Utilizing a Themed Workbook to Capture Insights to Young Women in Science, Technology, Engineering, Arts, and Mathematics (STEAM/STEM) Using the Internet of Things (IoT), Systems Engineering, and Data Science

Robert John Konczynski Jr.
Utilizing a Themed Workbook to Capture Insights to Young Women in Science, Technology, Engineering, Arts, and Mathematics (STEAM/STEM) Using the Internet of Things (IoT), Systems Engineering, and Data Science

by

Robert John Konczynski, Jr.

Bachelor of Science
Computer Science
University of Central Florida
2000

Master of Science
Software Engineering
Florida Institute of Technology
2015

A dissertation submitted to the College of Engineering and Science of Florida Institute of Technology in partial fulfillment of the requirements for the degree of

Doctor of Philosophy in
Science Education

Melbourne, Florida,
May 2022
We, the undersigned committee hereby approve the attached dissertation

Utilizing a Themed Workbook to Capture Insights to Young Women in Science, Technology, Engineering, Arts, and Mathematics (STEAM/STEM) Using the Internet of Things (IoT), Systems Engineering, and Data Science

By

Robert John Konczynski, Jr.

Samantha R. Fowler, Ph.D.
Assistant Professor
Department of Mathematical Sciences
Committee Chairperson

Kastro M. Hamed, Ph.D.
Professor
Department of Mathematical Sciences

Joo Young Park, Ph.D.
Assistant Professor
Department of Mathematical Sciences

Keith Brian Gallagher, Ph.D.
Associate Professor
Computer Science / Software Engineering

Gnana Bhaskar Tenali, Ph.D.
Professor and Department Head
Mathematical Science
ABSTRACT

Title: Utilizing a Themed Workbook to Capture Insights to Young Women in Science, Technology, Engineering, Arts, and Mathematics (STEAM/STEM) Using the Internet of Things (IoT), Systems Engineering, and Data Science

Author: Robert John. Konczynski, Jr.

Major Advisor: Samantha R. Fowler, Ph.D.

Young women may not realize that many of their cell phones, computers, TVs, cars, airplanes, and the technology around them, for the most part, have been designed by men. Men have been fundamental in designing these devices because women only account for a quarter of the workers in STEAM jobs. Because many women choose jobs and careers unrelated to STEAM, they are not part of the inclusive design and Engineering efforts that go into today’s products and technology. Given the underrepresentation of women as part of the design phase of Science, Technology, Engineering, Arts, and Mathematics, society is missing out on critical input, thoughts, and ideas that come from women.

For these reasons, the purpose of this study was to immerse young women into a STEAM workbook to capture their emergent ideas and thoughts about STEAM. In order to gain more insight as to why fewer women choose STEAM careers, this study aimed to answer the following research questions: (1) How do thoughts and ideas about STEAM change in young women by their participation in a STEAM workbook workshop? (2) What thoughts and ideas emerge from young women who participate in a themed STEAM workbook project? and (3) How does working on the STEAM workbook help
young women understand or see potential career opportunities that they might not have known about?

This qualitative study examined 11 female teenagers' experiences as they created a workbook about a STEAM topic of their choice. The young women created an exploratory workbook that explained the research topic they chose and how it relates to STEAM. Participants were interviewed at the beginning, middle, and end of their workbook creation. With the results of the young women’s interactions, one peeled back the onion and found ground truth utilizing coding techniques to understand and extract abstract themes about the young women's interest in STEAM.

Emergent themes from the data include design, relate, educate, social media, scrapbooking, forward, options, and role models. The theoretical framework: DRESS FOR STEAM, was created due to these findings. In addition, the framework yields guidance for future studies to consider for creating projects that motivate young women.

Limitations of the study include reduced ability to have group settings and group interactions. Hands-on learning and in-person interaction were highly degraded due to COVID.

In conclusion, the study revealed that young women are excited about STEAM. However, they may not know what Engineering is and that a new framework, DRESS FOR STEAM, can create future engaging studies.
# TABLE OF CONTENTS

ABSTRACT......................................................................................................................... iii

LIST OF TABLES ................................................................................................................ xiv

LIST OF FIGURES ............................................................................................................. xv

ACKNOWLEDGMENTS ....................................................................................................... xvi

DEDICATION ...................................................................................................................... xix

CHAPTER 1 .........................................................................................................................1

  General Problem ........................................................................................................... 1

  Study Focus .................................................................................................................... 3

  Study Purpose ............................................................................................................... 5

  Research Questions ...................................................................................................... 5

  Study Importance/Significance .................................................................................... 5

  Inquiry Framework ...................................................................................................... 6

  Inquiry Statement ........................................................................................................ 7

  Study Boundaries ....................................................................................................... 8

  Terms ............................................................................................................................. 8

  Significance .................................................................................................................. 10

  Summary ..................................................................................................................... 11

CHAPTER 2 .........................................................................................................................12

  Overview ..................................................................................................................... 12
<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chain of Reasoning</td>
<td>12</td>
</tr>
<tr>
<td>Social-cultural Perspectives</td>
<td>17</td>
</tr>
<tr>
<td>From STEM to STEAM</td>
<td>22</td>
</tr>
<tr>
<td>Learning Based on History</td>
<td>23</td>
</tr>
<tr>
<td>Steampunk</td>
<td>27</td>
</tr>
<tr>
<td>Bibliotherapy Learning based on Fairy Tales</td>
<td>28</td>
</tr>
<tr>
<td>Data Science</td>
<td>30</td>
</tr>
<tr>
<td>Vygotsky</td>
<td>32</td>
</tr>
<tr>
<td>Vygotsky Scaffolding</td>
<td>35</td>
</tr>
<tr>
<td>Systems Engineering</td>
<td>36</td>
</tr>
<tr>
<td>Active Learning</td>
<td>39</td>
</tr>
<tr>
<td>Internet of Things (IoT)</td>
<td>41</td>
</tr>
<tr>
<td>Scrapbooking</td>
<td>42</td>
</tr>
<tr>
<td>Textiles and Puppets</td>
<td>44</td>
</tr>
<tr>
<td>Naturalistic Inquiry</td>
<td>47</td>
</tr>
<tr>
<td>Grounded Theory</td>
<td>48</td>
</tr>
<tr>
<td>Grounded Theory Framework</td>
<td>49</td>
</tr>
<tr>
<td>Substantive Findings</td>
<td>52</td>
</tr>
<tr>
<td>Methodological Findings</td>
<td>52</td>
</tr>
<tr>
<td>Summary</td>
<td>53</td>
</tr>
</tbody>
</table>
CHAPTER 3 ................................................................................................................54

Research Approach .................................................................................................54

Research Questions .................................................................................................54

Study Design ...........................................................................................................55

Researcher as the Instrument .................................................................................55

Phase One: Pilot Study ............................................................................................56

What Should be in a STEAM Workbook .............................................................56

Target Population and Sampling ..........................................................................56

Interventions/Treatment/Procedures ....................................................................58

Data Collection ........................................................................................................63

Instrumentation ......................................................................................................65

Data Analysis ..........................................................................................................66

Phase Two: Workbook Construction .....................................................................68

Build your Own STEAM Workbook ....................................................................68

Framework and Grounded Theory Methodology ...............................................70

Target Population and Sampling ..........................................................................75

Interventions/Treatments/Procedures ...................................................................76

Workbook Construction Materials .......................................................................77

Workbook Test Run .................................................................................................78

Workshop One – The S in Science ........................................................................78
<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workshop Two – Exploring STEAM</td>
<td>82</td>
</tr>
<tr>
<td>Workshop Three – The Conclusion</td>
<td>85</td>
</tr>
<tr>
<td>Focus Group</td>
<td>87</td>
</tr>
<tr>
<td>Instrumentation</td>
<td>87</td>
</tr>
<tr>
<td>Construct Validity</td>
<td>89</td>
</tr>
<tr>
<td>Data Collection</td>
<td>89</td>
</tr>
<tr>
<td>Data Analysis</td>
<td>90</td>
</tr>
<tr>
<td>Data Analysis – Odin’s Eye, the Well of Truth</td>
<td>92</td>
</tr>
<tr>
<td>Data Analysis – Initial Coding</td>
<td>94</td>
</tr>
<tr>
<td>Data Analysis – Intermediate Coding</td>
<td>95</td>
</tr>
<tr>
<td>Data Analysis – Advanced Coding</td>
<td>95</td>
</tr>
<tr>
<td>Data Analysis – Theoretical Sampling</td>
<td>96</td>
</tr>
<tr>
<td>Data Analysis – Theoretical Sensitivity</td>
<td>96</td>
</tr>
<tr>
<td>Trustworthiness and Credibility</td>
<td>97</td>
</tr>
<tr>
<td>Work Plan</td>
<td>98</td>
</tr>
<tr>
<td>Resources</td>
<td>99</td>
</tr>
<tr>
<td>CHAPTER 4</td>
<td>101</td>
</tr>
<tr>
<td>Introduction</td>
<td>101</td>
</tr>
<tr>
<td>Choosing a Victorian Steampunk Name</td>
<td>102</td>
</tr>
<tr>
<td>Research Question 1</td>
<td>103</td>
</tr>
</tbody>
</table>
Research Question 2............................................................................................................ 108
Generating/Collecting Data........................................................................................................ 109
Initial Coding............................................................................................................................... 109
Intermediate Coding.................................................................................................................... 111
Advanced Coding.......................................................................................................................... 112
Memoing ......................................................................................................................................... 113
From STEM to STEAM.................................................................................................................. 116
Active Learning.............................................................................................................................. 118
Saving Sharks .................................................................................................................................. 118
Dress Construction ....................................................................................................................... 119
Spreading of Infectious Diseases.................................................................................................... 119
Obsessive Compulsive Disorder.................................................................................................... 120
Education App............................................................................................................................... 121
Nutrition and Antioxidants .......................................................................................................... 121
Water Pollution in the Indian River Lagoon.................................................................................. 121
Monitoring Trains for Civil Engineering..................................................................................... 122
Learning Based on History........................................................................................................... 122
Steampunk....................................................................................................................................... 123
Bibliotherapy Learning Based on Fairy Tales................................................................................ 123
Data Science.................................................................................................................................. 124
Trustworthiness: Consistency .................................................. 145

Trustworthiness: Neutrality...................................................... 146

Credibility: Persistent observations....................................... 146

Credibility: Peer Debriefing................................................... 146

Credibility: Triangulation....................................................... 147

Credibility: Member checks................................................... 147

Credibility: Focus Group....................................................... 147

Credibility: Purposive Sampling............................................. 148

Credibility: Constant Comparative Analysis.......................... 148

Salary................................................................................. 148

Emergent Themes and Framework ........................................ 149

DRESS FOR STEAM ............................................................. 149

Design.................................................................................. 152

Relate.................................................................................... 152

Educate.................................................................................. 152

Scrapbooking........................................................................ 154

Social Media.......................................................................... 155

Forward ................................................................................ 157

Options.................................................................................. 158

Role Models .......................................................................... 159
APPENDIX C. PARENTAL CONSENT FORM FOR PHASE 1...........................................222

APPENDIX D. PARENTAL CONSENT FORM FOR PHASE 2..........................................226
LIST OF TABLES

Table 1: List of Project Ideas ........................................................................................................ 64
Table 2: List of Workbook Activities ............................................................................................ 65
Table 3: List of Instruments and Collection Methods ................................................................. 90
Table 4: Example of Initial Coding ................................................................................................ 110
Table 5: Intermediate Coding ...................................................................................................... 111
Table 6: Advanced Coding ........................................................................................................... 113
Table 7: Memo Examples .............................................................................................................. 114
Table 8: Theoretical Framework DRESS FOR STEAM ............................................................ 150
Table 9: Example of Theoretical Framework Development ....................................................... 162
Table 10: Word Clouds and Themes ............................................................................................ 164
Table 11: Areas of Interest ........................................................................................................... 185
LIST OF FIGURES

Figure 1: The Three Spheres of Vygotsky, Social-cultural Perspectives, and Active Learning ................................................................. 6

Figure 2: Meet the Puppets, Left to Right, Gallagher, Maggie, Harry, Victoria, and Emerson ........................................................................... 47

Figure 3: Research design framework from Chun Tie et al. (2019) modified for this study ................................................................. 72

Figure 4: Participant Workbook Example ................................................................................................................................. 102

Figure 5: Meet Gale ........................................................................................................................................................................ 130

Figure 6: Excerpt from Katherine's Workbook Regarding Scott the Sidekick .......... 131

Figure 7: Puppets in Play Learning STEAM ........................................................................................................................................ 192
ACKNOWLEDGMENTS

Thank you to the members of my Dissertation Committee, who have helped me along the way:

To Dr. Samantha Fowler, thank you for helping me through my journey here at Florida Tech and becoming my advisor. I have enjoyed working with you over these past years and treasure all the knowledge you have imparted to me. I enjoy your sense of humor and your candid guidance to help see me through this lengthy endeavor. Harry and I have appreciated working with you every step of the way.

To Dr. Keith Gallagher, thank you for all the support and time you have given me to help inspire, drive, and enrich my experience at Florida Institute of Technology (FIT), and to make this dissertation a reality. I enjoy chatting together and exploring new technologies. It’s a beautiful day in your neighborhood.

To Dr. Kastro Hamed, thank you for your insights and apt analogies that have helped me to see the world in a different light. Sculpting is not only about what one sees, but also about what one cannot see, especially regarding what one removes. Thank you for being the light that helps us on the path without getting lost in the branches of the trees. Thank you for the sound advice and stewardship throughout my time at FIT.

To Dr. Joo Young Park, thank you for your mathematical knowledge and your stories of Columbia University. You have a great sense of humor, and I appreciate all your help and assistance to ensure the mathematics of the statistical analysis is correct. Harry and I are beyond happy with your continued support and guidance.
To Dr. Judith B. Strother, thank you for your help in polishing this dissertation by ensuring I communicate clearly. I appreciate your time in helping me to edit the document. Thank you for always being there when I need your help and assistance.

Thank you to my family and friends, who have helped me along the way:

To Wendy Gaydar, thank you for your support over these many years and engaging with the girl scouts and other committee members. Thank you for always being there and offering a helping hand.

To Tracy Konczynski, thank you for your help with everything you have done through the years to help -- from stuffing puppets into bags and helping to keep things organized, to helping track down articles whose citations got lost, and overall being there to help in any way.

To my parents Robert Konczynski, Sr, and Marilyn Konczynski, thank you for your constant help, support, and guidance throughout the journey of this dissertation. Our friends Dot, Candy Corn, and the rest of the gang have all been invaluable helpers on this journey.

To Amanda Rose Newton and Shelia Young, thank you for being a sounding board and willing participants as my beta study group. Thank you for your insights and wealth of knowledge on the various topics we discussed. Thank you for the Zoom meetings during COVID-19 and the meet ups when things started to get normal again.

To all the participants who worked on the workbook and helped to make this dissertation possible. Thank you for your help, support, and making this whole experience enjoyable. Thank you to your parents and guardians, who made this all possible. I wish you much success and happiness in your years ahead.
To Harry, you have been my best buddy in this whole journey. Thank you for always being there and providing insightful thoughts and opinions on the various topics we explored together. Thank you also to your brothers Chef Alfredo, Linguine, Emerson, your sisters Maggie, Victoria, and the rest of the gang. All your help has helped to make this whole experience fun and enjoyable. Although you are all made of felt, you have hearts of gold.
DEDICATION

I dedicate this dissertation to my parents, Robert and Marilyn, my sisters, Tracy and Wendy, to my Brother-in-Law John, and my nieces, Erin and Colleen. Your help and inspiration have guided me. You have all been my candle on the water, helping to guide my ship to port. Thank you for your love and support and for being there along the way.
CHAPTER 1
Introduction

General Problem

As new technologies emerge, such as Data Science, big data, and the Internet of Things (IoT) that are now part of the societal and cultural landscape, there is an overwhelming concern that not enough women are entering Science, Technology, Engineering, Art, and Mathematics (STEAM) careers, especially in Computer Science and Engineering (Cheryan, 2015; He, 2016; Talley, 2017). To understand this concern, one can look at the current trends and statistics to see the state of women working within STEAM fields. The current women’s labor effort in STEAM careers is at 28% while the men’s labor effort in STEAM careers is at 72% (Silva, 2019). The takeaway here is that there is not an even balance of men and women in STEAM careers. The STEAM fields have a much higher male population, three quarters more than the female population. In general, there are lots of ideas as to why this may be occurring, but as a society, the issue is baffling.

One issue that has emerged from studies is that of attrition. Over time, women who enter STEAM careers often do not stay in them. Research conducted by MIT (Vinopal, 2016) shows some ideas as to why women may decide to leave a STEAM career. Ideas that have emerged from the study are: (1) women are often given administrative style jobs within their working group; (2) women have poor internship experiences; (3) there is ageism and (4) sexism is a continual problem in such fields (Vinopal, 2016). All of these have played various roles to dissuade women from staying in the profession (Vinopal, 2016). Although this study indicates why women may leave
the STEAM field, another needed perspective is to understand why young women may decide not to enter a STEAM career in the first place.

Studies have shown us that men and women have the same aptitude for math and science, but when they get into college, men predominantly choose STEAM-related fields while women do not (Spelke, 2005; O’Dea, 2018; Silva, 2019). Before tackling the problem, it is essential to discuss motivation.

Motivation is the byproduct of our humanistic intrinsic and extrinsic desires (Cook, 2016; Ryan, 2000). These desires constitute human behavior and allow one to pursue engaging and challenging activities within life. When motivating women to enter a STEAM career path, it is prudent to focus on the past to see how others have motivated women to enter predominantly male professions.

There needs to be a rally of support and encouragement to motivate young women to seek out STEAM careers if they choose. In the 1940s, the US government designed an advertising campaign known as “Rosie the Riveter” to help attract women into a predominantly male profession (Milgram, 2011). Since men were away fighting in the war, the women were called upon to help with wartime production, and this was one way that women entered the field. Today, there is not a war to motivate women to go into the computer science and Engineering workforce. Instead, we need to find a way to motivate or encourage women to want to investigate such careers.

One way to pursue such a quest is to embark on the understanding of why women may choose not to enter STEAM careers and what sort of motivation could encourage them to join such careers (Milgram, 2011). An interesting fact about women in STEAM, especially in computer science, is that in the 1960s and 1970s, women were in computer
science in substantial numbers (Gurer, 2001). In 1984 and beyond, their presence in the workforce began to dwindle (Henn, 2014). One prevailing thought as to why women began to lose interest was due to marketing campaigns that primarily used male actors interacting with personal home computers (Henn, 2014).

One such ad, as mentioned in the article, was the ad for the Commodore 64 (He, 2016; Retro VG Media, 2013). Movies such as *War Games*, *Revenge of the Nerds*, and *Weird Science* all featured men in the leading role, and they used computers in these films (Henn, 2014). In short, computers have links to male stereotypes (Henn, 2014).

These commercials may have led to social and cultural change that discouraged women from wanting to join computer-related careers. Another aspect of the problem is that even though STEAM is a buzz word used around education and careers, many people do not know what STEAM is (Breiner, 2012). One way to help mitigate this issue is to provide a hands-on lab that helps the learner understand it (Connors-Kellgren, 2016). To gain an understanding of why this might be, it is essential to examine women in their youth and to collect their thoughts and insights as to why they decide not to pursue a STEAM career.

