identity of a scientist and see themselves as one
-know what a solution is, make one and use it,
-learn role model chemist who makes solutions
-what motivates you?

2. How did you do?
Great considering technology this weekend during practice didn't go that well. It was so much smoother than I thought it would go.

3. How did it go?
Same as answer above.

4. What did your students learn?
So much. What STEAM is and how it is different from STEM. What a solution is. Who is a role model in chemistry. That she went to MIT and where it was located. Story CECE Loves science about a kid scientist and her project.

5. What did you learn?
Kids are really good at adapting to the new learning environment. They navigated technology so smoothly. Kids come in late and had to leave early. Not all kids came to class. One dropped out yesterday.

6. What would you do differently?
Check the boxes on zoom to allow my sound to transfer through the participants' screens louder.
Take handwritten attendance.
Continue to write notes, take screen shots, etc.

7. What will you do next?
Hand write lesson plans for next day, take attendance, check submissions of pre-survey

8. Artifacts of learning. Pics, video clips, student work. etc.
Seesaw turn in
Camila & Taylor, picture of a scientist

Tuesday
June 16, 2020
1. What was your learning objective?
Students will be able to...
Start to think independently about materials they can use to design their own inventions. For some this came easily. For others they were stuck. One kid said they couldn't do it. I had to demo alternative options.

2. How did you do?
Good. I followed up with every kid. They all shared. Everyone tried out ideas and gave it their best.

3. How did it go?
Some kids really gave this their all and others kind of fizzled out. One kid added lights. Others built up a wall. It was super inventive. Others hit a wall. Those were the ones I had to open up to possibilities.

4. What did your students learn?
To take risks. Try again. Fail forward.

5. What did you learn?
Model, demo, show, ask questions. Follow my intuition about kiddos that look stuck. They are.

6. What would you do differently?
Demo first then go find supplies. Trying this strategy tomorrow.

7. What will you do next?
Same answer as #6.

8. Artifacts of learning. Pics, video clips, student work. etc.
Seesaw & data file

Wednesday
June 17, 2020

1. What was your learning objective?

Students will be able to...
Create a bubble solution, try out different types of materials to turn into bubble wants, be creative with their thinking, be resourceful with what they find, use objects they have in the house, and most of all try, try, try!

2. How did you do?

Great in the sense that everyone did the experiment. Tech worked well. Some kids were bored at certain times and I am changing the order in which I deliver information tomorrow.

3. How did it go?

Good! All kids were able to try this experiment out. Taylor needed some guidance because her mom and grandma were busy. She did it! Even Camila's sister came to join today! Overall super successful experiment!

4. What did your students learn?

How to make their own solution and to test their ideas. They also learned about Sheryl Sandberg.

5. What did you learn?

To switch things up. Try to keep finding ways for kids to share their work. Keep them engaged. When they share they tune in.

6. What would you do differently?

Again, just try different order for delivery. Continue to preview videos and scavenger hunt items.

7. What will you do next?

Plan Thurs., make sure questions are good for parent survey, and work on ordering items to mail for experiments next week. Want to send thank you notes & certificates to each kid.

8. Artifacts of learning. Pics, video clips, student work. Etc. Remind parents to share kid's work. I need to document from seesaw, FB or emails :)

Thursday
June 18, 2020
1. What was your learning objective?
Students will be able to...
Play with water and understand its properties. What is surface tension and cohesion.

2. How did you do?
Good in terms of varied instruction and meeting kids where they are at with what supplies they have. Helping one another and trying different people or ideas out. Sharing went well. Some still seem bored at parts and engaged at others.

3. How did it go?
Good overall. I cannot figure out why kids turn of screens. Its like they are doing something naughty and don't want me to see or they are shy. I would rather they leave their screen on the entire time. I will ask that next week.

4. What did your students learn?
About water and its properties.

5. What did you learn?
Kids are interested in different segments or parts of the lesson. It feels like an interactive TV show for kids.

6. What would you do differently?
It is hard to balance the different ages. To be advanced enough to keep the 10 year old entertained and explained enough to have the 8 year olds interested in learning.

7. What will you do next?
Email communication to parents HW: dumpster dive, link for survey, PDF of Fri-YAY activities.

8. Artifacts of learning. Pics, video clips, student work. etc.
Seesaw and ask for help from parents to send me pics of journal.

Monday
June 22, 2020
1. What was your learning objective?
Students will be able to...
To know that they can be more than a princess and understand what STEAM jobs are and how they work in real life.

2. How did you do?
Good. Next time have author visit 15 mins into class. Kids want to share their work ASAP. OR share videos first, then journal, then meet the author.

3. How did it go?
Well, the kids loved meeting the author! She really inspired them to work for whatever they want and to understand all the possibilities for the future. They included arts.

4. What did your students learn?
Glitter tornadoes and how to make a centripetal force. What is a vortex?

5. What did you learn?
That they loved this activity. TELL THEM the day before about what kind of jars they need for this activity.

6. What would you do differently?
See #2 & #5

7. What will you do next?
Send author a thank you note.

8. Artifacts of learning. Pics, video clips, student work. etc.
Documents are in seesaw, FB &/or emails.

Tuesday
June 23, 2020
1. What was your learning objective?
Students will be able to...
Know what an engineer does and start to imagine the future.

2. How did you do?
Good in terms of introducing them to engineering. They were not big fans of the engineering TED Talk girl as a role model BUT they did love her message.

3. How did it go?
They crushed the finding things to knock over in a row. Like books.

4. What did your students learn?
Rube Goldberg, domino effect, chain reaction and what an engineer does

5. What did you learn?
That the kids are willing to try this in many different ways. It was a great activity.

6. What would you do differently?
At the beginning of class tell them what they need (scavenger hunt) in case they need parent help.

7. What will you do next?
Next time include the Emily Roebling book in the course. It is a good book.

8. Artifacts of learning. Pics, video clips, student work. Etc.
Documents are in seesaw, FB &/or emails.

Wednesday
June 24, 2020

1. What was your learning objective?
Students will be able to...
Inventor, Medi Teddy Ella Casano
Fireworks in a jar. This one is really about showing the girls that they can do anything they put their minds to. It is about finding something you are passionate about and pursuing that work.

2. How did you do?
The kids really are starting to get the message. It went really well being able to show them how to do the experiment. We went step-by-step.

3. How did it go?
See above.

4. What did your students learn?
Oil & water don't mix.

5. What did you learn?
To make videos that are shorter. They are too long for kids to watch. They need to be like 5-3 mins tops.

6. What would you do differently?
Update video and scavenger hunt to be correct and shorter.

7. What will you do next?
See #6

8. Artifacts of learning. Pics, video clips, student work. etc.
Documents are in seesaw, FB &/or emails.

Thursday
June 25, 2020

1. What was your learning objective?
Students will be able to...
Learn about women who work for NASA. What does that mean?

2. How did you do?
It was also the last day and many kids wanted to share. I needed to make time for that. I needed a video of me doing an explosion in a bag.

3. How did it go?
It was good but lots of direction between kids and tinkering with the recipe.

4. What did your students learn?
Really the importance of not giving up. To keep trying. I needed to connect this to the last day and the lesson about STEAM. Fail many times before you succeed.

5. What did you learn?
I can teach online. Lots of pre-planning work. Extremely time consuming.

6. What would you do differently?
Make vinegar video & kids share time

7. What will you do next?
Email the parents a thank you note.
Transcriptions, print, analysis, follow up interviews, draft findings.

8. Artifacts of learning. Pics, video clips, student work. etc.
Documents are in seesaw, FB &/or emails.

APPENDIX I

VIDEO TRANSCRIPTIONS

Monday, June 15th, 2020

"I just wanted to say that the scientist could be anyone. It doesn't have to be someone wearing a lab coat in a lab. It could be a normal person in their backyard."

The researcher used specific question prompts,

"Who can make that possible?"
"Who's got a solution for us?"
"How can we solve the problem?"
"Who wants to give us another possibility?"