**Study Focus**

To understand the motivation and social-cultural perspectives of women to choose or not to choose STEAM careers, one must rewind the clock and look at those young women when they were in middle school (Ormrod, 2012). Middle school is a significant development time for young adults, and it is the appropriate time to involve them in active STEAM projects (Cohen, 2020).
First, in middle school, students can start to have negative opinions of science and math and may carry those opinions with them as they become adults (Hirsch, 2011). Giving students positive and engaging STEAM projects in middle school may help offset those negative opinions and allow them to look at STEAM with an open mind (Cohen, 2020). Second, students start to think seriously about their career paths at this time (Cohen, 2020). Third, STEAM will help students with problem-solving skills that they can take forward to any career they choose, even ones not related to STEAM (Cohen, 2020). Fourth, involving everyone in STEAM at a young age will reduce any bias towards men or women as the students get older (Gjersoe, 2018). They equally had a chance to participate and make up their minds in regard to STEAM (Gjersoe, 2018). Finally, hands-on STEAM activities will demonstrate to the students that learning is fun and will empower them with the needed skill sets and critical thinking skills they will need when they are older (Mervis, 2018).

Young women often have a vague notion of what STEAM is. One way to increase the participant's knowledge of STEAM is to immerse them in a project-based STEAM experience and show practical examples of how it relates to society and careers. This study immersed young women in a STEAM project that they create themselves. The fundamental idea is that the participants have chosen a meaningful problem to solve and engaged in the construction of a STEAM workbook to document how the problem would be solved. This activity showcased the thoughts and ideas of young women today. The use of qualitative research methods and designs helped to triangulate emerging themes from the workbooks that the participants created.
Study Purpose

The goal of the study was to provide an active learning experience for all the female participants in STEAM to detect emergent themes and to determine if such an experience can produce a motivational change to consider a career in a STEAM Engineering field. The study is unique in that helpful and competent adults guided the participants through a STEAM science and Engineering project that they documented in their STEAM workbook. The goal was to discover the thoughts and perspectives of the participants as to why young women may not choose STEAM careers. Another way of looking at the study was to discover the thoughts that are present in a young woman’s mind that can illustrate to the community things that should go into workbooks and teaching materials that are relevant to young women, using inspiration from previous research (Connors-Kellgren, 2016; Wass, 2011).

Research Questions

1. How do thoughts and ideas about STEAM change in young women by their participation in a STEAM workbook workshop?

2. What thoughts and ideas emerge from young women who participate in a themed STEAM workbook project?

3. How does working on the STEAM workbook help young women understand or see potential career opportunities that they might not have known?

Study Importance/Significance

The study is critical because it provided a hands-on learning experience that directly relates to STEAM. It provided a walkthrough of Science, Technology,
Engineering, Arts, and Mathematics in a structured way. The hands-on lab work sparked
the student’s curiosity. The result is a workbook that shows the thoughts and insights of
a young woman and a workbook that showcases those thoughts. The study leveraged
active learning and constructivism to engage the participant. Additionally, the study
addressed various degrees that students may earn in college. These degrees are relevant
because they lead to job prospects and careers.

Inquiry Framework

![Figure 1: The Three Spheres of Vygotsky, Social-cultural Perspectives, and Active Learning]

The inquiry framework consists of three central concepts. The concepts are
classified as three spheres that intersect to form a Venn diagram shown in Figure 1:
The Three Spheres of Vygotsky, Social-cultural Perspectives, and Active Learning. The
overlap within the Venn diagram shows the fundamental core of how these aspects come
together to encourage young women into STEAM.
The first sphere is the educational theories of Vygotsky and how they relate to competent adults in helping them achieve a new level of understanding that they would not have been able to achieve on their own (Ormrod, 2012, pp. 313-351; Smolucha, 1992; Wass, 2011).

The second sphere is that of social-cultural perspectives. Environmental and cultural settings play a significant role in the development of one’s interests and motivations for STEAM. Setting up an appropriate environment is critical in having successful outcomes for young women and their interest in STEAM (Conradty, 2019).

The third sphere is the theories that deal with active learning and constructivism. The thoughts and emotions that may come into play either make a woman encouraged to join a STEAM career or discouraged and unmotivated to do so (Carlson, 2011).

**Inquiry Statement**

The participants were given workbooks that contained helpful prompts for them to build a mini-science project. The projects they chose were theoretical and explained the use of STEAM. The participants first explored the Science (the S in STEAM) of the topics they had chosen. Next, the participants were exposed to Technology (the T of STEAM), such as the Internet of Things (IoT). The next aspect of the project showed them Engineering (the E of STEAM) and how technical aspects of design and Engineering orchestrate together to create a system to address their mini-science projects. Orchestration wove the components together utilizing aspects of Systems Engineering. All the electronics together can make quite a mess but tying them together in an artistic way brings out the Art (the A in STEAM). Lastly, the participants pulled data together and used Data Science skills to make sense of the data through Mathematics (the M in
STEAM). As one can see, the project not only walked the participants through STEAM, but it showed them how it all comes together in a succinct way (Gallant, 2010). The workbooks were themed around the Steampunk genre, helping to address the A in STEAM for Arts.

**Study Boundaries**

The study was limited to young women ages 11 to 18 to gather insights about their thoughts and perceptions of STEAM. The study was limited to the accessible population and was a qualitative study. The study utilized interviews, the researcher's notes, and content analysis to extract vital information regarding a young women’s motivation. The study was not a fishing expedition but instead a focused study looking to peer behind the lens of a young woman to see her thoughts and perceptions of STEAM and of STEAM as a career.

**Terms**

The following terms included in this dissertation are defined as follows:

*System of Systems (SOS)* is a term used to describe systems that interoperate to create a system. Various systems and subsystems collectively come together to create the systems of systems.

*Internet of Things (IoT)* is a term used to describe a collection of small gadgets that can connect to the internet and can come together and serve a single purpose or collectively solve a more complex problem. Many examples of the Internet of Things include The Ring Doorbell, Amazon Alexa, security cameras, weather stations, the Raspberry Pi, and Arduino.
Raspberry Pi “is the name of a series of single-board computers made by the Raspberry Pi Foundation, a UK charity that aims to educate people in computing and create easier access to computing education.” (What is a Raspberry Pi?, n.d.)

Arduino “is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board.” (What is an Arduino?, n.d.)

STEM is an abbreviation for Science, Technology Engineering, and Mathematics (Boy, 2013)

STEAM is an abbreviation for Science, Technology, Engineering, Arts, and Mathematics (Boy, 2013)

Scrapbook is “a blank book in which various items (such as newspaper clippings or pictures) are collected and preserved” (Scrapbook, n.d.)

Bibliotherapy is “the use of reading materials for help in solving personal problems or for psychiatric therapy” (Bibliotherapy, n.d.)

Workbook is “a book designed to guide the work of a student by inclusion of questions, exercises, etc.” (Workbook, n.d.)

Data Science “is the study of data” (Data Science, n.d.)

Puppet “a small-scale figure (as of a person or animal) usually with a cloth body and hollow head that fits over and is moved by the hand” (Puppet, n.d.)

Steampunk “science fiction dealing with 19th-century societies dominated by historical or imagined steam-powered technology” (Steampunk, n.d.)
INCOSE is the International Council on Systems Engineering (Incose, n.d.)

TBD is an abbreviated term for To Be Determined (TBD). The term applies to situations, events, or documents whose delivery date is indeterministic at the time of document completion. Generally, a TBD is backfilled with an actual date once it is known.

PBL is Project Based Learning and sometimes referred to as Problem Based Learning (Slykhuis, 2015).

Significance

The significance of the study is that women were excited about the experiment and enjoyed working on it. The previous studies have fallen short of delivering a well-thought-out STEAM approach. This study provided the S, the T, the E, the A, and the M in STEAM; i.e., the science of the topic the young women chose, the technology of the Internet of Things, the Engineering of Systems Engineering, where everything was built and assembled, the A for the arts such as human factors and Data Science visualization, and the M in mathematics for Data Science, in which data was explored helped to jump-start the imagination and creation centers of the young women to engage in STEAM.

The participants first selected the problem that they wished to solve. This goes back to Problem Based Learning and Project Based Learning (PBL) (Slykhuis, 2015); once the problem was identified, the participants then walked through the S, T, E, A, and M, to identify the various interdisciplinary components that they needed to bring their theoretical device to fruition.

The unique contribution that this study brought to the educational field is an experiment that demonstrates some of the newer technologies available so that students
may find their own intrinsic desire to build on their own skills. The hope is that young women are inspired by their workbook creations and follow through in implementing various parts or the whole project. They saw how STEAM and related careers that a person can follow create a pathway to solving real world problems that affect the community and adds meaning to the lives of everyone around them.

**Summary**

The dissertation research study engaged young women in STEAM with the intent to enlighten them on the various opportunities that are available to them in society, especially in STEAM-related careers.
Overview

Engaging young women in STEAM is important for helping to increase the number of women in STEAM fields and to benefit society itself. There are many reasons why women do not enter the STEAM fields, and among them are not enough opportunities for them to explore STEAM before they make career decisions.

Chain of Reasoning

The goal of this study was to bring forth new ideas regarding the content that young women would like to engage in for a STEAM activity. It was essential to understand some of the thoughts and perspectives of today's youth when it comes to meaningful experiences with STEAM. A crucial distinction in this study was that the participants focused on STEAM and not STEM. STEAM brings the A for Arts into the realm of STEM. The A emphasizes the interdisciplinary field of Science, Technology, Engineering, Arts, and Mathematics. The arts bring in creativity and the humanities into the solutions of tomorrow. This study utilized a Systems Engineering approach to solving problems to assist young women in choosing a problem-based learning activity.

The participants chose a topic of interest that they were curious about and used the systems Engineering process. They constructed their very own workbook, which depicted their ideas. The workbook was very similar to an Engineering notebook that captures the requirements of any project. In the case of the STEAM workbook, the book captured the participant's journey through each of the S, T, E, A, and M elements.
first aspect of building the workbook was functional or requirements analysis; this was where the participants collected and identified the problem that needed to be solved and aspects of the solution. An excellent way to capture this was through scrapbooking. Scrapbooking allows one to be creative in constructing and expressing ideas. The ideas were formalized into a workbook.

The participants used investigative skills to locate various products and devices that are part of the Internet of Things to use as part of the solution to their problem and idea. The components that they chose, along with science and technology, brought together the aspects of Engineering. The different parts of the project were orchestrated together utilizing Systems Engineering to compose the solution, which were the premise of the workbook. The participants constructed a storyline within the Steampunk era (Onion, 2008).

The Steampunk theme intended to make the workbook construction activity highly engaging. The Steampunk genre allowed the participants to tailor their workbooks to a specific realm so that the different participant projects would be able to integrate with each other. The participants wrote a tale of a Victorian character who solved a problem in the Steampunk world (Onion, 2008). By having the participants create a story, they utilized elements of bibliotherapy.

Bibliotherapy helped learners connect to foreign concepts or ideas by providing storylines with actors and settings that the reader can find relatable. For the workbook project, the participants wrote stories that others could read. The goal is that future readers can see themselves through the characters and, therefore, vicariously get more comfortable with the terminology and concepts present in the story. The reader relates to
the character, environment, and content of the story, thus achieving a connection that was not previously possible. An example of such work is utilizing fairytales to help participants learn and enjoy STEAM another way. In this current study it provided a fun, creative, and engaging activity that helped the participants to learn the A in STEAM (Dahlstrom, 2014; Friedman, 1995; Ormrod, 2012; Furner, 2017).

The act of working together with other participants and adults utilized the work of Vygotsky and the Zone of Proximal Development (ZPD) (Ormrod, 2012, pp. 313-351). These educational theories helped us to understand that creating a proper environment for STEAM is crucial in getting young participants involved. The environment setup, through the use of videos and interacting with everyone, helped paint a new social-cultural perspective to motivate young women towards the “I can do it” attitude of Rosie the Riveter (Milgram, 2011).

The workbook project strove to make meaningful connections between the project at hand through lessons of the past. The participants faced challenges to discover historical role models to help tie aspects of what they themselves were doing to what was done in the past. Steampunk itself was written in the time of H.G. Wells and Jules Vern, who also provide excellent sources for historical references (Onion, 2008). Each of the workbook experiments touched upon history in some shape or form.

One of the challenging careers in today’s society is Data Science. Data Science now operates as the M for Mathematics in STEAM. It is an interdisciplinary field that is interested in finding and documenting relationships within data.

In the workbook project, the participants were exposed to Data Science so that they could see how integral it is in STEAM. The various topics and themes that compose
the workbook follow the chain of reasoning to merit their inclusion. Altogether these varying aspects of STEAM are linked together with Vygotsky’s work. The social-cultural perspective based on women in Engineering and active learning tie together to form a workbook activity that provided ample engagement for new and emergent themes.

This literature review was aimed at three main areas of research and tied them together with other selections that comprise the workbook creation activities. The first task was to examine articles that discussed women in Engineering. The second was to find articles that utilized project-based labs. The third was to examine the theoretical educational framework and to show how it weaves the other two areas of research together. The outcome of the literature review provided insight into how one should conduct a study to address areas in which published research is weak. The resultant study design helped to shore up knowledge and fill in the gaps to be more inclusive of women. Additionally, the research into these articles produced new areas of research to be considered for this project, such as the Engineering process, Vygotsky’s work, ZPD, scrapbooking, bibliotherapy, textiles, puppets, Internet of Things, and history.

For the theme of social-cultural perspectives, articles were searched particularly for those types of words and titles. The words were then combined with “education” to find more relevant articles. Some of the results of these inquiries reveal why some women choose not to enter STEAM careers. Articles about STEAM camps and activities were found and included in this study.

For the theme of “Project-Based Learning,” articles were searched for project-based labs, hands-on learning, and active learning. Additionally, this is the area in which the investigation of technologies addresses parts of active learning. Technologies such as
the Raspberry Pi microcontroller, Leyden jars, lab projects, Software Engineering, Systems Engineering, 3D printing, and the Internet of Things (IoT) were just some of the areas researched.

For the theme of Vygotsky, articles were searched for discussions relating to play and how the use of the Most Knowledgeable Other (MKO) is used. The term STEM/STEAM is used interchangeably here due to the lack of articles for STEAM. The Art in STEAM is relatively new and to restrict the research to STEAM would significantly limit the results of available research. The research led to the conclusion that this study should focus on emergent ideas from young women regarding STEAM utilizing a qualitative study instead.

The last topic revolved around the theme of “Workbooks” and their role in education. Workbooks provide a guided workflow of information gathering, exploring, and solving. Not only do they provide active learning engagements, but they also provide standardization between researchers and teachers. Content in the workbook remains static and ties closely to the syllabus. The workbook also ties in Engineering notebooks and documentation that can depict and document the Engineering process. The construction of the workbook is a Systems Engineering activity, and the outcome is the book itself. The book can also be generalized to other technologies such as websites, mobile apps, and books. A surprising discovery in researching workbooks was the lack of papers and journal articles about them. Many works about workbooks deal with primary education, and not many deal with higher education, such as STEM and STEAM projects. Due to the lack of articles on workbooks, other areas were explored, such as
scrapbooking. The following works explore and expand upon the three main themes of this study.

The three main themes of this study are Social-cultural Perspectives, Vygotsky, and Project-Based Learning (PBL). Social-cultural Perspectives included From STEM to STEAM, Learning Based on History, Steampunk, and Data Science. Vygotsky included the work of Vygotsky, Vygotsky Scaffolding, and Systems Engineering. Project-Based Learning included the Internet of Things, Scrapbooking, Textiles, and Puppets.

**Social-cultural Perspectives**

The first theme is social-cultural perspectives with women in Engineering. The critical aspect of this theme is to understand more about women in Engineering. Cheryan (2015) explores why women are not in STEM careers, especially Engineering and computer science. A story was written showing how Mattel developed a new version of Barbie, where people were able to choose a career path for her. The participants chose a Computer Engineer as a career role for Barbie. Although the Computer Engineer won out, Mattel was nervous about releasing this Barbie, so they released two Barbie’s instead. One was a Computer Engineer, and the other was a News Anchor.

Cheryan (2015) evaluated various surveys and drew conclusions and ideas as to why women are not pursuing degrees in Engineering. Results of several studies were reported where participants took surveys. The data collected backed up many of the general thoughts people have regarding women in Engineering. Some of the results include the following:

1. Girls may be steered away from Computer Science and Engineering by parents, teachers, and others.
2. If girls do not see computer scientists and engineers as people with whom they feel similar, they may be reluctant to enter these fields.

3. Girls systematically underestimate how well they will do in these fields, and this predicts their lower interest in entering them.

4. Girls may anticipate encountering greater work-family conflicts in these fields.

5. There is discrimination in these fields that prevents qualified women from receiving the same opportunities as their male counterparts.

6. Women who enter traditionally masculine domains can be socially and professionally penalized. (Cheryan, 2015, pp. 1-2)

The analysis shows that user experience is a vital part of making a woman feel welcomed and belonging. Variability is the most important aspect to involve women in computer science and STEM. Women need to feel that they belong, and advertisements need to show women working in the field and enjoying themselves. They must feel welcome, and everyone needs to understand they provide additional insights that can benefit all. The article relates to the subject matter in that the research discusses reasons why many women choose not to enter STEM fields, especially computer science and Engineering. Various surveys support the point of view that the researchers found (Cheryan, 2015). It is all very relevant as to the type of inquiry that should be addressed and to help find solutions to the dilemma (Cheryan, 2015).

Sinkele (2011) discusses various statistical outcomes of a study regarding women in STEM careers. The results of the study highlight that women are underrepresented in many of the STEM fields and discuss various ways to correct this issue. The researchers conducted a study where they examined workshops where girls would build robots and
cook hot dogs with solar power. The main outcome was to identify factors that encourage girls to study Engineering fields. The researchers were also curious if all-girl workshops were beneficial and what sort of takeaways or ideas they hold. One of the takeaways is that the high school girls did not understand what an engineer does. They thought that Engineering is for nerdy people who love science and math. Many of the girls were not interested in STEM careers. What they were interested in is careers that are relevant, rewarding, have decent pay, and are impactful. The message conveyed is that girls need to understand that a career in STEM is rewarding, impactful, and has decent pay.

Sinkele concluded that it is important to express to the girls human experiences and stories that stress the human factor of Engineering. Participation in workshops that expose participants to the exciting world of science and Engineering and the type of work that engineers and scientists do can increase the number of students wanting to pursue STEM careers. The study indicated that girls, despite not having a clear understanding of Engineering roles, did have positive associations with robotics and the more hands-on STEM activities they are exposed to, the more they warm up to the field. Parents are another key influence on girls’ career choices, and those whose parents supported exploration in STEM-based activities were more likely to have positive feelings towards Engineering-based careers. The final results of the study showed that to recruit women in STEM, the women need to have actual knowledge of the Engineering profession, a network of support, and relevant personal goals (Sinkele, 2011).

Milgram (2011) explores ways in which women and girls can be recruited into Science, Technology, Engineering, and Math. Various surveys were analyzed to explore
women’s thoughts and motivations on STEM. The survey results were then discussed to find emergent themes. Sending messages to women through advertisements or direct encouragement has the potential of having girls choose Engineering (or one of the STEM) fields. The insight gained by Milgram’s study showed that girls prefer the company of other girls, and they like to work together. One of the interesting aspects of the study reported that women do like the color pink and that many women like wearing pink (Milgram, 2011). This is important due to studies that question if toys are gender stereotyped by color. One way of mitigating against gender stereotyping based on color is to use gender neutral colors.

Milgram (2011) explains ways that some women are motivated and encouraged to join in STEM activities. The article discusses Rosie the Riveter, which was created by the U.S. Government in the 1940s to motivate women to join predominantly male careers due to the shortage of men. The article states that one must provide images of women in technology occupations, and they must be provided repeatedly. Learning requires hands-on experience, repetition, and practice. (Milgram, 2011). The same concepts must be applied to recruiting women. Workshops that were conducted for the current study will help to provide the message to women that they will be welcomed into these fields.