And the students replied with answers, such as,

"I think that one possibility is…"
"You could try…"
"One idea that is realistic is…"
"To make this possible try…"
"You might have a solution here…"

Monday, June 22nd, 2020

Delanda shared with the students that the princesses in her story, "*are all very smart women who grow up to do very cool and amazing things. Your interests today can turn into your future. With some practice and hard work, you can grow up to do amazing things*."

Princesses are fantastic, but they're all also very smart women, and then they grow up to do very cool and amazing things. Your interests today can turn into your future. With some practice and hard work, you can grow up to do amazing things.

Okay, and so that's an example. So if you like to build things, but you also like to draw things, that's a great example of an engineer. You have to multi-task. Who here has multiple skills? Many of the students raise their hands. Right. Engineers draw something and also use their hands to actually build what they've drawn.

After meeting a role model students, the researcher asked the students what they got out of it?
One child replied, "I got her message and she was inspiring."

One student said, "girls can do anything boys can do."

Thursday, June 25th, 2020

When asked, what impact did the camp have on you?

One student said, "it makes you love STEAM and try new things."

Another explained that "it's so inspiring," and one more student shared, "it's the best class I have ever taken."

APPENDIX J

THE IMPOSSIBLY POSSIBLE GAME

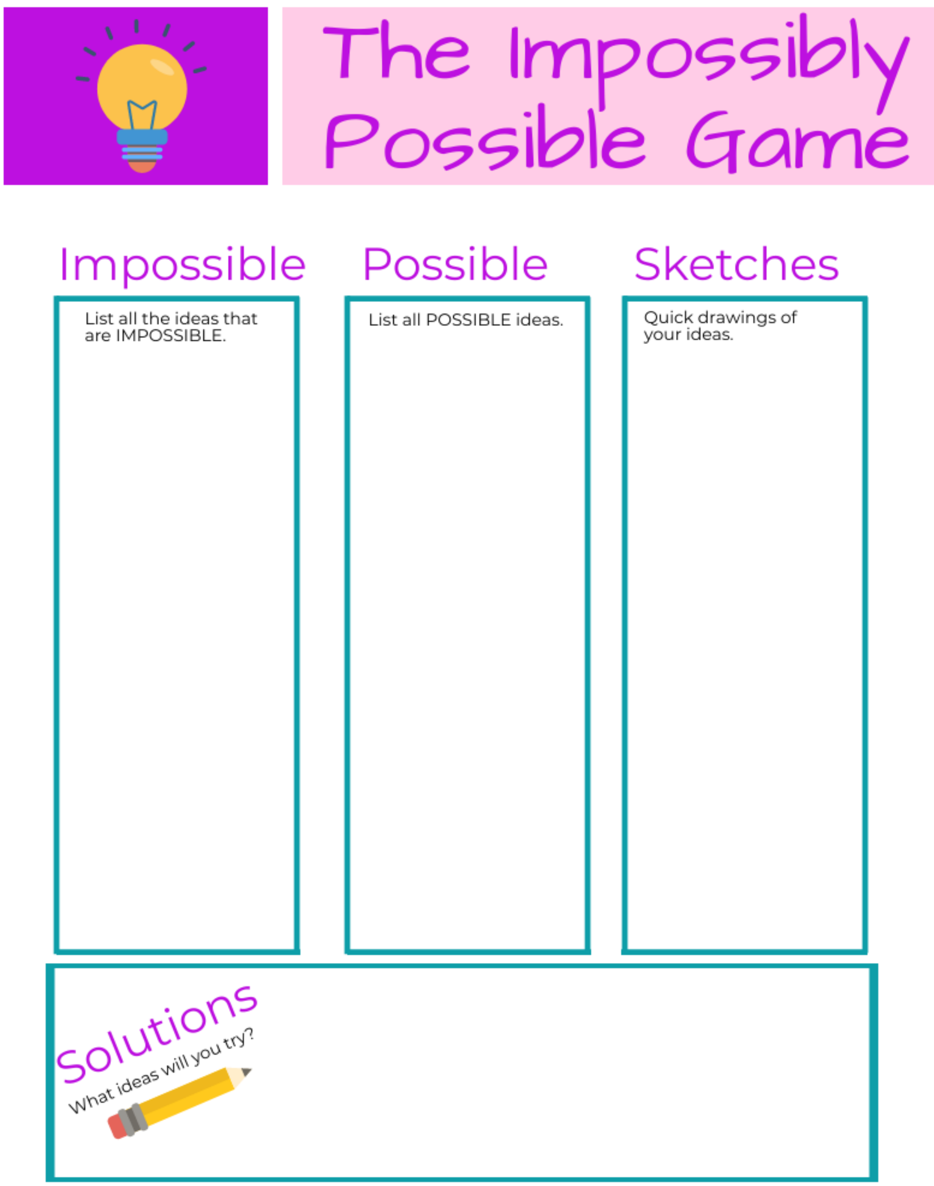

Figure J.2. The impossibly possible game.

APPENDIX K

STEAM EDUCATION STANDARDS

NEXT GENERATION SCIENCE STANDARDS

K-5-ESS2-1. Use and share observations of local weather conditions to describe patterns over time. 2-ESS1-1. Use information from several sources to provide evidence that Earth events can occur quickly or slowly. 3-ESS3-1. Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.

K-5-ESS3-2. Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather. 2-ESS2-2. Develop a model to represent the shapes and kinds of land and bodies of water in an area. 3-ESS2-2. Obtain and combine information to describe climates in different regions of the world.

K-ESS3-3. Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment. 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

K-5-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. 2-PS1-1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties. 3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. 4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.

K-5-PS2-2. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull. 2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose. 3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