Liao (2016) had the goal of exposing girls to various digital art forms where they could utilize their knowledge of STEM for the arts in STEAM. Girls were asked to make multimedia presentations where they were able to interact with Science, Technology, and Math to understand their connections to art. Emphasis was not on any individual tool but on the ability to utilize digital artmaking in any setting and how 21st Century tools can be used for artistic purposes for STEAM.
Liao (2016) explained that students explored initial storytelling and game-making to help them see the relationship to STEAM. The games used programming skills such as interoperative scripts to tell the participants’ stories. The students learned skills in technology literacy by programming, critical thinking, and problem-solving. They conducted pre- and post-surveys asking about the curriculum and their interest in STEM. The students’ interest in STEM improved after the courses. “Students gained different perspectives and insights on technology as well as the understanding that women can also make a difference using technology. Students learned that collaboration and teamwork skills are essential to digital creation. Students gain digital media skills empowering them to understand that everyone can learn how to use the computer as an expressive art medium” (Liao, 2016, p. 34). The article is important because of its emphasis on the A in STEAM. It recognizes that STEAM is now getting more attention and that the artistic, creative aspects of STEAM relate to cultural perspectives.

Many companies today create a STEAM box. A STEAM box is generally a small kit that contains everything one would need for constructing a small STEAM project. These boxes are marketed so they are visually stunning and appeal to a large audience who would buy them. The box itself is intended to educate the person assembling it with concepts of STEAM. A STEAM box requires some level of art, creativity, and advertising to make it appealing. The article demonstrates how one can rally teams to work collaboratively while also exposing students to STEAM.

Shapiro (2012) carried out research to demonstrate the role of environmental factors that can play into undermining women’s interest in STEM. The study examined experiments that were conducted to see if the young women would respond differently to
a math test if they had to report their gender. Additionally, similar tests were conducted when reporting ethnicity. When white males were told that Asians perform better in Math, their scores on math tests were lower than those of the control group who were not told the statement about Asians (Shapiro, 2012).

A content analysis of various studies was used to reveal issues associated with gender stereotypes. Research studies were examined and used to evaluate the use of women's stereotypes and ethnicity. The results showed that gender-related cues could cause gender-specific threats to emerge for participants exposed to stereotypes. The gender stereotype is not a singular construct but instead is a broad umbrella that encompasses a Multi-Threat framework. The study focused on girls and factors that put them at risk for negative stereotype experiences based on gender (Shapiro, 2012).

The results of Shapiro’s study show us that one must be aware of the stereotypes and mitigate against them. That article relates to the proposed study with the understanding of how stereotypes can disrupt or create a bias for participants in a study. Research indicates that girls will respond in a negative manner to projects that are biased towards men. The implication of this study is that it is important that material that is supplied to participants should be gender neutral to prevent bias. Additionally, questions and wording of instrumentation cannot have a negative connotation associated with women or men. For example, one should not write Jack went up the hill, but Jill could not. That would impose a bias and extend the stereotype threat (Shapiro, 2012).

From STEM to STEAM

Boy (2013) discusses why there needs to be a shift from STEM to STEAM. When looking at the various aspects of STEM, one can realize that to make them truly
interdisciplinary, there is another aspect that is missing, and that aspect is Art. Art allows one to bring together the various aspects of STEM in a well-orchestrated concert of interworking disciplines. The A, according to Boy, brings back the focus of creativity. Creativity can be expressed in many forms, but the main aspect is that creativity needs to be expressed in STEM, and it is done so by using STEAM.

One aspect that Boy mentions is that of Human-Centered Design. Human-Centered Design and User Experience Centers are at the forefront of what STEAM is evolving to. These centers promote the collaboration of interdisciplinary fields to orchestrate a solution amongst all the various components of a project. The components can be anything from Subject Matter Experts, the end-user, the actual parts technology, and Engineering that goes into devices to science, mathematics, the arts and creativity.

One of the aspects of the workbook in the current study is to collect and gather requirements from the participants. The requirements are collected as part of a workbook experience, which also utilizes ideas of “storyboarding, participatory design, scenario-based design, and formative usability evaluation” (Boy, 2013, p. 3). Boy adds that Human-Centered Design is at its core all about “creativity, innovation, and critical thinking” (Boy, 2013, p. 3).

**Learning Based on History**

Educators want to be able to create and utilize authentic STEM activities and experiences within their classrooms but are often bound by the curriculum that is already in place. Today’s curricula still treats the main subjects of STEM individually without addressing the interdisciplinary notion and intent of STEM. Due to this, it is often found that projects and activities can only touch upon certain aspects of STEM. For example,
one learning activity might address Science and Math for the SM part of STEM but does not address Technology or Engineering. Another project might address Technology and Engineering but does not address Science and Mathematics. Effectively, the students are learning various parts of STEM but in isolation, also known as silos. Concepts from one area of study are not generalized to the other area because the activities do not bring them together. According to Slykhuis (2015), STEM activities need to be problem-based and authentic so that today’s youth can understand how the various aspects of STEM are orchestrated together to create an outcome.

STEM projects need to be authentic, so learners can really understand and use critical thinking to solve problems. The projects should not only be Problem-Based Learning, but they should also be part of Professional Learning Communities (PLC) (Slykhuis, 2015). PLCs help to create PBLs in that they utilize the resources of local business partners within the communities to help create problems that are relevant to the problem at hand (Slykhuis, 2015). An example of this is that in Melbourne, Florida, there are some issues regarding pollution within the Indian River Lagoon (IRL). A PLC would identify issues and problems that can be solved to help assist the Indian River Lagoon, and a PBL could be created as STEM activities to engage students in critical thinking and problem-solving skills that address all aspects of STEM. Slykuis (2015) mentions that history is also a motivator for STEM projects. In the paper, the author discusses how a STEM project was based on the Charles Page Electromagnetic Engine. The relevant history, along with schematics of the engine from 1854, is shown to students to help provide the scaffolding of what is needed in order to convey the concept of a commutator, which is a part of the engine (Slykhuis, 2015). In the current study, with the
STEAM workbook, various projects were used as a scaffolding to help inspire and motivate young women to investigate and brainstorm their own ideas. History and community engagement can assist the scaffolding to bring forth the enthusiasm that can help motivate the participants to excel in their own problem-based studies (Slykhuis, 2015).

An essential aspect of STEAM projects is the ability to engage the participants, to get them excited, curious, and immersed; by doing so, the participants can make various connections to the world around them. An aspect of engagement that caters to some learners is a connection to the past. History itself teaches us past narratives of amazing lives people have led (Dahlstrom, 2014). From Benjamin Franklin and the discovery of lightning effects to Ada Lovelace, who is considered the mother of computer sciences, these people from our history have paved a way forward to where we are today (Dahlstrom, 2014; Fradin, 2002). Examining all the past accomplishments of humanity provides a fantastic opportunity to tie social sciences into lessons created today. Since people often have different ways in which they are motivated, individuals are not all motivated by the same concepts in generating interest in STEAM careers. Therefore, finding intrinsic motivations that girls can latch onto is key.

Intrinsic motivations are things we want to do that are internal to how we operate, want, and crave. Motivation drives human behavior and the human condition (Kossen, 1978, pp. 105-133; Cook, 2016). Tying the history of the past and recreating experiments is a fascinating and rewarding way of engaging young women in STEAM. The Steampunk theme that is part of the storytelling of the workbook activity helps young women learn from the past to give them the opportunity to find motivational people who
existed before us. The historical narratives provide this feeling of connection, and similar to bibliotherapy, provides unique ways of showing us that ordinary people live extraordinary lives. The aspect of having the participants choose someone in history that they can connect with is another aspect of motivating them in STEAM (Zaman, 2016). The following is a list of just a few women in history who can have contributed to areas in STEAM:

Ada Lovelace – mathematician and computer scientist

Emmy Noether – most influential mathematician.

Grace Hopper – computer scientist (COBOL programming language)

Rosalind Franklin – British chemist and crystallographer (DNA)

Ana Roquě de Duprey - astronomer and educator (wrote Botany of the Antilles)

Lillian Gilbreth – psychologist and industrial engineer

Barbara McClintock – cytogeneticist

Ruth Rogan Benerito – chemist and pioneer in bioproducts (saved the cotton industry after World War II)

Edith Clarke – electrical engineer (the first professionally employed female electrical engineer in the United States)

Sally Ride – astronaut (first female American astronaut in space)

Lydia Villa-Komaroff – molecular biologist (demonstrated that bacteria could be engineered to produce human insulin)

Mollie Orshansky – food economist and statistician (worked on American public policy)

Rachel Carson – marine biologist (author of Silent Spring)
Katherine Johnson – American mathematician who calculated and analyzed the flight paths of many spacecraft.


Steampunk

When the idea arose that, in the current project, a workbook would be the mechanism for collecting the ideas and interactions of young women in STEAM, it was realized that the activity and project needed a centralized theme. The purpose of the theme is to provide some grounding points in the activity so that the participants could work together consistently. Various workbooks were looked at for ideas and inspiration to see how a workbook should be constructed. Most of the books are composed of small projects that do not necessarily relate to the entire STEAM aspect. When looking over the entire breadth of what is to be accomplished with the interdisciplinary nature of STEAM, it was realized that there needed to be a powerful theme. The theme needed to be one that can resonate with people and allow for individual freedom of art and expression. To meet this need, the genre of Steampunk was chosen.

Steampunk itself is an interdisciplinary composition of gears, clothing, time, settings, and collections of literature (Onion, 2008). As stated previously, the intent with the workbooks was that the participants create their own storylines that can connect their actors to the work they are creating in the book. Steampunk allows for this.

According to Onion (2008), Steampunk was born out of literature and the writings of Jules Vern and H. G Wells. Stories and movies such as The Time Machine, The
*League of Extraordinary Gentlemen, 20,000 Leagues under the Sea,* and the *Wild Wild West* all contain components of Vernian stories and ties to what is known as Steampunk. The characters in these stories dress as in the Victorian age and that of the wild west. All these separate Vernian features are tied together within the Steampunk genre, just like it is intended to tie the STEAM elements together for its interdisciplinary aspect (Onion, 2008).

The first reason that Steampunk was chosen is due to its overall design and appeal. It is a form of artistic display that brings together the Midwest, high society, and goth. The genre of Steampunk was chosen for this study due to overlapping ideas presented in the literature (Onion, 2008). One way to emotionally connect with young women is to tie history to the present. Steampunk was chosen because of its uncanny way of tying the past to the present and for its color scheme. Colors and materials of brass, leather, wood, gold, copper, silver, nickel, pewter, suede, and lace are just a sampling of the palette available to choose from when designing clothes and apparatus of the Steampunk genre. A bonus aspect of Steampunk is that the color palette itself is gender-neutral, which makes it appealing to both girls and boys. There are no stereotypical blues or pinks (Onion, 2008).

**Bibliotherapy Learning based on Fairy Tales**

One of the aims of this study is to work with young women and engage them in the activities. One way of engaging them is through writing and reading. According to Furner (2017), bibliotherapy can be used as a way to connect readers to subject matter. Bibliotherapy is the use of literature that contains material that can connect the reader to the subject matter at hand. An example of such a book is *A Cloak for the Dreamer* by
Friedman (1994). The book is about how three sons work together to sew pieces of clothing together that form a cloak. The cloak is created by using various geometric designs, and these designs help the reader to explore various aspects of mathematical investigations and tessellations (Furner, 2017; Friedman, 1995). In the paper, Furner (2017), discusses how students with math anxiety or students who are struggling with the concepts being taught can often find a connection by reading books that discuss the topics. These books can be based on the content to be learned or they can be fairy tales that are woven together to spark the interest of the reader. Based on these findings, the notion of a Steampunk workbook was born. The workbook consists of an overarching storyline that acted as a conduit for the students to use the A in STEAM to showcase their writing talents. The writings they produced engaged them and created another aspect of the active learning experience.

Another aspect of bibliotherapy is the way in which a reader may connect with the character in the book and realize that they could see themselves in the book. As an example, if one can relate to oneself as being Harry Potter or Hermione Granger, then one is able to connect to the story and thus connect to the ideas they are discussing. For the purpose of the workbook, the participants designed a story based on a character that they created and therefore can relate to. The expected outcome is that these characters will be relatable to other participants in the future, and this be generalizable to similar participants that have the same characteristics (Furner, 2017). The storyline should tie together the aspects of Science, Technology, Engineering, Arts, and Mathematics to create a cohesive plot that one can follow. Not only does the storyline link the aspects of
STEAM together, but it also allows one to understand the critical thinking and how engaged the participant was when he or she wrote the storyline.

Another aspect of bibliotherapy as it relates to STEAM is that the participants create their own storylines, which helps them work over any fears or anxiety about STEAM as they craft their own solutions. This concept is generalizable to the participants in the study in that they could write about STEAM and relate to it in different ways. This helped to reduce negative thoughts they may have had about STEAM as they generated the content. Furner (2017) also emphasizes how students exhibit a lot of math anxiety and that tying literature about mathematics into a math learning experience can help reduce anxiety. This is also true for the other elements of STEAM. Finally, Furner states the following, which is totally relevant to STEAM: “When teachers use fairy tales and children’s literature in their classroom to teach math, they are allowing for creativity, imagination, and making connections for students better preparing them for a world which is ever advancing mathematically and technologically” (Furner, 2017, p. 108).

**Data Science**

The field of Data Science is a crucial part of today’s STEAM careers. Data Science encompasses the analytical parts of mathematics, which is the M in STEAM. Data Science utilizes the ability to look at large volumes of data and create meaningful insights and situational awareness about the discoveries and the relationships of the data within. To this end, since Data Science will be a major part of the future landscape, it is important as part of the STEAM project to introduce the participants to the terms and the relevance it has. For the purpose of this project, Data Science primarily focused on data analytics. This means that, as the participants created their workbooks, they also needed
to consider the data aspect of their project. If the project dealt with counting the number of bees entering and exiting a hive, then this had to be accounted for, and Data Science is the perfect way to approach this. Within the Data Science aspect of the project, the participants could discuss how they intended to do descriptive statistics on the data sets (Berman, 2015).

Women need to be attracted to Data Science at an early age, especially in middle school, to help the career pipeline for the future. Data Science and data analytics provide engaging opportunities for software, for example, what Netflix uses to predict and suggest shows for its subscribers. Data Science is used to track flu epidemics and the spread of highly infectious diseases such as the coronavirus (COVID-19). It is also used for marketing to help locate the correct markets to promote products. For these examples alone, one can see its interdisciplinary nature and its role in science education and STEAM. Another important aspect of including Data Science in this study is its ability to provide positive social messages regarding the uses for and need of Data Science in many of the STEAM-related fields. Lastly, by including Data Science in this study, it provides an opportunity for cultural change in how young women will perceive this field in relation to their environment. It will also give young women powerful tools that they can use in all their future endeavors and enhance their critical thinking (Berman, 2015).

The research discussed varying aspects of social-cultural perspectives. Environmental factors and gender stereotyping can undermine a woman’s interest in STEM. Including the A in STEM to make STEAM is a great idea of how to reach out to women, utilizing aspects of humanities, to motivate and engage them in STEAM. Much of the theory of social-cultural perspectives came from the work of Vygotsky.
Vygotsky

The second theme is how the work of Vygotsky assists social-cultural theory (Ormrod, 2012, pp. 313-351; Wass, 2011; Abeysiriwardhane, 2016). Social-cultural Theory is one of Vygotsky’s main pieces of work. Vygotsky believed that we, as humans, do not always learn on our own; instead, we often learn from our society and cultural perspectives that are around us. Our grandparents, parents, teachers, and other adults all help to shape our knowledge and the things that we learn. Different cultures and experiences create an environment that we learn within. The whole aspect of this type of learning is focused on what is commonly known as socio-cultural theory. Vygotsky also believed in a principle called the Zone of Proximal Development, also known as ZPD. In this principle, Vygotsky believed that children learn more by attempting new tasks that they are only able to accomplish with the helpful aid of a competent knowledgeable person. Once the More Knowledgeable Other (MKO) is involved, the child can overcome any learning obstacle and then can start learning again until the next roadblock. The More Knowledgeable Other is either able to help the child solve the problem to get them past the stumbling block or provide a new perspective that had not been previously considered.

Adults can engage children in activities that require collaborative use of particular strategies. Through joint discussion and use of strategies—typically with considerable adult guidance and scaffolding at first—children gradually internalize the strategies and begin using them independently (Freund, 1990; Gauvain, 1999, 2001)” (Ormrod, 2012, p. 329)
One of the aspects of Vygotsky’s work discusses how the environment can influence a learner. Although one does not alter the environment in which the participants live, the researchers, for this study can alter the environment in which the STEAM workbook is discussed and implemented. Originally it was envisioned that the researchers would bring props and decorations to the workshop room to help change the environment and make it fun and exciting. Due to COVID, this became impractical since face-to-face meetings would not be allowed. Instead, the researchers decided to make engaging videos to help capture the attention and excitement of the young women. The purpose was to help spark the interest and engagement of the participants.

Vygotsky focused his research on different ideas than fellow researchers of his day. Piaget was interested in what tasks a child could do at a certain age, while Vygotsky was interested in what tasks a child could do with the assistance of an adult. Ormrod (2012) said, “Society and Culture are critical for the development of higher mental functions,” (p. 314), which details the need for society to help people learn.

The idea of the workbook is supported by the work of Vygotsky and constructivism. Children learn and remember when they can talk about their experiences or in the case of the workbook, when they are able to document their experience. In the current study, the workbook facilitated this type of information exchange in that they could work with an adult to help flush out ideas which they may have not come up with on their own.

Children also learn best when they are confronted with and engage in authentic activities. Activities that represent real-world problems allow the participants to truly understand the connection of their work and how they can influence the outside world.
Allowing the participants to work on authentic activities allows them to see the connections of their work to the world around them. In (Ormrod, 2012, pp. 333, 419-420), authentic activities are part of what is known as Problem-Based Learning (PBL) or Project-Based Learning. With PBL activities, the participants build their own knowledge, and using the work of Vygotsky and the ideas of ZPD, the participants could carry out their workbook ideas in tandem with competent adults. The workbook has added prompts within it to help guide the participants with the idea and provides the scaffolding, which is discussed in the following section. This allowed the participants to understand what was required of them and gave a meaningful experience.

Lastly, the idea of working with competent adults also leads to the discussion of apprenticeship and cognitive apprenticeship. The idea of apprenticeship ties in very nicely with the theme of Steampunk. When one puts his or her Steampunk thinking cap on, one can realize that for a steam-powered society to truly exist and operate as science fiction paints it out to be, there would need to be apprenticeships. An apprenticeship truly shows the relationship of a more experienced individual helping someone who has the potential to become the same. Ormrod (2012) gives the example of a graduate student working closely with a professor participating in an apprenticeship in exchange for information. The workbook experience provided a small taste of what the apprenticeship part would be like. As participants came up with their own ideas, the researchers were able to help them learn and investigate more information about the idea. This, in turn, provided an opportunity for the adults to mentor the children to help them to overcome obstacles, such as the ones depicted in ZPD.
**Vygotsky Scaffolding**

Scaffolding is the support that a learner is given to accomplish a goal and to stretch their ZPD (Wass, 2011). Scaffolding is an important aspect of learning and comes from the work of Vygotsky (Wass, 2011). Oftentimes, learners face roadblocks or setbacks that cause frustration with their ability to learn new knowledge. The frustration comes from setting learning goals that are beyond the ZPD into areas of unknown knowledge. Scaffolding helps a learner to create a path to the unknown knowledge by providing guidance and information and perspectives that may not be known.

Scaffolding is an instructional principle that helps a learner to master material piece by piece and bit by bit. The support is differentiated and tailored to each participant’s needs. Earlier in this document, the term apprenticeship was used. Apprenticeships have similar styles of behavior to scaffolding. They build on prior knowledge until the apprentice becomes a master of the new knowledge.

The current study was broken into three sessions so that it gave the participants time between sessions to learn more and to ask questions to their Most Knowledgeable Others. The concept of the Most Knowledgeable Others comes from the point of view that learners will need guides in their journey to conquer and learn new material. The Most Knowledgeable Other is such a person who has already been on the learning journey and already contains the knowledge that the learner is seeking. This person is a guide who assists along the way by breaking the information down into more understandable pieces. One analogy that can be thought of is the idea of one learning about how to build and operate a quantum computer. Building a quantum computer would require the guidance and assistance of a Most Knowledgeable Other. This is a
dramatic example but illustrates the need for the Most Knowledgeable Others. In the example of Quantum Computing and its construction, it is a fairly new topic without many guides. The guides are the people who are currently working on it.

We learn by focusing on themes that are within our ZPD. There are three zones; the first is current understanding, the second is ZPD, and the third is knowledge outside of what it is known. As the learners learn and advance, their understanding of their ZPD moves, and they grow with the knowledge. If learners try to learn subject matter that is too advanced and is outside their ZPD, then they may lose self-confidence and have negative feelings. This is where scaffolding comes into play. Scaffolding is the support structures that Most Knowledgeable Others, or mentors, use in order to help advance learners through their ZPD. Mentors help to build interest and engagement in the subject. The mentors help break tasks into subtasks and use what they know to create appropriate steppingstones to help one gain more knowledge and stay on track. Lastly, the mentors use their own knowledge to demonstrate, model, and show the apprentices new strategies of solving a problem, thus stretching and challenging the apprentices’ ZPD. In the context of this study, the mentors or Most Knowledgeable Others helped the participants choose and work with the subjects they chose for the problem-based activity of constructing the workbook (Ormrod, 2012, pp. 313-351; Wass, 2011; Abeysiriwardhane, 2016).

**Systems Engineering**

Middle school students are not usually exposed to Systems Engineering; however, Systems Engineering provides the necessary glue that can combine Science, Technology, Engineering, Arts, and Mathematics. As the world around us is changing and becoming
ever more technological, it is important to immerse young students in the way in which the world works. One way to show students how the world works is to teach them varying aspects of Systems Engineering. The E in the case of Systems Engineering is all about the orchestration of all the other disciplines S, T, A, and M to execute an idea. Systems Engineering first starts out with requirements gathering. In requirements gathering, one looks at the problem he or she is trying to solve and then collects the requirements that are needed to solve this problem.

Systems Engineering complements project-based learning. With problem-based learning, one is examining the problem and using critical thinking skills to help solve the problem. In the case of systems Engineering, one must discover what requirements are necessary to solve the problem.

One of the suggested topics that emerged from the pilot study is bees. Let’s, for a moment, look at one small aspect of the bee problem. The problem is: how frequently do bees come and go from the hive? The requirement that comes forward is: One shall have the ability to count bees entering and exiting the hive. As a systems engineer, one must now build and put together a system that can accomplish this goal. The systems engineer must consider the technology available and then make rational decisions on how best to solve the problem. The result will be some gizmo that can count the number of bees entering and exiting the hive.

In systems Engineering, there is a famous model known as the V-model. The V-model depicts one of the systems Engineering processes that takes place in order to deliver an operational system. In the case of the participants and their workbooks, the operational system was their workbook, which is their Systems Engineering Process. The
first phase of the V-model is to identify the concept of operations. In parallel, within the workbook, the young women would identify the problem they are trying to solve in problem-based learning. The next phase in the V-model is requirements and architecture. Here requirements are gathered, and an architectural plan is put into place to document how the requirements will be fulfilled. In the case of the workbook, the participants had to identify the requirements that they needed in order to solve their problem.

The next phase of the model-V is detailed design. This step is where everything is identified in order to carry out the overall system. In the case of the workbook, the participants detailed each of the aspects of their design. They identified the S, the Science. Next, they identified the T, the Technology that will be used. The technology that was used came from the Internet of Things as these gadgets and gizmos are readily available and documented. Next is the E for Engineering, which is the entire V-model and the documentation of the project. In the case of this study, the workbook is a loosely defined version of the detailed design. It encompassed aspects of scrapbooking, activities, and scientific explanations of the problem the participants are trying to solve.

The next aspect is the A for Arts, the look and feel of the end project. Art can also be how creative design is used. The A and its use and interpretation are very fluid and can flex to the needs of the project. Last is the, M, which is expressed as either pure mathematics or as Data Science. All of these components were considered by the participants and were incorporated in the workbook. Getting back to the V-Model, the next phase is Implementation. The implementation phase is how everything is orchestrated and interconnected to finally create a project that can be used to solve the problem.
The next part of the V-model is Integration and Testing. This would involve putting the device out into the field and testing it. Once everything works as expected, the next phase of the V-model is System Verification and Validation. This is used to certify that what one wanted to build was indeed built as expected. Usually, at this phase, the requirements identified are sold off to the stakeholders so that the project can be certified. The last part of the V-model is the operation and maintenance phase. An example of maintenance would be changing a battery every ten days on the device (Karwowski, 2014; Erwin, 1998; Clark, 2009).

Vygotsky believed that humans learn best when limits are challenged but not pushed too far beyond their ZPD. One way of learning new knowledge is not only having scaffolding but a framework or system in place that can assist the scaffolding take shape. The V-model of systems Engineering is one of the many ways in which one can execute project-based learning, which helps to bring meaning to the activities that participants perform.

Active Learning

The third and last theme is active learning utilizing Project-Based Learning: A key ingredient to PBL was the discussion of the Internet of Things and possible micro-controllers. In Pfalzgraf’s (2014) study, the researchers utilized a low cost, easy to construct, and an effective system, such as 25 Raspberry Pi’s Model B, to aid in high-performance computing education. The microcontrollers were configured into a cluster to demonstrate the power of parallel computing. The methods of their study were to use Vector Triad Math, Matrix-Vector Multiplication, and Matrix-Matrix Multiplication to demonstrate performance gains in parallel Raspberry Pi’s.
The various algorithms demonstrate the gains of using a parallel system to perform calculations over that of a serial configuration. The results showed that the Vector Triad was able to outperform the serial code providing the problem size is large enough, \( N > 45,000 \). The Matrix-Vector Multiplication was able to finish one-fourth of the time for the serial test. Lastly, the Matrix-Matrix Multiplication did not outperform the serial processor. The case of the failure provides an interesting opportunity for the students to understand why matrix-matrix multiplication failed in this configuration. In creating workbooks in the current study, participants also utilized Raspberry pi devices to encourage and engage the STEAM thought process. Pfalzgraf (2014) shows an experiment designed to expose students to high-performance parallel computing. The study is relevant because the topic is not trivial, which helps us to gauge how learners can respond to a more complex lab setup. The article formed a seed of knowledge to help pursue other interesting articles related to Raspberry Pi (Pfalzgraf, 2014).

The next article (Jamieson, 2015) in relation to the Raspberry Pi discusses how educators may be missing the boat because they are not utilizing micro-processing boards such as Arduino, Raspberry Pi, and Beagle Bone to help teach students about Engineering. The main challenge is to identify student projects that will work on the boards. Jamieson discusses Open-Source Projects, Prototyping Boards, Arduino, Raspberry Pi, and the Beagle Bone Blackboards.

Jamieson (2015) then discusses how student projects and courses are using these boards. Methods include choosing a project and reporting on it. Students proposed, both orally and in writing, details of what they wanted their project to be. Progress meetings were set up to help gauge projects, but ultimately only the seniors managed to construct a
design for their projects. Students often had difficult times applying techniques to their projects. First, the article mentions Project-Based Learning and provides a reference to an article called “A review of research on project-based learning” by J. W. Thomas (Thomas, 2000). Thomas’ article serves as an entry point to understand the research relating to project-based learning. The article also discusses the creation of Capstone projects and how the Micro-boards can be utilized for these types of projects. Since the essence of this study was devised around this type of technology and the Internet Of Things, it was insightful to see how others have applied it (Thomas, 2000).

**Internet of Things (IoT)**

As Slykhuis (2015) stated, one of the issues with STEM-based projects is how one can tie together all the elements of STEM and especially the T for Technology. The answer to this question is beginning to get easier. Thanks to the advances of the Internet of Things, very reliable and affordable gadgets are now making their way into the marketplace. This means that active learners with a bit of money can go out to websites like AdaFruit and buy one.

For this study, the participants were given a theoretical exposure to various devices that make up the Internet of Things. Participants saw real-world examples as a sort of “Show and Tell.” The idea and importance of this are that the participants had to think about how various devices could be used as of part a practical solution. Then, they documented their thoughts and ideas about the project in the STEAM workbook.

Namiot (2017) explored current educational offerings of seminars and universities that are offering courses in the Internet of Things to understand the best approach for teaching the technology by reviewing technology and identifying classes
that utilize technology in order to make use of the Internet of Things and education. Additionally, various technologies were identified that should be considered for inclusion in the teaching of IoT. The various technologies discussed include networks and communications, planning network traffic flow, real-time systems, geo-information systems, simulation, mesh networks, Quality of Service Telecommunications network architecture, deep learning, real-time processing, Arduino and Raspberry Pi platforms, Apache Storm, Apache Spark, as well as Lambda and Kapp architecture. The results of the study indicate that no one class could meet the needs of teaching the IoT. Instead, a class must be created and crafted to use the four basic components of application architecture, network interoperability standards, data storage systems, and principles of their analysis and processing. Currently, there is a push to include Big Data and the data analysis that comes with it. The study was interesting because it inspires plans on utilizing the Internet of Things, especially the Raspberry Pi and possibly Arduino. It is important to understand what the members of the industry are thinking and what they plan to do regarding educating people on the IoT. The article helped to outline some areas of interest that helped in the planning and designing of an IoT project for young women.

**Scrapbooking**

One of the fascinating aspects that came about during an interview with a fellow colleague was the aspect of a scrapbook. Scrapbooks are activities that have been around since the Civil War, if not before (Moyer, 2015). They help to capture snapshots in our lives and come with an incredible sense of creativity and fun. Another fascinating aspect of scrapbooks is they are a form of ethnographic research and discovery. A scrapbook is
one of the ways in which the A in STEAM can be expressed (Moriwaki, 2012). Scrapbooks generally involve their creator's clipping and adding things to the scrapbook to tell a story. This idea is fascinating because, from a systems Engineering perspective, this activity is similar to gathering requirements. The concept of doing a STEAM workbook already follows a parallel path of scrapbooking. The STEAM workbook is a more formalized version of a STEAM scrapbook. Moriwaki et al. (2012) discuss how they utilized scrap parts to create things such as The Noisemaker, Bottle Violin, Noisy Stuffed Animals, Draw Bots, Squishy Circuits, and support curriculum (Moriwaki, 2012). The activities and challenges had family members working together in a setting similar to that of scrapbooking where objects were connected together to create various new objects (Moriwaki, 2012). This idea was the catalyst to realize that scrapbooking, workbooks, and workshops run hand in hand (Moyer, 2015; Moriwaki, 2012).

This study utilized the concept of creating a workbook. The workbook is the mechanism or instrument being used in order to collect ideas and thoughts of today’s youth regarding a project one would build related to STEAM. One aspect of the workbook is to utilize an existing platform that many people in our culture already enjoy, scrapbooking. The term workbook can come with some challenges, and the idea of an Engineering notebook or scrapbook may have better appeal and acceptance. Another way to look at the activity might be storyboarding as used in Hollywood or scenario-based designs to help with learning in informal settings utilizing scrapbooking (Moyer, 2015; Moriwaki, 2012).
Textiles and Puppets

Creating active learning experiences can be a difficult challenge. One wants the activity to be exciting, engaging, and fun, all the while teaching and motivating STEAM. *Mr. Rogers Neighborhood, Lamb Chop's Play Along*, and *Sesame Street* are just some of the television programs that fascinate children as well as adults (Wright, 2001). The allure of a stuffed animal that is animated, talks, and one that you can relate to becomes a beautiful part of some people’s childhood. One often wonders why some people “grow up” and cast aside the thoughts, creativity, and ideas of fantasy and play (Woolley, 1997). A lot of what adults categorize as "play" is really a form of exploration, learning, and problem solving often mentioned in the work of Vygotsky (Smolucha, 1992). Children, when they are young, like to play. They play with dollhouses, imaginary spaceships made out of cardboard, tea party sets, treehouses, stuffed animals, puppets, and imaginary friends (Singer, 2003). When children get older, they like to dress up as adults, but at some point in time, they stop doing that. Nowadays, the line of where costumes and play stops has changed. Many teenagers, young adults, and adults often participate in Cosplay (Bonnichsen, 2011).

Cosplay is part of an art form where people like to create costumes and dress up as their favorite characters (Bonnichsen, 2011). People go off to various comic book and sci-fi conventions such as MegaCon, Tampa Bay Comic-Con, Dragon Con, Comic-Con, and New York Comic-Con. There at the conventions, they dress up as characters such as Wonder Woman, Batgirl, Spiderman, Iron Man, Rosie the Riveter, Doctor Who, Agent Carter, Steampunk, and countless others. One of the fascinating aspects of cosplay is play. Some of the people in the costumes like to play. They act out the roles and
impersonations of the characters they strive to be. Spiderman likes to shoot his webs and take on the classic poses (Bonnichsen, 2011).

Iron Man has his glowing circle on his chest. Wonder Woman talks about her imaginary jet. These are adults that are continuing to play just as they did as children. The costumes they create have become more and more elaborate as technology such as the Internet of Things has become more popular and more affordable. Many of the people you see in the Iron Man suits have a glowing circle in their chest, which is no doubt controlled by a Raspberry Pi or an Arduino microcontroller. The costumes and the various Engineering that goes into them have come a long way in a quick period. The people who create these costumes do it out of love and fun. Thanks to the popularity of pop culture phenomena, such as cosplay and comic conventions, costumes and role playing are having a resurgence with adults, blurring the lines of where traditional "play" stops (Madden, 2018; Prato, 2017; Bender, 2015; Dunne, 2015; Restrepo, 2019).

There seems to be an inherent link between women and their fascination with crafts such as quilting, knitting, sewing, crocheting, weaving, and others, which are all parts of textiles. A person involved in cosplay takes a lot of time learning and Engineering how to manipulate the lines and curves of fabric to pull off a specific costume. Without bringing much attention to it, the people creating cosplay outfits are utilizing all the activities in STEAM without even realizing it. The fascinating aspect of this is that no one asked them to make the costume, yet they spend countless hours striving to perfect the look and not only the look but to make it function so that the human inside can manage the costume and walk around in it. These activities unbeknownst to the cosplayer are all part of active learning and active learning
experiences. The only thing missing is the helping guidance of Most Knowledgeable Other linking the activities they are doing to the activities related to STEAM (Madden, 2018; Prato, 2017; Bender, 2015; Dunne, 2015; Restrepo, 2019).

According to Restrepo (2019), local workshops were created to explore puppetry. The puppets were created to allow the participants to create a puppet performance based on a short narrative. The puppets allowed the participants to show off creativity and also to expose them to aspects of STEAM. Puppetry allows for storytelling, and it is an artistic medium. The work that goes into building puppets is similar to the work of systems (Restrepo, 2019). An exciting aspect of utilizing puppets is to be able to allow the participants to work with familiar materials. The puppets utilize traditional craft materials along with new materials such as the Lilypad. The author mentions that this activity and materials speak to female students. Puppetry is fascinating because it creates engagement with the audience, which is different from other art forms (Restrepo, 2019; Bender, 2015; Dunne, 2015).

Puppets are an authentic cultural phenomenon, and they provide the ability to tell stories through the use of improvisation. Puppetry, along with the art of building puppets, is very applicable to STEAM. Puppets are whimsical, fun, and they seem to have a certain appeal that people tend to like. They are practical tools for STEAM education because not only do they teach STEAM concepts, but they work with familiar materials, and the participants are creating a new “person” to interact with their world. Due to their use of creativity and familiarity with participants, this study included the puppets as part of the workbook building activities (Restrepo, 2019; Bender, 2015;
Dunne, 2015). Figure 2: Meet the Puppets, Left to Right, Gallagher, Maggie, Harry, Victoria, and Emerson, shows the puppets and their names used in the study.

![Figure 2: Meet the Puppets, Left to Right, Gallagher, Maggie, Harry, Victoria, and Emerson](image)

Project-based learning is a practical way of teaching people about STEAM. It provides real world problems that participants can challenge themselves to solve. All the activities involved in project-based learning make it appropriate, relatable, and ideal to motivate a young woman in STEAM.

**Naturalistic Inquiry**

This study was conducted using qualitative methods and therefore extra care and forethought was used to ensure the tenants of natural inquiry remained throughout the study. Naturalistic Inquiry, as stated by Guba (1981), is the paradigm for arriving at truth. Among these truths are the various ways that the researcher can examine the nature of reality, the nature of the inquirer relationship, and the nature of truth. Under
qualitative research, the nature of reality assumes there are multiple divergent realities. As more knowledge is gained, the realities are interrelated and can therefore influence other parts of the knowledge that is emerging. In naturalistic inquiry, the relationship between that of the researcher and the participants is interrelated and can therefore influence each other. This speaks to the notion that the researchers themselves become the instruments of investigation and use fluid techniques and adaptability to adjust and respond to the participants and the information they are giving. The sought-after truth of the study is emergent ideas that are most suited for the phenomenon that one is researching (Guba E. G., 1981).

In Patton (2002, p. 57), there is drawing of a pigeon wearing a top hat and a tuxedo vest. The pigeon is flying to a bunch of pigeonholes and the text bubble from other pigeons says “the problem with some pigeons is they refuse to stay in their pigeon holes” (Patton, 2002, p. 57). The graphic is a great representation of what happens and what one can expect when doing qualitative research. Ideas and concepts should not be forcefully stuffed into a pigeonhole but instead be allowed to run free and see where the idea naturally lands.

**Grounded Theory**

The study that was conducted was based on grounded theory. In Charmaz (2006) the topic of constructing grounded theory is discussed at length and offers various insights as to how one should build a theory from the ground up. Charmaz (2006) goes into detail to explain the work of Glaser and Strauss and how they utilized grounded theory for their work on investigating the social setting of chronically ill patients. Charmaz (2006) lays down the framework that one should use to assist in building
grounded theory. When constructing grounded theory, one should first gather thick rich data; second, code the data with initial coding; third, perform focused coding; fourth, write memos; fifth, use theoretical sampling; and sixth, employ reconstructing grounded theory (Charmaz, 2006). The main concept that is being explored is the idea that data from interviews and other sources is coded into meaningful words and those words are broken into emergent themes. The themes are then compared across all the participants to see if any sort of crystals of knowledge begin to grow that one can anchor theory to (Charmaz, 2006). In Chun Tie et al. (2019), a streamlined framework for grounded theory was introduced. Building off the work of Charmaz, Glaser, Strauss, and others Chun Tie et al. (2019) lays down clear steps to follow when creating grounded theory.

**Grounded Theory Framework**

In Chun Tie et al. (2019), one first begins a study with purposive sampling. Purposive sampling is ensuring that the participants, i.e., the sample population, is representative of the phenomena one wants to study (Chun Tie, Birks, & Francis, 2019; Patton, 2002; Guba E. G., 1981). In this study, it was important to capture the insights of young women and their thoughts about STEAM.

The next part of the framework explanation is constant comparative analysis (Chun Tie, Birks, & Francis, 2019). This is done by coding the data collected from the study. Data is encoded and categories are created to best suit the data (Chun Tie, Birks, & Francis, 2019). Initial codes are constantly compared to other instances and the codes eventually reveal categories (Chun Tie, Birks, & Francis, 2019). Utilizing inductive, deductive, and abductive thinking during the analysis along with repeating the process
over and over again yields abstract thinking that emerges from the ground truth (Chun Tie, Birks, & Francis, 2019).