2-5-PS1-3. Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object. 3-PS2-3. Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other. 4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide. 5-PS1-3. Make observations and measurements to identify materials based on their properties.

5-PS1-4. Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

3-LS4-1 & 3. Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.

NGSS Lead States (2013) Complete list available here: https://www.nextgenscience.org/sites/default/files/AllDCI.pdf

INTERNATIONAL SOCIETY FOR TECHNOLOGY IN EDUCATION STANDARDS

Empowered Learner 1a-d. Students leverage technology to take an active role in choosing, achieving, and demonstrating competency in their learning goals, informed by the learning sciences.

Digital Citizen 2a-d. Students recognize the rights, responsibilities and opportunities of living, learning and working in an interconnected digital world, and they act and model in ways that are safe, legal and ethical.

Knowledge Constructor 3a-3d. Students critically curate a variety of resources using digital tools to construct knowledge, produce creative artifacts and make meaningful learning experiences for themselves and others.

Innovative Designer 4a-4d. Students use a variety of technologies within a design process to identify and solve problems by creating new, useful or imaginative solutions.

Computational Thinker 5a-5d. Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions.

Creative Communicator 6a-6d. Students communicate clearly and express themselves creatively for a variety of purposes using the platforms, tools, styles, formats and digital media appropriate to their goals.

Global Collaborator 7a-7d. Students use digital tools to broaden their perspectives and enrich their learning by collaborating with others and working effectively in teams locally and globally.

ISTE complete list of standards Available Here: https://www.iste.org/standards/for-students

ENGINEERING DESIGN STANDARDS

K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

NGSS (2017/2013) Complete list of standards available here: https://www.nextgenscience.org/sites/default/files/AllDCI.pdf

NATIONAL CORE ART STANDARDS

VA:Cr1.1.2&4a Brainstorm collaboratively multiple approaches to an art or design problem.

VA:Cr1.1.3a Elaborate on an imaginative idea.

VA:Cr1.1.5&6aCombine concepts collaboratively to generate innovative ideas for creating art.

VA:Cr2.1.5a Experiment and develop skills in multiple art-making techniques and approaches through practice.

VA:Cr2.2.K-5a When making works of art, utilize and care for materials, tools, and equipment in a manner that prevents danger to oneself and others.