After that, Chun Tie et al. (2019) discuss writing memos, which involves the researchers’ writing memos to themselves to document thoughts and reactions to the ongoing study. It also provides the opportunity to create a historic audit trail that assists with the creating quality of grounded theory (Chun Tie, Birks, & Francis, 2019). Memos are a reflexive tool where the researchers can place, store, and discuss ideation to help with the coding and theory building. It allows one to look a specific time in the study and review what was done and what the researcher was thinking. Memos help with abstract thinking and to help identify categories and relationships (Chun Tie, Birks, & Francis, 2019).

The next part discussed as part of the framework is generating and collecting data that was used for the analysis. Chun Tie et al. (2019) discuss how data can come in all forms and not just from interviews. Data can come from surveys, notes, memos, elicited data and much more (Chun Tie, Birks, & Francis, 2019). Elicited data can come from work that the researchers directed the participants to do such as building a workbook or researching a topic (Chun Tie, Birks, & Francis, 2019). Elicited data is one example of how one can generate data. Another example of generated data is memo writing as discussed previously (Chun Tie, Birks, & Francis, 2019).

After that, the authors discuss the importance and necessity of coding (Chun Tie, Birks, & Francis, 2019). Coding is the process of taking data and extracting key concepts and conceptual ideas from within the dataset (Chun Tie, Birks, & Francis, 2019). There are various types of coding such as open coding, axil coding, selective coding, as well as
initial, focused, and theoretical coding (Chun Tie, Birks, & Francis, 2019). Generally, the researcher chooses the coding method that best fits the study. The main concept of the coding process is to analyze the data, break the data up into smaller representative text, then take that text and look for more generalized concepts (Chun Tie, Birks, & Francis, 2019; Charmaz, 2006; Patton, 2002). The generalized concepts are interrelated amongst the codes and must be boiled down to grounded theory while also taking theoretical sensitivity into consideration (Chun Tie, Birks, & Francis, 2019).

The next part of the framework discussed is theoretical sensitivity, which takes place during the entire study (Chun Tie, Birks, & Francis, 2019). It involves being open and ready to discover emerging theory when it presents itself (Chun Tie, Birks, & Francis, 2019). It is part of the research process that helps to focus various concepts and ideas so that they can be part of the boiled down process to find the emergent theory (Chun Tie, Birks, & Francis, 2019). The more the researcher becomes immersed in the data, the more open they will be to recognize, detect, and act upon emerging themes (Chun Tie, Birks, & Francis, 2019).

Finally, grounded theory emerges, and it is represented to explain or understand the phenomenon that was being investigated in the study (Chun Tie, Birks, & Francis, 2019). The grounded theory takes the whole into consideration and explains the results of peeling the layers of the onion back to discover the themes that are ground in data and represent abstract ideas that have emerged from the study (Chun Tie, Birks, & Francis, 2019).
Substantive Findings

The findings of the literature review show us that when designing educational curriculum and studies, it is important to learn from feedback received over the years. The research indicates that young women require different accommodations when learning and engaging in STEAM. Such accommodations include group work, women role models, and experiments that are not gender stereotyped. The findings also indicate that complicated labs can be set up, and the students will be able to follow along depending on the complexity and skill level. Lastly, having people engage in puppets, textiles, storytelling, history, scrapbooking, and project-based activities offers unique opportunities to motivate and engage young women in projects that are meaningful so that the participant can feel competent, they can relate to it, and they have an internal drive to see it through.

Methodological Findings

The topic of the study is novel in that it combines Science, Technology, Engineering, Arts, and Mathematics into an interdisciplinary experience that was engaging and meaningful to the participants. The research indicates that one will be able to set up a competent study in which the participants will be able to follow along and see the project through. The main goal is to extract emergent themes of how the students engage with and select various studies for the STEAM workbook. Enthusiasm and excitement, along with a passion for STEAM, is the aim of this study. The findings were documented, and grounded theory is explained.
Summary

The literature review indicates several areas where women can feel put off or demotivated in a male-dominated profession. The clues learned from the literature help to understand actions that can be taken to entice and motivate women to join STEAM fields.
CHAPTER 3
Method Statement

Research Approach

The research approach was qualitative methods utilizing grounded theory. The qualitative approach was decided on based on the type of inquiry that was being explored. Research has shown that there are many STEM and STEAM camps that students can participate in. Many of these camps do not explore what interests a young woman may have if she were put at the helm of the controls. Having young women create a STEAM workbook is one way that one can gain insights into what STEAM activities that young women would like to see.

The research intent was to look at emergent themes and narratives that are gleaned through the interviews, observations, and journal notes with the participants of the study. This research looked for common threads and thoughts between the interactions of the participants and the workbooks that they create. According to Strauss and Corbin (1998), researchers, in general, must be open to multiple possibilities, use nonlinear thinking, trust the process, and maintain creativity. Due to the nature of this qualitative study, the procedures and methods were adapted as the situation required. The approach within this study was fluid and adaptable to change as needed.

Research Questions

This study explored the following research questions:

1. How do thoughts and ideas about STEAM change in young women by their participation in a STEAM workbook workshop?
2. What thoughts and ideas emerge from young women who participate in a themed STEAM workbook project?

3. How does working on the STEAM workbook help young women understand or see potential career opportunities that they might not have known about?

**Study Design**

The study consisted of two phases, Phase One and Phase Two. Phase One consisted of a semi-structured interview where the participants were asked questions about what they would like to see included in a STEAM workbook. Phase Two consisted of taking the information from Phase One and incorporating it into a hands-on, active learning experience where the participants built their own STEAM workbooks. Both phases were qualitative methods. The intent of the study was to examine the young women as they came up with ideas and built their own STEAM workbook. Phase Two details the more in-depth framework used when interacting with the participants.

**Researcher as the Instrument**

One of the main differences between qualitative and quantitative studies is the role of the researcher. In both studies’ design, the researcher plays an integral part in creating, designing, and implementing the study. In a qualitative study design, the researcher takes on a more immersive role than in a quantitative study. The researcher, the instrument of investigation, can change one’s behavior to extract the most meaningful and raw content from the participants in the study. This is done by using guided questions and semi-structured interviews, and by quickly adapting to situations as they present themselves. Later in this section, for the Phase One part of the study, an example
is given of how an emergent theme, “temperature of the hive,” became an unexpected discovery in the investigation. Based on the data and response that the researcher is receiving, one may also decide to augment or change how the study is being conducted. This change is to maximize the phenomenon that is being discovered or researched. Additional interviews or additional observations may be required. The most important part is to make the study trustworthy and valid by using various strategies such as triangulation and member checking to ensure the raw data is captured in its purest form for study and analysis (Guba E. G., 1981; Patton, 2002).

**Phase One: Pilot Study**

**What Should be in a STEAM Workbook**

The research question for Phase One is, “If you were building a STEAM workbook, what would you like to see included in it?” The phenomenon being studied from this question is an exploration of the thoughts and ideas of what people think should go into a STEAM workbook. The design is intended to collect ideas and activities for a workbook.

**Target Population and Sampling**

The pilot study was conducted from January 2020 to April 2020. The study was conducted by sampling participants at Girl Scout gatherings, science fair events, and other similar gatherings in Brevard County, Florida, The United States of America. Due to COVID-19, some interviews were conducted by phone call, Zoom, and Skype.

The inclusion criteria were young women, young men, women, and men, as defined below. The target population was middle school students and high school
students who are at the critical point in development where they may accept STEAM. Older representatives of the population were also included in this pilot study.

This pilot study focused on young women and women; however, for the purpose of inclusion, young men and men also participated. The target age is middle school students, 11 to 14 years of age. A secondary target age also included high school students, college students, and adults; the range of age for the second target group was 15 to adult (21+). For the purpose of this research, young men/women are defined by the *Publication Manual of the American Psychological Association* (APA) Sixth Edition as: “Young man and young woman and female adolescent and male adolescent may be used for individuals aged 13 to 17 years” (American Psychological Association, 2009). In this study the age of middle school students in the United States of America includes boys, girls, young men, and young women from the age of eleven to thirteen (grades seven and eight). The age of high school students in the United States of America is fourteen to eighteen (grades nine, ten, eleven, and twelve).

The target population for the Phase One study was middle school students (grades seven and eight), early high school students (grades nine and ten), high school students (grades eleven and twelve), but adults also participated based on accessibility, availability, and interest. For Phase One, the source of the population was Girl Scout troops and convenient sampling. The convenient sampling included social friends with accessible population and known adults who also participated. Examples of known adults are work colleagues, school colleagues, parents, relatives, friends, and people met by happenstance.
Interventions/Treatment/Procedures

In January 2020, the dissertation committee met and decided that this study would consist of two phases. Phase One of the project was the pilot study. The goal of the pilot study was to go off into the population and perform a semi-structured interview with young women, young men, women, and men to collect and understand ideas that could be leveraged and used to help provoke thoughts and engage the participants in Phase Two, which is the workbook construction study. For Phase One, an IRB form was created and sent to the IRB board. The form was approved to engage and ask participants questions regarding a STEAM workbook. During the 2020 spring semester, 25 people were interviewed about their ideas and thoughts about STEAM and what should go in a STEAM workbook. Out of the 25 participants, ten of them were young women, five of them were men, and the last ten were women. The semi-structured interview consisted of the following questions:

Q1: What would you include in a STEAM workbook, i.e., activities?
Q2: Think about the S or T or E or A or M. What would you put in the book to address these parts of STEAM (Science, Technology, Engineering, Arts, and Mathematics)?
Q3: What would motivate you to get involved in STEAM?
Q4: What do you think about a workbook being themed in Steampunk?
Q5: Would you like a workbook that explores lightning?

Initially, the interview was conducted as the questions were laid out. However, after the first two interactions, the interview changed slightly where the participants would come up with a problem and walk the researcher through how they would use
STEAM to solve the problem. An example of such an interaction is as follows: [Note: participant answers are paraphrased.]

The researcher asked question Q1:

What would you include in a STEAM workbook?

Participant replied to Q1:

paper dolls, hands-on activities, and scrapbooking.

The researcher asked question Q2:

What problem would you want to solve with STEAM, and if you could make a product, how would you see that product go through the S, T, E, A, M to be realized?

Participants replied to Q2:

I would like there to be a bee experiment.

The researcher did not get a detailed answer, so the researcher then asked follow-up questions that were not part of the original questionnaire.

The researcher asked question Q2.1:

What would you like to do with the bees?

Participant replied to question Q2.1:

I would like to know how many bees come and go from the hive.

The researcher then had a topic to work from but had to then drill down deeper in order to answer the S, T, E, A, and M elements. The researcher next asked the following improvised questions in order to get a full and complete answer for the study.

Researcher asked Q2.2:
What do you think the science of bees is? Or, putting it another way, if you were to study bees, what science would you use?

Participant replied to question Q2.2:

Well, the main science is biology, but the specific science, in this case, is entomology. Entomology is the study of insects.

Researcher asked Q2.3:

What technology, for the T of STEAM, do you think you would use to count bees?

Participant replied to question Q2.3:

I’m not sure. Perhaps a laser beam or a camera. Perhaps a sensor of some sort that could count the bees. We could also take the temperature of the hive too.

The researcher then jotted down notes of what the participant just said. One noticed that an emergent topic just appeared out of nowhere. That topic is taking the temperature of the hives. This is an elegant example of how the researcher was able to drill down deeper to the question being asked but was also able to capture something unexpected. The participant gave us two ideas. The first idea is to count bees. The second idea is to get a sensor that can take the temperature of the hive. The beauty of this is that the responses can now be generalized to other things we can take the temperature of. One can take the temperature of a bird’s nest or a family pet; one can take the temperature of a guinea pig’s home or a hamster’s home. The list of ideas and areas of exploration for the topic of temperature with bugs and animals is almost limitless although bound by practicality.

The researcher now brought the interview back into focus. To do this, the researcher asked the following question Q2.4:
How would you see the E in STEAM for Engineering working with the bee problem?

The participant replied to Q2.4:

I really don’t know. Perhaps somehow tying it together.

The researcher then asked Q2.5:

Tie what together?

The participant replied to Q2.5:

Well the technology, and how we are going to do it. Like collect the data.

The researcher then asked Q2.6:

So would you agree that perhaps we are concerned about the orchestration of how this will all occur? We are interested in how many devices we have. How they are powered. How often they count bees. How the data is downloaded. What we do with the data.

The participant responded to Q2.6:

Yeah, that’s what we would do.

The researcher then asked Q2.7:

So would you think that the workbook itself is part of the Engineering and it is helping to facilitate the collection of requirements and is acting as an Engineering manual?

The participant then said to Q2.7:

Yeah, I agree, the Engineering part is how we tie everything together and document. I like the idea of the Engineering notebook.

The researcher then asked Q2.8:
Now that we talked about the S, T, and E, how would you address the A for arts?

The participant answered Q2.8:

- Well we want to make sure the bees aren’t harmed by the detector and we want the detector to blend in with the hive.

The researcher then asked Q2.9:

- So, we are sort of concerned about the user experience, look and feel, and over aesthetics of the device?

The participant replied to Q2.9:

- Yes, we want to make it look neat in design and function.

Researcher:

- That’s great. I can see you are enthusiastic about this.

Last question, Q2.10

- How would you see the M working with this idea for mathematics?

Participant replied to Q2.10:

- Well, we want to collect data of the bees. We want to take measurements. So, I think we could do descriptive statistics on the data and also some Data Science to understand the data better.

As depicted in the interaction above, the researcher is the instrument. The researcher asked the basic questions for the questionnaire but based on the response, asked additional and guiding questions to help extract meaningful answers for the study.

The thoughts and ideas of the participants are in the lists below. The young women gave answers that were not as deep in response as did the adults. The young women’s ideas are less workable and indicated that the adult ideas would have to be used
as beacons when helping the participants pick topics for the workbook study. The following outcomes came about when interviewing the participants. Many of the themes and the ways in which participants would go about the workbook idea were similar but the projects themselves were all very different and led to a wealth of ideas for a STEAM project in general.

**Data Collection**

Data from the interviews was captured using note taking. Interviews occurred through (1) in person interviews, (2) phone calls, (3) Zoom calls, and (4) Skype calls. As stated earlier, 25 interviews were conducted and therefore 25 data samples were collected. Ten of the participants were young women. This data was collected at a social gathering in connection with the Girl Scouts where the girls were present. The data was collected before social distancing took effect in the United States of America due to COVID-19. For all persons under the age of 18, informed consent was given, and parents signed the relevant parental consent form. The form used is in Appendix C of this document. The remaining 15 people are 18 or older and they too gave informed consent. They were not required to sign the parent permission form.

To safeguard the participants’ identity, and due to the nature of the study, the participants’ names were not recorded with the data. During the semi-structured interview, the researcher took notes of the statements the participants made. Often examples needed to be provided so that the participant could understand what was meant for the S, T, E, A, and M. The data collected represents projects that can be used in project-based learning. These topics for the workbook are listed in Table 1: List of Project Ideas.
### Table 1: List of Project Ideas

<table>
<thead>
<tr>
<th>Project</th>
<th>Activity</th>
<th>STEAM Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>COVID-19</td>
<td>Kaleidoscope</td>
<td>Artificial Intelligence and Machine Learning</td>
</tr>
<tr>
<td>Save Sharks</td>
<td>Cooking</td>
<td>Lego Robotics</td>
</tr>
<tr>
<td>Catch Sharks</td>
<td>Ecological Footprint</td>
<td>Robotics</td>
</tr>
<tr>
<td>Train</td>
<td>Scrapbooking</td>
<td>Weather Station</td>
</tr>
<tr>
<td>Pollution IRL</td>
<td>Space</td>
<td>Lightning Detection</td>
</tr>
<tr>
<td>Oil Industry</td>
<td>Astronomy</td>
<td>Sunlight Detector</td>
</tr>
<tr>
<td>Instagram</td>
<td>Bee’s</td>
<td>Protective Wear</td>
</tr>
<tr>
<td>Build your own app</td>
<td>Cockroaches Utilizing</td>
<td>Airship</td>
</tr>
<tr>
<td>Music</td>
<td>Cockroaches Killing Them</td>
<td>Society</td>
</tr>
<tr>
<td>Music and Math</td>
<td>Pest Control</td>
<td>Dress Construction</td>
</tr>
<tr>
<td>Growing Plants</td>
<td>Game Creation</td>
<td>Cosmetics</td>
</tr>
<tr>
<td>3D Printing Plant Pots</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Besides asking participants about what problems they would like to solve with STEAM, the researcher asked the participants to provide examples of activities they would like to see within a workbook. Activities that were suggested are shown in Table 2: List of Workbook Activities.
Table 2: List of Workbook Activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Create Path and Step</th>
<th>Handheld Toys</th>
<th>Creative outlets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper models</td>
<td>Create Path and Step</td>
<td>Look and Feel of the products</td>
<td>Handheld Toys</td>
</tr>
<tr>
<td>Puzzles</td>
<td>Create Path and Step</td>
<td>Look and Feel of the products</td>
<td>Creative outlets</td>
</tr>
<tr>
<td>Q&amp;A</td>
<td>Work with People</td>
<td>Creative outlets</td>
<td>Creative outlets</td>
</tr>
<tr>
<td>Drawing</td>
<td>Color by Numbers</td>
<td>Focus on STAM not the E Formula Sheet of Definitions</td>
<td></td>
</tr>
<tr>
<td>Walk through a circle</td>
<td>Math Equations</td>
<td>Interest -&gt; Major -&gt; Job/Career flow chart</td>
<td></td>
</tr>
<tr>
<td>D.I.Y. Experiments</td>
<td>Build as you go the story line</td>
<td>Get the point across that it is fun</td>
<td></td>
</tr>
<tr>
<td>Drawing</td>
<td>Overall Objective</td>
<td>Get the point across that it is fun</td>
<td></td>
</tr>
<tr>
<td>STEAM Careers</td>
<td>Connect it all together</td>
<td>Fact box about History</td>
<td></td>
</tr>
<tr>
<td>Matching Game with Projects</td>
<td>Visuals</td>
<td>Visuals for specific to each topic</td>
<td></td>
</tr>
<tr>
<td>Creative Writing</td>
<td>How it relates to history</td>
<td>Salaries of jobs</td>
<td></td>
</tr>
<tr>
<td>Involve Multiple People</td>
<td>Draw an Example</td>
<td>Get the point across that it is fun</td>
<td></td>
</tr>
</tbody>
</table>

The ideas that were collected were incorporated into Phase Two for the inspiration ideas for the participants to examine.

**Instrumentation**

The instruments that were used for the study are:

Instrument One – Semi-Structured Interview

Instrument Two – The Researcher
Data Analysis

The data analysis for Phase One: The Pilot Study was descriptive in nature. The idea was to collect as many thoughts as possible regarding ideas about a STEAM workbook. Data were collected from 25 participants; the number of 25 participants was the cutoff because the study had reached saturation. Interviews began showing repeated themes with only slight variations. It was concluded that there was enough data to terminate this phase of the study. Credibility and confirmability were present in the study. First, all the interviews utilized member checking to validate the responses. After the data was collected, the researchers performed member checks. Notes were read back to the participant allowing the participant an opportunity to change or revise any statements. Second, the interview protocol was demonstrated and performed on several faculty members of the Florida Institute of Technology. Third, the data was primarily descriptive. The participants stated the information, and the researchers wrote the notes down. Fourth, peers read and discussed the data for peer reviews.

The results of the study supported research that indicated that women lean toward safety, family, and the environment. The results of the study were incorporated into Phase Two: Workbook Construction. Naturalistic inquiry and emergent design flexibility were used as part of the design strategy. Simple coding was used in the beginning for the review of the transcripts but in the end was not needed. Each interview produced a unique project; however, the way in which the project would be conducted was similar. Many of the participants struggled with what Engineering is. Often, it was conceded that Engineering would be the orchestration of all the other aspects of STEAM.
During the interviews, 34 different projects emerged from the inquiry of the 25 participants since some participants provided more than one idea that was then considered. Additional natural reciprocals were introduced as meaningful results of the interviews. An example of a natural reciprocal is that one participant indicated that roaches could be used to assist science. The natural reciprocal would be that roaches are a nuisance and need to be removed from the environment. On the whole, everyone was excited to share ideas for STEAM projects. There was a difference in response between women and men. Women seemed to lean toward the environment and helpfulness (e.g., pollution, bees) where men seemed to lean toward straightforward applications (e.g., catch a shark, build a game). Of the men that were interviewed, their subjects were: oil industry, game development, artificial intelligence and machine learning, robotics, and catching sharks. When the participants in the study were asked about Steampunk, almost everyone was genuinely excited about the idea and several of the girls said it was a “cool” idea. This validated the decision to make it the overall theme of the workbook.

When participants were asked about the topic of lightning, their response was blasé. This was an unexpected result, which helped the researchers realize why each participant should make his or her own topic for a workbook. The key point is to engage the young women and to do so effectively; therefore, they need to work on projects that are important to them. This also indicates why certain STEAM workshops fail. If the response is blasé, then the participants are not inspired and intrinsically motivated to participate. They might give the minimalist amount of effort at that point.
Phase Two: Workbook Construction

Build your Own STEAM Workbook

The design of Phase Two of the study consisted of having young women build a STEAM workbook themed in Steampunk. As stated in Chapter two, Steampunk was chosen as a way to create a common theme amongst all the workbooks. This was done so that the young women could talk to one another about their projects, and the writing part, the A, in STEAM could create a bridge between the projects.

The researchers assisted in the study. For the study to be successful, it is important to have support for the workshops. To this end, many community members volunteered to assist the study. The volunteers were excited about the idea and wanted to help. Members of the team also took on the role of the Most Knowledgeable Others.

The following peer-reviewed questions were created to help drive the initial interviews at the beginning of the study. The B stands for Before. Each participant was asked the following questions in Workshop 1:

QB1: Explain what STEAM is to you as if you are talking with your friend.
QB2: What do you plan on doing after you finish school? Or college?
QB3: Explain how you plan to pursue your goals that were mentioned in the previous question (QB2) and why do you want to pursue them?
QB4: Explain how the field of study you chose may relate to STEAM.
QB5: Explain what you think you will learn by building a STEAM workbook.
QB6a: Some say that STEAM fields are predominantly geared toward men. What are your thoughts on this topic, and does it dissuade you? (Why?)
The following peer-reviewed questions were created to help drive the concluding interviews at the end of the study. The A stands for After. Each participant was asked the following questions at the end of Workshop 3:

QA1: Explain what STEAM is to you as if you are talking with your friend.

QA2: What do you plan on doing after you finish school? Or college?

QA3: How has your thinking changed regarding what kind of career you would pursue?

QA4: Explain how the field of study you chose may relate to STEAM.

QA5: Explain how your thinking may have changed about STEAM after working on this workbook.

QA6: Explain how you might change things to make women more eager to join STEAM fields.

Each of the participants were asked the semi-structured interview questions. Interviews of the participants were conducted to get a richer data set to understand the participants’ opinions and thoughts. Field notes were collected to help with the analysis. The notes and observations were diligently recorded to create a narrative that records the participants’ interaction with the various parts of the experiment. Due to COVID, the participants’ interactions were on Zoom and the sessions were recorded with consent in accordance with IRB.

The research was conducted in the following manner: Participants, with the consent of their guardians, registered into the study. Due to COVID, the workshops were reimagined and done through Zoom sessions to protect the participants from the spread of the COVID virus. Each participant along with the researchers scheduled a series of
Zoom calls to facilitate the online workshop. Prior to the beginning of Workshop One, each participant was given a workbook kit that contained their workbook to create, supplies to help, and a puppet to be their Steampunk’s character sidekick. At this point and at various points during the study, the participants were asked questions and were interviewed about their thoughts about and opinions of STEAM. After all the participants had registered, they attended three workshops. The workshops were staggered so there was at least a week, if not more, between the workshops. The workshops and their design represent the pedagogy that was implemented in the study. The workshops are:

**Workshop One:** Introduction to the Workbook and the S in Science.

**Workshop Two:** A walk through of the S in Science, the T in Technology, the E in Engineering, the A in Arts, and the M in Mathematics.

**Workshop Three:** Conclusion to the workbook and wrap up.

**Focus Group One:** A focus group of some the participants to revisit some of the questions and see if there was a group opinion or consensus. The primary purpose of the focus group was to assist with triangulation and trustworthiness of the study.

**Framework and Grounded Theory Methodology**

Grounded theory is a qualitative exploratory method to find and discover emergent ideas and themes that may be observed in a study and grounded in truth. Through observations and interviews, the researchers can witness new insights and ideas that emerge from the participants within the study and the data that is created. The concept is that by performing a study within the grounded theory, one is looking at the
nursery of new thought patterns and ideas that can then lead to further study with more investigations (Guba E. G., 1981). Grounded theory generally gets its data from observations, interviews of the participants, and other sources such as notes, memos, and journals. Rich, thick, detailed notes and recordings are captured so that they can be later analyzed using various qualitative data analysis techniques to find generalizable themes, emergent ideas, and new thoughts of inquiry. Due to the nature of grounded theory and its place in qualitative research, it was the ideal choice for the STEAM workbook study. The intent was to find emergent themes and data that presented itself in ground truth, as the participants in the study built and created their own STEAM workbook (Guba E. G., 1981; Patton, 2002; Johnson, 2004; Charmaz, 2006; Chun Tie, Birks, & Francis, 2019).

To perform proper research and to utilize grounded theory, the researchers were mindful of many of the current techniques and strategies regarding grounded theory. To this end, various aspects of the framework of Chun Tie et al. (2019) was utilized to ensure proper adherence to collecting the best insights. Chun Tie et al. (2019) depict a design framework that can be followed based on work that was developed from Charmaz, Glaser and Strauss. Chapter two discussed the theoretical framework for grounded theory and the following discusses the application of grounded theory to this study.

The initial framework is identified in Chun Tie et al. (2019, p. 3) as a graphic (see Figure 1 in the original paper). The framework is reproduced here in Figure 3 with some modifications to make it more applicable to this study. The figure contains the block diagram of the modified framework from Chun Tie et al. (Chun Tie, Birks, & Francis, 2019). The modifications include the following:
First, a new block was added to the block diagram, below Collecting Data, to represent data transcription operations. Transcribing data can often be a large undertaking and requires several passes depending on how the transcription was done. Human and machine errors can take place that need to be cleaned up. Data cleaning is part of the Data Science workflow, and it is essential to have representative data when performing analysis. Often words spoken in the English language may sound like other words. Even with the use of artificial intelligence, machine learning, and transcription services, mistakes can happen when transcribing data.
Next a block was added below Transcription to represent the creation and use of Word Clouds. The Word Clouds are discussed in the data analysis section.

Finally, lines and arrows were placed on the diagram to symbolize a process flow. The original diagram showed various activities included through a brace. It was decided to change this image to look more like an activity and flow chart that one would see in the systems Engineering discipline. The boxes represent processes that must take place and there is a certain level of effort associated with ensuring these tasks take place.

The following details the framework used for this study and each of the various sections are discussed in the Data Analysis section. To assist with the description of the framework, numbers (1, 2, 3, 4, 5, 6, 7, & 8) were added to the diagram along with letters (A, B, & C) and Roman numerals (i & ii) to indicate areas of interest in the diagram. The framework of the study was constructivist grounded theory utilizing the framework laid out by Chun et al. (2019) The first part of the framework is to perform purposive sampling (1). The target population and sampling are discussed in the next section.

The next part of the framework was to generate and collect data (2). Data for the study came from interviews, a focus group, the workbook that was created, and other data such as memos and field notes.

The next part of the framework, the added part, is transcription (3). The interview data was transcribed into text and the resulting text was cleaned up using Data Science techniques.

Next in the diagram was Word Cloud creation (4). Word clouds were created for each participant based on the data from the transcripts.
After that was initial coding (5). The data was coded using initial coding techniques. The initial codes, as discussed in Chun et al. (2019), were created by looking at each of the sentences of the participant and capturing their meaning and intent in the form of summary words.

Next, intermediate coding (6) took place. Once summary words were created, the words were analyzed, and core category selection took place. This allowed the researchers to see if similar categories could be compressed into more abstract ideas. The categories that were then created from this process began to convey the overarching theme that was emerging.

After that, advanced coding (7) took place. This is where theoretical coding and a story line was created from the ground truth, built from the ground up.

The last step, grounded theory (8), is where the final themes came together to create the grounded theory that was assembled from the data. The results and rationale were then explained.

While those various parts of the framework were underway, concurrent data collection and analysis (A) was on going. In parallel, Constant Comparative Analysis (B) was taking place as well.

Meanwhile, memos (C) were also used to reflect on what the young women were discussing along with their emotions. Theoretical sampling (i) and theoretical sensitivity (ii) were also occurring simultaneously to help understand the thoughts and ideas of all the young women. Essentially all the participants’ realities were now intermingled within the codes, and one had to focus down to abstract thoughts that revealed the participants thoughts about STEAM.
The framework diagram in Figure 3: Research design framework from Chun Tie et al. (2019) modified for this study, shows how the components of the framework interoperate alongside each other to create the holistic view of the study and the data collected and analyzed.

**Target Population and Sampling**

As mentioned earlier, the study utilized purposive sampling. To this end, the following attributes were used when selecting the participants. The study focused on a population consisting of all young women; however, for the purpose of inclusion, young men were allowed to participate (i.e., a brother) but their data was only to be used to compare that of the target population. The target population of Phase Two is middle school students and high school students who are at the critical point in development where they may accept STEAM. The target age is middle school students, eleven to fourteen years of age and high school students, fifteen to eighteen years of age. For this research, young men/women are defined by the *Publication Manual of the American Psychological Association* (APA) Sixth Edition as: “Young man and young woman and female adolescent and male adolescent may be used for individuals aged thirteen to seventeen years” (American Psychological Association, 2009). The age of middle school students in the United States of America includes those from the age of eleven to thirteen (grades seven and eight). The age of high school students is fourteen to eighteen (grades nine, ten, eleven, and twelve). The target population for Phase Two of this study is middle school students and high school students.

The population was obtained by reaching out to Girl Scout Troops and other similar organizations and aligning their needs for personal growth and development. The
purpose of choosing these groups was to understand the mindset of today’s female youth toward helping humanity. Additional participants were recruited through interrelated social circles such as dance schools, church groups, and other organizations.

The sample population consisted of 11 young women from the target population. The young women came from suburban areas of Brevard County, Florida, USA. The participants of the study were given informed consent. Consent was given when the participants and or guardian signed up for the activity. For all participants who were under the age of 18 at the time of the study, a parent consent form was provided. The parent or guardian of the participant filled out this form to allow their ward to participate in the study. The parent/guardian consent form is included in the appendix of this document. No threat was identified to affect the participants while participating in the research. Approval for the participation of the young women was given by the Florida Institute of Technology Institutional Review Board (IRB) before data collection began (see Appendix B for the researcher’s IRB certification). The number of participants was chosen to be ten at a previous committee meeting. It was also suggested to add any additional participants to the study. In the end, eleven participants were chosen so that the study would be feasible and practical given the time constraints, the nature of the study, and COVID restrictions that added an unforeseen burden onto the study. Participation in the research activity was voluntary. The population chosen was specific and was intended for this qualitative study.

**Interventions/Treatments/Procedures**

The procedures for this study utilized a framework utilized in systems Engineering. As explained in Chapter 2, systems Engineering utilizes the systems
Engineering process known as the V-Model. The V-Model is used to capture system requirements, execute the design, and test and create the final product. To this end, the workbook itself is the framework for taking the participant through the S, T, E, A, and M elements of the study. It provides the necessary steps and procedures to make the outcome a success. The participants did not build the gadgets and gizmos due to time and cost; however, the participants documented what would be needed to achieve the results in their workbooks and interview answers.

The workbook workshops took place in the last half of 2021. All together as planned, there were three workshops and one focus group. The dates and times of the workshops were scheduled with the participants. Due to COVID, the workshops were facilitated using Zoom. The first workshop had one or two participants each. The second and third workshops were one on one sessions since each participant was working on their chosen topic and intermingling participants would have caused confusion. Lastly, a focus group was held in the later part of 2021. This focus group was held in person where participants revisited some questions about STEAM. The focus group was made possible by the refiling of the IRB request and following CDC guidelines for COVID.

The following sections detail the procedures and pedagogy that was implemented in the STEAM workbook construction activity.

**Workbook Construction Materials**

To make the workbook construction a success and due to COVID, it was realized that each participant would require a Steampunk workbook kit. The kit was required to give each participant access to the necessary supplies so that they could build the workbook; see Appendix A. Workbook Kit Contents, for the list of the contents of the
workbook kit. Each workbook had helpful prompts placed within the book. The prompts were made on thermal shipping labels that were pasted into the workbook at specific pages. The workbook was wrapped in Steampunk inspired fabric to give the young women the feeling of something old and special.

**Workbook Test Run**

Once the workbook kit was realized, three sample kits were created. These kits were peer reviewed by fellow women researchers at FIT and they expressed their thoughts and considerations for the workbook kit. Their thoughts were accepted as feedback and the recommended changes were employed. Such changes included adding scotch tape to the kit, adding a page that expressed where a major activity should take place in the workbook, and finally using brand name markers to create excitement for the workbook. The researchers went through the workbook and filled it out as if they were in the study. By watching their interaction with the workbook, one was able to see firsthand how the workbook kit is a completely hands on constructivism project that helps to inspire women about STEAM. The researchers fully endorsed the workbook and agreed with the design.

**Workshop One – The S in Science**

Workshop One, called “The S in Science,” was a forty-five minute to one hour workshop in which the participants chose a topic that they wanted to focus on for their Steampunk workbook. The workshop began with each participant choosing a Steampunk name. This was done for anonymity for the study. Each participant would be referenced by the Steampunk name instead of their real name. After the participant chose their
Victorian Steampunk name, they were asked the following questions (repeated from Phase Two: Workbook Construction: Build your Own STEAM Workbook):

QB1: Explain what STEAM is to you as if you are talking with your friend.

QB2: What do you plan on doing after you finish school? Or college?

QB3: Explain how you plan to pursue your goals that were mentioned in the previous question (QB2) and why do you want to pursue them?

QB4: Explain how the field of study you chose may relate to STEAM.

QB5: Explain what you think you will learn by building a STEAM workbook.

QB6a: Some say that STEAM fields are predominantly geared toward men. What are your thoughts on this topic, and does it dissuade you? (Why?)

The participants were given a brief overview of the study and information about the three different workshops. The participants were told about the Steampunk theme and that they were to imagine a character they would create who lives in the Steampunk world. To support the Steampunk theme, the participants were given a canvas bag that contained items that would assist them in creating their Steampunk workbook. The participants were told that they were to write a story about their character who has a problem to solve in the Steampunk world. The participants were then shown examples of projects that they might want to pursue. They were presented with over thirty-one topics to choose from and given the freedom to choose their own. Videos were constructed of more than fifteen topics that they might choose to watch. In each session, the participants were asked to select two videos to watch that would help inspire them. When the session was
an individual session, then the single participant chose two videos to watch. When the session was two participants, then each participant chose one video to watch. The videos were made from the topics listed in the outcome of the pilot study shown in Table 1: List of Project Ideas. Additionally, the participants were told about Victoria, who is a puppet who is also doing the workbook along with them. The Victorian dressed puppet was doing her topic on Lightning Detection and the science behind it. Inside Victoria’s workbook, they read a small story that she created about Ada, the Steampunk character she chose. The story described how Ada lives in the Steampunk world and how she had to help her brothers by building a lightning detector.

Although one does not alter the environment in which the participants live, the researchers can alter the environment in which the STEAM workshop is discussed and implemented. Originally, for this study, the concept was to change the environment. The researchers would bring in lots and lots of props to help inspire and motivate the participants. The purpose would be to help spark the interest and engagement of the participants. The following are examples of things that would have been brought to the active learning sessions to help motivate and inspire: the replica of a beehive, fishing nets, a kaleidoscope, camera, camera obscura, Raspberry Pi, Arduino board, 3D printed objects, a kite, fabric, puppets, posters of COVID-19, posters of lightning, a book about Benjamin Franklin’s life, a train model, space vehicle model, space station model, Steampunk gears, cogs, and keys. All these aforementioned items emerged from the pilot study. The participants would have seen a science demo from Victoria’s workbook and then they would get to walk around the room and choose a topic they wished to study for the creation of a project-based workbook. Due to the impact of COVID, this process and
interaction had to be reimagined. To that end, it was decided to create as many topic videos as possible to offer similar excitement and enthusiasm that would have been present in person. Short topic videos were created in themes such as COVID 19, Save Sharks, Catch Sharks, Trains, Pollution and the Indian River Lagoon, the Oil Industry, Scrapbooking, Ecological Footprint, Space, Astronomy, Data Science, Bees, and Dress Construction. The participant was allowed to choose any topic they would like but they had to keep in mind that the topic must relate to STEAM, it had to be feasible to actually get accomplished, and should involve some technology from the Internet of Things.

The participants’ workbooks documented their choices and discoveries. The participants did not build the gadgets and gizmos they thought about for this study; instead, they researched them and documented them in the workbook and interview so that they could be created in the future. The workbook acted as an Engineering manual that collected the systems requirements for the study. For the first workshop, the participants chose a problem they wished to solve, discussed the science behind the project, and identified, if possible, Internet of Things devices that could help the investigation.

It was hoped that the participants would come up with their own problem they wished to solve. If the participant did not come up with a unique idea, the guiding adult suggested that the participant do one of the studies already shown in the videos. After the participants chose a problem that they wished to solve, they were instructed to think about the S, for the science behind their project. This workshop overviewed pages 1 to 29 of the workbook.
At the conclusion of the first workshop session, the participants were asked to write a short story about their Steampunk character and their problem. The researchers then went forth and researched each of the projects the participants had chosen. The reason for this is so the researchers could maintain the role as Most Knowledgeable Others and assist the participant. The goal was for the researchers to identify Internet of Things devices that could help solve the problem to help the participant as needed. Their research was also to be part of the scrapbooking exercise where they could take clippings or printouts for gadgets and gizmos that could be used in the workbook. During the workshop, the participants were asked to think about careers that could be pursued with the science they chose. The workbook session was over Zoom and the researchers recorded the interaction. After the workshop, the researchers wrote down memos that contained reflections of the workshop.

**Workshop Two – Exploring STEAM**

Workshop Two, called “Exploring STEAM,” was a forty-five minute to an hour and a half workshop in which the participants took their idea from Workshop One and started applying it to science, technology, Engineering, art, and math. This provided an opportunity for the participants to see how interdisciplinary fields all can be tied together in STEAM.

The workshop started off with a comprehensive discussion about the topic they chose and the science behind it. The participant explained what they knew about their topic and the various aspects of how it relates to science. When the participant concluded their discussion, the researchers then continued having a dialog about the
project they had chosen and the science behind it. The purpose was to help the participants understand the application of science to their project.

Once the science had been discussed in adequate detail, the next part was a discussion on the Internet of Things and Technology. The participants had an interactive conversation regarding their project and various technologies that were needed to turn their idea into a product. The participants were allowed to freely wander with their thoughts and ideas and were not tied down to existing gadgets and gizmos. The Internet of Things was explained to them, and the participants got to see various categories that the Internet of Things could offer. Temperature gauges, wind speed, water tests, virtual reality, mobile phone apps are just a sampling of topics discussed relating to the Internet of Things. The participants were allowed to talk about devices that exist, or ideas about augmenting devices, or ideas about devices that do not even exist. This allowed the participant to see how they could utilize the technology without getting overwhelmed with the practicality of it all. This was also done so that the participants had a positive experience with the workshop (Sinkele, 2011).