VA:Cr2.3.2a Repurpose objects to make something new.

VA:Cr3.1.2a Discuss and reflect with peers about choices made in creating artwork.

VA:Cr3.1.3a Elaborate visual information by adding details in an artwork to enhance emerging meaning.

VA:Pr4.1.5a Define the roles and responsibilities of a curator, explaining the skills and knowledge needed in preserving, maintaining, and presenting objects, artifacts, and artwork.

VA:Pr5.1.5a Develop a logical argument for safe and effective use of materials and techniques for preparing and presenting artwork.

The complete National Core Art Standards available here: https://www.nationalartsstandards.org/sites/default/files/Visual%20Arts%20at%20a%20lance%20-%20new%20copyright%20info.pdf

COMMON CORE MATH STANDARDS

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

MP.5 Use appropriate tools strategically.

K.CC.A Know number names and the count sequence.

K-4.MD.A.1 Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object.

1.MD.A.1 Order three objects by length; compare the lengths of two objects indirectly by using a third object.
4.MD.A.1 Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table.

K-3.MD.A.2 Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference.

3.MD.A.2 Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem.

K-3.MD.B.3 Classify objects into given categories; count the number of objects in each category and sort the categories by count.

3.MD.B.3 Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in scaled bar graphs.

1.MD.C.4 Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another.

1.NBT.B.3 Compare two two-digit numbers based on the meanings of the tens and one digits, recording the results of comparisons with the symbols.

1.NBT.C.4 Add within 100, including adding a two-digit number and a one-digit number, and adding a two-digit number and a multiple of 10, using concrete models or drawings
and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method and
explain the reasoning uses. Understand that in adding two-digit numbers, one adds tens and tens, ones and ones; and sometimes it is necessary to compose a ten.

2.MD.B.5 Use addition and subtraction within 100 to solve word problems involving lengths that are given in the same units, e.g., by using drawings (such as drawings of rulers) and equations with a symbol for the unknown number to represent the problem.

5.MD.C.3 Recognize volume as an attribute of solid figures and understand concepts of volume measurement.
Additional Common Core Math Standards available here:
http://www.corestandards.org/wp-content/uploads/Math_Standards1.pdf

COMMON CORE ELA/Literacy STANDARDS

RI.K-5.1 With prompting and support, ask and answer questions about key details in a text.

RI.k-5.2 Identify the main topic and retell key details of a text.

RI.1.10 With prompting and support, read informational texts appropriately complex for grade.

RI.2.1 Ask and answer such questions as who, what, where, when, why, and how to demonstrate understanding of key details in a text.

RI.2.3 Describe the connection between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text.

RI.2.8 Describe how reasons support specific points the author makes in a text.

RI.4.1 Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.

RI.4.3 Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text. \

RI.4.9 Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably.

SL.K.3 Ask and answer questions in order to seek help, get information, or clarify something that is not understood.

SL.K.5 Add drawings or other visual displays to descriptions as desired to provide additional detail.

SL.1.1 Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups.

SL.4.5 Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes.

W.K-5.1 Use a combination of drawing, dictating, and writing to compose opinion pieces in which they tell a reader the topic or the name of the book they are writing about and state an opinion or preference about the topic or book.

W.2.1 Write opinion pieces in which they introduce the topic or book they are writing about, state an opinion, supply reasons that support the opinion, use linking words (e.g., because, and, also) to connect opinion and reasons, and provide a concluding statement or section.

W.1-5.2 Write informative/explanatory texts in which they name a topic, supply some facts about the topic, and provide some sense of closure.

W.K.2 Use a combination of drawing, dictating, and writing to compose informative/explanatory texts in which they name what they are writing about and supply some information about the topic.

W.K-5.7 Participate in shared research and writing projects (e.g., explore a number of books by a favorite author and express opinions about them).

W.1-5.8 With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question. Recall information from experiences or gather information from provided sources to answer a question.

Complete ELA/Literacy Standards available here: http://www.corestandards.org/wp-content/uploads/ELA_Standards1.pdf