As the participants narrowed down the Internet of Things and how it could work along with the science, the next topic was Engineering. Engineering was discussed to bring everything together. Requirements analysis, the system V-Model, system interfaces, materials, electronics, software Engineering, electrical power, communications, data reporting, and data collection were discussed. The Engineering was discussed as the orchestration in their project that would tie all the subcomponents together. It was important for the participants to see what an important role Engineering has in STEAM. The young women were asked to create an Engineering diagram of their
concept and put it in their workbook. Additional information was shared about careers that one could have in Engineering where they could be System Engineers, Data Engineers, Software Engineers, Electrical Engineers, Material Engineers, and various other types of Engineers.

Art was the next topic that was discussed. For many of the participants, a tangible object using technology was discussed. Therefore, the art was twofold. The first part was what would the object look like in the real world and why? Would it blend into the environment, or would it grab one’s attention? The second part went hand in hand with the math part. If one were creating diagrams, bar charts, scatter plots and other types of graphics to convey a message, then what would that message look like. How would one use art to paint a picture of the result of their project. Would the art and presentation of the graphics capture the audience and stakeholders? Would it give concern, fear, or foreboding? Would the art and presentations convey happiness and excitement? What sorts of images would be used when showing and using the product? What would the story lines be for the product? Would interesting stories be created to discuss the product? The concepts of Data Science visualization were discussed as well. All these ideas were presented for the young women to consider when it came to art. Additionally, music, dance, social media, videos, puppets, and other creative outlets were discussed in association with art.

The final topic discussed was math. To engage the participants in math, the researchers put an emphasis on Data Science. The Data Science process was explained to the participants along with a discussion of the modern Data Scientist. Not only was it important to collect data and report data but it was also important to perform calculations
and statistics on the data. The participants were asked to imagine the data they would be collecting and to draw some basic charts to show the data. The participants were instructed to look up charts on the internet or imagine what they would look like and to use those images. Math was also explained for the various projects and how it helps to paint a holistic picture of what was going on. Lastly, the presentation of the Data Science was discussed and went hand in hand with the art section.

This workshop overviewed pages 30 to 89 of the workbook. When all the aspects of STEAM had been discussed, the researchers asked the participants to continue working on their workbooks. The workbook session was over Zoom and the researchers recorded the interaction. After the workshop, the researchers wrote down memos that contained reflections of the workshop.

**Workshop Three – The Conclusion**

Workshop Three, called the Conclusion, was the last workshop in the series. Each participant was asked how the workbook creation process was going and they shared some thoughts about the workbook. The intention of this workshop was to walk the participant through several questions and then to wrap everything up.

The participants were asked to discuss a conclusion story about their Steampunk character and how their character was able to use Science, Technology, Engineering, Art, and Math. Next, the researchers asked the participant if they knew what field of study they or their Steampunk character would pursue in college. Various degrees were discussed and the tradeoffs of what these degrees would mean for particular circumstances. The question concluded with what profession they would pursue if they graduated with the degree.
The next question that was explored was their understanding of salary and what mid-level professionals would be paid for a particular job. To help give the participants a frame of reference, it was discussed with each participant what $15 United States Dollar (USD) an hour is and how that equates to a annual salary of $31,200 USD. After that, the next question asked was what did they learn from doing this activity and had their thoughts about STEAM changed in anyway. The participants were also asked about goals and if their goals had changed after working on the workbook. Finally the last part of the workshop entailed asking the participants the following questions (repeated from Phase Two: Workbook Construction: Build your Own STEAM Workbook):

QA1: Explain what STEAM is to you as if you are talking with your friend.
QA2: What do you plan on doing after you finish school? Or college?
QA3: How has your thinking changed regarding what kind of career you would pursue?
QA4: Explain how the field of study you chose may relate to STEAM.
QA5: Explain how your thinking may have changed about STEAM after working on this workbook.
QA6: Explain how you might change things to make women more eager to join STEAM fields.

At the conclusion of the workshop, the participants were asked to take pictures of their workbooks and to send them to the researchers. This workshop overviewed pages 90 to 110 of the workbook.
Focus Group

A focus group is a great way for collecting additional information and having a way to review preliminary results with the participants in the study. A focus group was arranged, and the researchers were able to clarify questions. The focus group consisted of several of the participants who were available to meet up. The focus group was in person and followed the IRB and CDC guidelines. All the participants wore masks. The focus group allowed the participants to share a common dialogue and to form a consensus to some of the answers to the questions that were asked. The conversation was fluid and started from the question: why you would be more motivated to be part of a STEAM career knowing that the field is composed of predominantly men? The second question asked was: why do you think women choose fields that seem to help people? The third question asked was: would you want your science classes to incorporate an extended version of the workbook idea, such as a longer engagement for the whole school year? The conversations were fluid and provided additional information for the study.

Instrumentation

To gather information regarding young women’s thoughts regarding STEAM and to gather information to answer the research questions, the following instruments were used in the study:

Instrument One – A semi-structured interview that asked the participants about their current thoughts and opinions on STEAM and STEAM careers. This instrument was administered throughout the study to collect thoughts, ideas, and emergent information during the workbook workshops. Answers were recorded through the Zoom software. The participants knew they were being recorded and an IRB was filed.
Instrument Two – The researchers. The researchers and assistants were around to assist and help the participants. They fulfilled the role as the Most Knowledgeable Others (from Vygotsky’s work). They worked with the participants to help them overcome any hurdles that they may have faced.

Instrument Three – The workbook. The workbook provided an opportunity for content analysis so that the researchers could understand the thoughts and perspectives of the participants in the study.

Instrument Four – Field Notes and Memos: The field notes provided insights into the study from the perspective of the researchers (observers). The field notes were also used to help detect any irregularities and to help reduce and mitigate risk. Risk would be threats to validity. The memos were used as a way for the researchers to provide reflections on the study and to document what was observed and thoughts regarding the interactions.

Measurement Instrument One: Excel. Excel was used to capture data for coding and analysis.

Measurement Instrument Two: PowerPoint. PowerPoint was used to capture thoughts and ideas of the participants. PowerPoint assisted in the organization of the ideas and was used as a tool for screen sharing with the participants during Zoom calls. PowerPoint was used to create workbook prompts that were used as labels within the workbook.

Measurement Instrument Three: Odin’s Eye, the Well of Truth. This is software written utilizing Anaconda, Jupyter Notebooks, and Python coding environment. This software is discussed in the Data Analysis section.
Construct Validity

To maintain construct validity, the workbook prompts were peer reviewed by various members of the community. The pedagogy and scaffolding procedures were also reviewed. A dry run of the study was performed with the researchers to determine if anything was overlooked or needed to be changed.

Data Collection

Data for the study was collected at various stages. The data collected aligned with the various instruments that were used. First, data was collected when the participants signed up for the study. Their parents or guardians filled out a parental consent form and they were told about informed consent. Data was collected in the form of interviews. An important aspect of data collection for qualitative studies is that data that is collected is full of rich thick descriptions. The rich thick descriptions help to maintain trustworthiness and creditability in the findings. The data collected was Zoom recordings of the participants’ workshops. Data was also collected from the researchers’ notes and memos as well as pictures from the participants’ workbooks. Table 3: List of Instruments and Collection Methods provides an overview of each instrument and the type of data that was collected.
<table>
<thead>
<tr>
<th>Instrument</th>
<th>Data Collection Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instrument 1 – Semi-Structured interview</td>
<td>Zoom Recordings with Audio and/or Video.</td>
</tr>
<tr>
<td>Instrument 2 – The researchers</td>
<td>Zoom Recordings with Audio and/or Video of the Researchers interacting with the participants.</td>
</tr>
<tr>
<td>Instrument 3 – The workbook</td>
<td>Content analysis from the workbook transcribed into text. Photographs of the workbook were also taken to preserve the work so that the workbook could be returned to the creator.</td>
</tr>
<tr>
<td>Instrument 4 – Field Notes &amp; Memos</td>
<td>Rich thick notes created by the researchers about the participants, themselves, the environment, and each other.</td>
</tr>
<tr>
<td>Parent Consent Form</td>
<td>The document that was signed and dated by the parent/guardian</td>
</tr>
</tbody>
</table>

**Data Analysis**

One of the important aspects of qualitative research is to ensure that the proper conclusions can be drawn. To help the researchers reach the conclusions, emphasis was placed on ensuring the correct adjectives were used to describe content. From the data collected, the researchers peeled back the onion to discover information that could have been expected and unexpected. It was crucial that the researchers remained unbiased and that they saw what was to be seen and did not seek to find things that could not be seen. Truth is what needed to be discovered. The research was conducted in a safe environment and the researchers were free to explore their findings with other researchers. The following actions were performed with the data collected:

Field Notes and Memos: Field notes and memos were collected about observations for the participants engaging in STEAM. The notes and memos provided insights into the researchers and what scaffolding was administered to assist the
participants in the project matter: what they did, how they did it, and how the participants reacted or behaved.

Interviews: Interviews were conducted with the participants during the research to understand their thought process through the study. The interviews were transcribed into notes for the researchers to analyze.

The data collected by instruments underwent content analysis to see what emerged. The data was coded to help with analysis wherever possible. The data collected dealt with values, experiences, and thoughts about STEAM. For qualitative data, initial coding was first used, which yielded a method for intermediate coding. Initial coding diverged into intermediate coding. Initial coding was used to create keys to assist with intermediate coding. The data was analyzed several times to work out the common keys for coding. Theory building was based on everyone’s response. Every effort was made to have exhaustive codes where all aspects of concern were identified. Additional codes were created to represent overlapping ideas. The video recordings and audio recordings were transcribed and encoded based on what made sense to the researchers based on what was captured.

Altogether, the results of the data collected provided a narrative of some insights into what young women might be thinking regarding science, technology, Engineering, art, and mathematics, as well as various careers they would consider.

Earlier in the section titled Phase Two: Workbook Construction - Framework and Grounded Theory Methodology, Figure 3: Research design framework from Chun Tie et al. (2019) was discussed. This section continues the discussion by discussing (3)

**Data Analysis – Odin’s Eye, the Well of Truth**

The data collected from interviews contained a lot of information, and it was decided to use a software approach to assist with the analysis. Various software packages were recommended, and they were examined for their merits in assisting with the conversion of video data to textual data for analysis. In the end, these various software packages were difficult to master, required a lot of hands-on actions, and many of them required the user to purchase an expensive license to use them. Instead of investing in a software package, the researchers decided to write their own software package that was nicknamed Odin’s Eye, the Well of Truth. The software used was Python code running inside a Jupyter Notebook that was launched within Anaconda, a software package for scientific computing and Data Science (Anaconda, 2022). Various Python libraries, system libraries, and third-party Free and Open-Source Software (FOSS) were employed along with various voice-to-text libraries, machine learning, and artificial intelligence algorithms to comprise the suite of tools for Odin’s Eye. The video footage in MP4 format was converted to audio footage in MP3 format. Next, the MP3 format was converted to WAV format resulting in only audio files. The Python code read in the audio files and performed chunking on them to make them more manageable. Next, the Python code was able to extract textual data from the WAV files. The text data was then opened in Excel and was cleaned. To clean the data, the researcher listened to the audio recordings and marked, in Excel, who was speaking a specific sentence. Some of the lines of speech that were spoken by the participants contained errors that were then fixed.
by hand within Excel. One such correction was that sometimes the participants would
say the word “STEAM,” and the software thought it was “Steve.”

Once the interview data was converted to text within Excel and the lines of speech
were identified for each participant, the researchers utilized Excel’s ability to filter data.
The data were filtered so that only the participant's responses were selected. The data
was then copied and written out to a text file. The text file was then run through Odin’s
Eye to create a Word Cloud.

The Word Cloud utilizes algorithms to remove common words in the English
language. Words such as the, a, it, is, and or are removed so that they do not interfere
with the Word Cloud building process. Additionally, words are analyzed based on
frequency counts, and they are then converted into a stylized graphic, which gives one an
idea of the main conversation that took place. Word clouds are very helpful tools for
helping to remember conversations and were used in this research to study some of the
ideas of young women.

The Word Cloud shows dominant words within a conversation and paints a valid
representation of the conversation that was held. Utilizing member checking, the Word
Clouds were shown to the participants to receive feedback if they agreed with the data
collected, and they all agreed. Many of them were amazed and were curious about how
this was done. The researchers then explained how the software made the Word Cloud,
and the young women were excited about it.

The process of converting the video files to textual data was repeated for each
participant for each session of the study. This means that 11 young women were
interviewed three times each resulting in 33 run-throughs of video data being converted
and cleaned using Odin’s Eye and Excel. Although data transcription was done to capture the spoken words of the young women, it is important to note that this did not necessarily capture all that there was to observe. Hamed (1999) discusses that physical transcripts may miss some key parts of the interaction with the participant. The participant may give off an emotion such as excitement or confusion when they respond to a question. This emotion helps to give an understanding of what may be happening in their reality and is also a part of the data being collected.

Once textual data was created, the process of further analysis was able to commence. In Charmaz's (2006) book, the author states that there are several layers of coding. The layers of coding are initial coding, focused coding, axial coding. The intent, according to Charmaz (2006), is to take initial codes, break them up with focused coding, and then reformulate them using axil coding. In Chun Tie et al. (2019), the authors introduce a design framework for novice researchers. They take what Charmaz (2006) stated and apply it to a new framework. To perform coding, they suggest one should perform Initial Coding, Intermediate Coding, and Advanced Coding. To facilitate the building up of grounded theory, the researchers in the current study took the approach detailed in Chun Tie et al. (Chun Tie, Birks, & Francis, 2019).

**Data Analysis – Initial Coding**

As stated in Chun Tie et al. (2019), the process of initial coding is to take the data set and fracture the data. Fracturing the data allows one to create codes from the dialogue of the participant. This task is done inductively and can generate as many codes as needed. Charmaz (2006) indicates there are various ways to perform initial coding. One such way is line-by-line coding. This is essentially what was done with the data in these
workshops. Software transcribed the data into sentences in Excel. Each sentence was on a row within the Excel spreadsheet. In Excel, each line was forensically examined, and the initial codes were created. Some sentences would create more codes depending on what was being said. At the completion of this part, an initial list of initial codes was created along with the initial categories that the data represents. The initial codes captured emotions when they were present.

**Data Analysis – Intermediate Coding**

As stated in Chun Tie et al. (2019), the process of intermediate coding is to bring the data to an abstract level that is related to the data, grounded in truth, but begins to show an overarching theme that can be identified. At this point, theory started to emerge and gave insight as to what the participants were saying but at an abstract and holistic level. In the data in this study, the initial codes of the data were analyzed, and abstract thoughts were seen and recorded as abstract words. Theoretical saturation began to take place as codes began to converge to similar categories.

**Data Analysis – Advanced Coding**

As stated in Chun Tie et al. (2019), advanced coding is the process of creating theoretical integration by weaving together the core categories into a storyline. The storyline brings credibility and power to the resulting grounded theory as it is based on real truthful statements grounded in data. The storyline provides explainability and comprehension of the final theory. During and after data collection, theoretical sampling and theoretical sensitivity were constantly working to help extract and find the best representation for the data. Through constant data collection and analysis and constant comparative analysis, core theory topics emerged from the data. The collected memos
that were analyzed also helped to create a rich storyline that tells the results of the study in the final grounded theory (Chun Tie, Birks, & Francis, 2019).

Data Analysis – Theoretical Sampling

As stated in Chun Tie et al. (2019), the process of coding the data can start to lead one to theories as they begin to develop. These ideas and theories help to give one a clue, or a Spidey sense, of what needs to be asked and collected in further data collection points. The insights gained in the data helped to drive further conversations with the participants. Another analogy would be the old saying “to beat the bushes.” With (i) theoretical sampling, as shown in Figure 3, one was able to pick up on clues and hunches to help direct and investigate the theory that was emerging. The result is a theoretical category that needed to be queried and understood (Chun Tie, Birks, & Francis, 2019). The process of additional query and analysis is part of (B) Constant Comparative Analysis, as shown in Figure 3.

Data Analysis – Theoretical Sensitivity

During all stages of the analysis, Chun Tie et al. (2019) point out that theoretical sensitivity takes place during the entire grounded theory development. As shown in Figure 3 (ii), theoretical sensitivity encompasses all the stages of theory generation. During this study, the researchers were astute and mindful of any theories that represented themselves. Even before data began to saturate, there was an innate sense of some key ideas that were emerging within the data set. This also allowed the researchers to ask more guided questions to target the theory. As the researchers were emersed in the data, several ideas seemed to reappear and present themselves. Different words and
expressions were used, but from an abstract vantage point, it was clear that there was an emergent theory (Chun Tie, Birks, & Francis, 2019).

**Trustworthiness and Credibility**

To maintain the trustworthiness and credibility of the research, several steps were performed.

For trustworthiness, the following were incorporated into the study:

- **Truth Value** – To ensure truth value, genuine and authentic work took place in recording and capturing the thoughts and emotions of the participants in the study. Member checking was also utilized to ensure the captured data accurately reflects the thoughts of the participants (Guba E. G., 1981).

- **Applicability** – Findings that were discovered are relevant to the activities that the participants engage in. Discoveries and notes were taken as timely as possible to prevent the decay of ideas or thought. The thick, rich description was also captured and created to ensure the emergent ideas and thought patterns were collected correctly (Guba E. G., 1981).

- **Consistency** – This was maintained by providing sequences of events that took place in the study so a reasonable person could see the clear intent of the process (Guba E. G., 1981).

- **Neutrality** – This was maintained by removing bias as much as possible and letting the data speak for itself without the need for or interpretation of the researcher (Guba E. G., 1981).

For credibility, the following was adapted into the study:
o Persistent observations: Constant observations were made by all members of the research team. The inquiry showed that enough time was spent observing the workbook creation allowing for the naturalist inquiry to express itself and to be captured (Guba E. G., 1981).

o Peer Debriefing: Ideas and thoughts of the study were be shared amongst the researchers to find the truth. The peer debriefers, the researchers, and assistants acted as a jury to ensure that the logical thinking and parts of the study were sound (Guba E. G., 1981).

o Triangulation: This was performed by examining several sources of data such as interviews, journal notes, observations, and memos. The different methods were pitted against each other to find the truth in the data (Guba E. G., 1981).

o Member checks: the researchers reached back to the participants and asked if some of the items that had been collected provided a reasonable check and balance to what was observed. Thoughts were shared about how the topics were selected, what the topic means, and their general thoughts. The member checking validated that the notes were recorded adequately to capture the observation (Guba E. G., 1981).

All the aspects were briefed to the researchers so that study remains authentic, credible, and trustworthy.

**Work Plan**

The work plan for the study began in the summer of 2020. The summer was spent collecting necessary supplies and working with various groups to help secure the
needed participants for the study. Due to COVID-19, most preparatory work took place in the summer and fall of 2020. The work involved creating videos, designing a Google docs website, kits for the workbooks, and gathering ideas. Additional materials on Steampunk and puppets were acquired.

The workbook itself was scaffolding for the pedagogy of the study. Participants were made aware of the study so they could plan for it. A dry run of the study was conducted with fellow researchers. Various what-if scenarios were discussed to ascertain how best the study would be conducted. The Researchers Development Plan identified potential risks and provided instruction to help reduce those risks in the study. In the Spring of 2021, the study commenced. Three sessions were held to build the STEAM workbook. At the end of the Fall 2021 and Winter of 2022, all research activities were finished. The data was analyzed in the Winter of 2022, and the results were documented in this dissertation for the completion of Spring 2022.

The experiment ran the risk of mortality as well as maturation. The sample size was large enough to survive some dropped students. Maturation was documented within the field notes and observations.

**Resources**

The required resources needed to conduct the experiment from an equipment and practical standpoint were obtained through personal funding. The sample population was acquired with assistance from faculty and outside individuals to help round up enough participants for the study to be meaningful. Due to this concern, the age of the participants were twelve years of age or older. The accessible population was available through various support groups and assistants. One group was Girl Scouts; the second
group was a dance school. The third group was through a network of colleagues who had access to the intended population. With all these various groups, the researcher was able to enlist enough participants into the study.
CHAPTER 4
Results

Introduction

This study followed eleven young women in grades nine to twelve as they endeavored to create and participate in a themed STEAM workbook of a topic of their choosing. From the onset of the study, the researchers had a slight bias that the participants in the study had a working knowledge of STEAM. However, as previously mentioned in Chapter Three, the participants engaged with the researcher in three interactive sessions to discuss and create workbook ideas to explore a STEAM workbook. The results of these interactions and rich notes were transcribed, coded, and analyzed to answer the three main research questions identified in Chapter two.

The quotations provided within the study, for the most part, are unedited and are in the raw. It was the intent for the reader to experience some raw dialogue from the participants to not only show the authenticity of the research but to also show how some of the young women think without editing. In some areas, the text may have been edited but in those cases, it was done to add clarity. An example of such is adding in the word workbook because it helped the context. One will also notice that many of the young women constantly use the word like when speaking. These have been left in the dialogue. The use of the ellipse … was used to represent there was a break in a quote to remove errata. Lastly, the authenticity of this dialogue is true to the spoken words of the young women. Artificial intelligence was used to create the transcriptions taken from the audio recordings. The text was then cross referenced to the original dialogue to ensure it was representative of what the young women spoke. There will always be some level of
error in an activity such as this, but the amount of error is negligible, and the intent of the young women’s words are present in the text.

**Choosing a Victorian Steampunk Name**

Each of the participants within the study was asked to choose a Steampunk name for themselves to create anonymity in the preparation of data and analysis of the results. Learning from previous interactions with young women, it was identified that sometimes the participants would require a helping hand to be creative, and this was particularly true when choosing their Steampunk name.

![Figure 4: Participant Workbook Example](image)

By a happy coincidence, while searching for ideas and activities for the workbook, the researcher stumbled upon a set of 100 cards about famous women in science. To facilitate the choice of a Steampunk name, each participant received a random shuffle of ten of the cards from within the deck. When it came time for the participants to choose their Steampunk name, they were asked to choose a Victorian name that they could think of, or they could choose a name from one of the random cards.
they received. To the surprise of the researcher, all eleven of the young women chose a name from the set of names in the deck instead of creating a name of their own choosing. Figure 4: Participant Workbook Example shows one of the cards the participants had in the study. The card is affixed to the workbook along with the Steampunk character name she chose.

**Research Question 1**

1. How do thoughts and ideas about STEAM change in young women by their participation in a STEAM workbook workshop?

As each participant was brought into the study, they were each interviewed and asked the questions that were outlined in Chapter 3. Among the questions, the first question that was asked was could they describe what STEAM is as if they were talking with a friend. This first question was designed to collect a baseline from each participant to see what they really understood about STEAM. Using the semi-structured interview technique, one by one, the young women were interviewed and asked the same questions. Some participants gave lengthy descriptions of what STEAM was in their minds, while others did not really understand or know what STEAM was. Many were able to work out that STEAM stood for Science, Technology, Engineering, Arts, and Mathematics. Others had much more difficulty in giving a basic definition of STEAM. Most of the young women gave a very high-level, broad definition of STEAM. When the answers fell short of what was expected, the researchers asked the participants to provide richer detail to their definition. One participant confidently told the researchers what STEAM was but failed to realize that the M was for mathematics and not Music. The following was the interaction with the participant:
Researcher:

Explain what STEAM is to you as if you are talking with a friend?

Participant:

It's like science, technology, Engineering, art, and music, I believe. And their different Creative. Things to learn about and do.

Researcher:

And do you know more? Do you know more meaning behind those letters like what those letters mean to you?

Participant:

Um, for me I want to go into science and the Engineering and work like biomedically and stuff like that. I like that aspect of it more than the art and music.

The explanation that the participant gave as to the definition of STEAM was very representative of most of the young women in the study. All the responses from the participants were transcribed, had initial coding, intermediate coding, and advanced coding performed following the framework and process described in Chun Tie et al. (2019).

When analyzing the notes, it became clear that the young women only had a superficial understanding of what STEAM was. Quite quickly and to the surprise of all, all the participants had a hard time with this seemingly trivial question. The researchers were quite surprised at this emergent theme, which was absolutely something unexpected. Job descriptions, posters, school signage, school activities all use the buzz word STEAM but the young women in this study did not know or understand what
STEAM stood for. There was an assumption that all the advertising and constant mentioning of STEAM would have worked in the schools and that the young women in the study would know what the acronym meant. The revelation was that STEAM was not known to the young women. As seen with this interaction, a small notion or idea began to brew within the researchers’ minds. The main thought was: how could these young women, who are so far along in school, not know what STEAM is? An example of this interplay within one’s mind and notes is an example of theoretical sensitivity. It was clear that as part of theme building, this idea must now be accounted for. While collecting and looking at the data, the researchers were looking for clues that the participants did not know what STEAM was.

During the first working session, each participant listened to the researcher, the Most Knowledgeable Other, and the participant was told what STEAM is. In addition, they were also taught about Vygotsky and the concept or idea of the Most Knowledgeable Other. All the participants understood the small lecture and were eager to continue. The researcher, as indicated in Chapter 3, worked with each participant to give them a basic understanding that STEAM was Science, Technology, Engineering, Arts, and Mathematics. At first, the researcher let the participant mentioned above continue to describe that M was for Music and did not offer a correction until she fully described what, in her reality, the M meant (Guba E. G., 1981). Once the participant was done, the researcher, acting as the Most Knowledgeable Other, offered the suggestion and correction to the participant that the M stood for Mathematics and not Music. The participant gave an expression of “Oh” as she realized her misunderstanding. All the participants in the study had very similar reactions to what STEAM is. They all had
known of the acronym but never really understood the deeper meaning and understanding behind each letter. The emergent theme that presented itself in this line of inquiry was that the young women in this study did not have a sufficient working definition of STEAM. The researchers built a scaffolding framework for each of the participants. The participants used this scaffolding to work through concepts of constructivism to explore what STEAM is within the reality of each participant’s mind. As the scaffolding was built for each participant, so did the emergence of themes that contributed greatly to reveal aspects of grounded theory to indicate opportunities for future enhancements of young women’s understanding of STEAM (Charmaz, 2006; Chun Tie, Birks, & Francis, 2019; Patton, 2002; Guba E. G., 1981; Wass, 2011).

As the scaffolding was constructed around the reality of each participant, the researchers acted as forensic scientists peeling away the various layers of the onion revealing the young women’s thoughts about STEAM. The researchers needed to develop a richer understanding of the participants’ base line of knowledge and to create opportunities to shore up and enrich their working definition of STEAM. The enrichment came about by working on the STEAM workbook and having additional interactions with the young women to help them understand and explore STEAM. When comparing the participant’s first definition of STEAM to the last definition of STEAM after completing all three workshops, she had a change in definition. The change in definition now aligned with what STEAM actually is. From workshop one to the end of workshop three, learning took place. The Most Knowledgeable Other had taught participants what the definition of STEAM was. This was not just a brief description of the word but a full on detailed explanation of what STEAM was. She was able to relate to it and have a much
deeper understanding of what STEAM is. When comparing the participant’s responses against the other participants, utilizing constant comparative analysis, we see a similar change in all the young women. What had happened here, and is grounded in the data, is that the participants learned what STEAM is. Not only did they learn what STEAM is, but for every letter of STEAM they also had a richer deeper understanding of the letters and an appreciation for what they meant and how they are interconnected. The emergent theme that presented itself for this investigation was Educate. The young women spoke of words such as learn, know, and understand. These intermediate codes led to the more advanced code Educate, which was part of the theory building in grounded theory. So to answer the question:

1. How do thoughts and ideas about STEAM change in young women by their participation in a STEAM workbook workshop?

The answer is that they undergo education and learn a deeper understanding and appreciation for the acronym of STEAM. They understand that not only is STEAM an acronym, but it is also a way to go about problem solving and way of looking at the world differently. They learned, through the act of education, that STEAM is Science, Technology, Engineering, Arts, and Math and these concepts are all strung together to represent a way one can examine the world around to see how problems can be solved using STEAM.

In the essence of grounded theory, one important aspect is storytelling to paint the holistic picture of the study to demonstrate its authenticity. To this end, it was necessary to explain how the first theme of Educate came to be. The theme is backed by codes,
grounded in data, and abstracted to an import aspect of a STEAM workshop. Education is a key takeaway when trying to get young women motivated in STEAM.

**Research Question 2**

2. What thoughts and ideas emerge from young women who participate in a themed STEAM workbook project?

As one can see, and as mentioned above, the two research questions are interwoven as is often the case with grounded theory and qualitative research. As emergent themes and ideas came about, they answered Research Question one as well as support Question two. The workbook activity and interactions allowed for a unique opportunity to investigate the various thoughts of eleven young women and their thoughts and interests regarding STEAM. As mentioned in Guba (1981), it is very apparent from the interaction with these young women that each participant has their own reality, and their realities may not often coalesce with each other and that of the researchers.

In each of the sessions with the young women, each of them had the task of selecting their own science project that they would enjoy. As mentioned in Chapter 3, Methods, the participants were shown at least two videos of their choosing to help inspire and help them decide on a workbook topic. Each of the young women selected their science projects from the videos that were presented to them. They were given multiple opportunities to select any topic of their choosing but they decided in the end to pursue one that was depicted in the videos. The topics the young women chose were saving sharks (four participants), civil Engineering in regard to trains, psychology of OCD, food nutrition (antioxidants), pollution of the Indian River Lagoon, dress construction, infectious diseases, and education with application construction (program language
coding). An important observation that occurred here is that the participants were able to choose a topic of interest. The participants were given an adequate number of choices and within those choices they picked something that they would enjoy. They also kept within the videos they saw and did not choose a topic that was not represented. This coincidence may speak to how the young women are conditioned to ingest social media content. The videos created bear a resemblance to social media such as TikToks, Instagram Reels, and YouTube.

After the initial data was collected, it was time to employ the framework identified by Chun Tie, et al. (2019). The following sections illustrate how the various phases of collecting data and coding was performed. This document is linear in nature but it is important to know that while coding and theory building were taking place, other activities such as memoing, constant comparative analysis, adherence to theoretical sensitivity, and theoretical coding were all taking place at or about the same time to stay in accordance with Chun Tie, et al. (Chun Tie, Birks, & Francis, 2019).

**Generating/Collecting Data**

Data was collected at each part of the study phase. Each workshop was done over Zoom calls and those calls were recorded. Data was generated by running video files through Odin’s Eye, the Well of Truth, which resulted in csv files. Data was also generated through memoing, which is discussed later.

**Initial Coding**

The participants’ transcript data, which was created from the video files using Odin’s Eye, the Well of Truth, was saved into a .csv file and imported into Microsoft
Excel as a spreadsheet. The researchers began Initial coding on the data. Coding was done by hand on printed pieces of paper and digitally within Excel. An example result of initial coding is shown in Table 4: Example of Initial Coding, which shows a subset of data that was taken from the participants.

Table 4: Example of Initial Coding

<table>
<thead>
<tr>
<th>Original Text</th>
<th>Initial Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maybe having like teachers explaining.</td>
<td>Teachers can explain STEAM more</td>
</tr>
<tr>
<td>In a more interesting way.</td>
<td>More interesting ways to explain STEAM</td>
</tr>
<tr>
<td>Cuz whenever I’ve learned about it.</td>
<td>Learned</td>
</tr>
<tr>
<td>or like then it's been introduced</td>
<td>Introduced</td>
</tr>
<tr>
<td>like my teachers they don't really make it very enthusiastic, so nobody wants to listen.</td>
<td>Teachers don't make it enthusiastic</td>
</tr>
</tbody>
</table>

For each block of original text, a code was created to describe the original data. Line by line, relevant statements from the participant were coded in this manner. Only relevant statements were coded. Coding the data is an exceedingly long and time extensive task. Each row on the spreadsheet, which represented a whole sentence or a part of a sentence, was given brief codes to summarize and capture what was being spoken about in the conversation. As stated in Chun Tea, et al. (2019), the initial codes are intended to fracture the data, break it out from the sentences, and see what ideas or categories begin to emerge.
Intermediate Coding

Once initial coding took place on some of the participants’ data, the researchers were able to commence intermediate coding. Table 5: Intermediate Coding, shows the same example data set shown in Table 5: Intermediate Coding, with the addition of the intermediate codes.

<table>
<thead>
<tr>
<th>Original Text</th>
<th>Initial Coding</th>
<th>Intermediate Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maybe having like teachers explaining.</td>
<td>Teachers can explain STEAM more</td>
<td>Explain</td>
</tr>
<tr>
<td>In a more interesting way.</td>
<td>More interesting ways to explain STEAM</td>
<td>Interesting Way</td>
</tr>
<tr>
<td></td>
<td>More interesting ways to explain STEAM</td>
<td>Interesting to Who?</td>
</tr>
<tr>
<td>Cuz whenever I’ve learned about it.</td>
<td>Learned</td>
<td>Learned</td>
</tr>
<tr>
<td>or like then it's been introduced</td>
<td>Introduced</td>
<td>Introduced</td>
</tr>
<tr>
<td>I like my teachers they don't really make it very enthusiastic, so nobody wants to listen.</td>
<td>Teachers don't make it enthusiastic</td>
<td>Enthusiastic</td>
</tr>
</tbody>
</table>

The main idea of the intermediate coding is to generalize and boil down statements made in the initial coding while also keeping in mind theoretical sensitivity. Theoretical sensitivity is being aware that emergent themes may start to present themselves and this should be followed up where possible. In intermediate coding, one is
looking for more abstract concepts to bubble up to the surface so to say. The data is boiled down and reduced so that more abstract themes reveal themselves. This is done as often as needed and is part of the inductive analysis that takes place with the research. In Table 5: Intermediate Coding, one will notice an arrow in one of the cells of the original text column. The arrow shows that the statement above was repeated because another code could be made from the same statement.

**Advanced Coding**

As stated in Chun Tea, et al. (2019), advanced coding is the point where data code saturation has been reached and the abstract codes that tell the story founded in grounded theory can be told. The storyline that gets created weaves back together the fractured data with interrelated codes that explain the final framework. The abstract codes woven into the storyline provide explanatory power to the grounded theory findings. Table 6: Advanced Coding shows how some of the final theoretical codes that were developed based on the abstracted data came from the fractured data. One notices that words are repeated in advanced coding, and this is part of how the data is intermingled within the study and represents the emergent themes.
Table 6: Advanced Coding

<table>
<thead>
<tr>
<th>Original Text</th>
<th>Initial Coding</th>
<th>Intermediate Coding</th>
<th>Linking Ideas</th>
<th>Advanced Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maybe having like teachers explaining.</td>
<td>Teachers can explain STEAM more</td>
<td>Explain</td>
<td>How to Explain</td>
<td>Educate</td>
</tr>
<tr>
<td>In a more interesting way.</td>
<td>More interesting ways to explain STEAM</td>
<td>Interesting</td>
<td>What needs to be done</td>
<td>Design</td>
</tr>
<tr>
<td>Cuz whenever I’ve learned about it.</td>
<td>Learned</td>
<td>Learned</td>
<td>How one learns</td>
<td>Educate</td>
</tr>
<tr>
<td>or like then it's been introduced</td>
<td>Introduced</td>
<td>Introduced</td>
<td>How was it introduced</td>
<td>Design</td>
</tr>
<tr>
<td>I like my teachers they don't really make it very enthusiastic, so nobody wants to listen.</td>
<td>Teachers don't make it enthusiastic</td>
<td>Enthusiastic</td>
<td>What needs to be done</td>
<td>Design</td>
</tr>
</tbody>
</table>

Memoing

Memoing was a fantastic way of capturing insights of the participants. Memoing created a way to add authenticity to the study by documenting thoughts of the researchers. The researchers documented interactions and thoughts for the study. The memoing also served as an audit trail and added to triangulation. The memoing helped the researchers to keep an eye on theoretical sampling, theoretical sensitivity, and
constant comparative analysis. Table 7: Memo Examples shows excerpts from the memos.

Table 7: Memo Examples

<table>
<thead>
<tr>
<th>Date</th>
<th>Memo Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/11/2021</td>
<td><strong>Researchers Test Drive the Workbook</strong></td>
</tr>
<tr>
<td></td>
<td>Today Clara and Rachel came over to my house to see the workbook kits I have been talking about. They each received a kit and were very excited about the contents. The joy expressed by Clara was priceless as she tore into the kit and explored everything that was inside. Clara tore into the workbook. It was fascinating. She even started cutting apart the Vixens of Steampunk book. They each gave me positive accolades of the kit and assured me this was the best approach for dealing with the young women. Clara made some unexpected remarks that I will incorporate into the study. She mentioned it was important for the participants to have brand named markers and tools. She was very excited that the markers and pens were Crayola. I also took Dad’s advice and bought washable markers for use on the stencils. Rachel makes a few recommendations that I also incorporated. Rachel just like Clara was excited and thrilled with the kit. She looked at all the stencils and made comments about how this can be fun. She immediately started flipping through the book. Among them was to list a table of contents in the beginning of the workbook so the participants would know where action would be needed. Both Clara and Rachel commented on how they thought the prompts in the book was [sic.] a great idea. The prompts in the book were intended to help focus the young women and try to make it less like the wild west. (The researchers names have been anonymized for privacy)</td>
</tr>
<tr>
<td>10/17/2021</td>
<td><strong>First Batch of Zoom Calls</strong></td>
</tr>
<tr>
<td></td>
<td>I managed to get the participants signed up to the study. Today will be the first day I talk to them about the study. I managed to arrange to talk to several of the young women. I hope my videos play and they like them. I have a workbook that I plan to use to help guide the conversation. I wonder what topics they will pick.</td>
</tr>
</tbody>
</table>
Reflection

I talked to many of the young women yesterday and they provided interesting points of view regarding the questions I asked. I was surprised to learn that many of them are not intimidated by men as various researchers have pointed out but instead, they think going head-to-head with a guy would be exhilarating and they would find it fun. Many of them mentioned that they would like to show their fellow peers that women can do these things. As the research had pointed out most of the young women want to study fields that deal with compassion. Examples include water pollution, saving sharks, foods that people eat, education, and psychology. These are all very interesting topics. All the young women really liked the puppets. I was really excited about it. They loved the idea that the puppet could be used as a sidekick and buddy. All of the participants enjoyed the Steampunk idea, the workbook, and they had no problems coming up with Steampunk names. I am sure lucky I stumbled upon the deck of cards of famous women in science. They surely helped the participants pick out names and become curious. It was interesting doing the interview and interaction through Zoom but that is something I guess we all must get used to these days. I did notice that some of the participants were shy while others were more outgoing. Harry, my puppet, helped to break the ice in some of these occasions. I was really surprised that the participants didn’t really know what STEAM or even STEM was. I myself have always seen signage about STEM and I was really surprised that the definitions were lacking any sort of details. I also was happy to see that many of the participants were genuinely excited about the workbook and were eager to explore it. Some of the participants were very excited about learning more about STEAM. I did not expect this eagerness and I was really happy about it.

It was important to explain how the coding and memoing was done but now it is time to return to the research question.

2. What thoughts and ideas emerge from young women who participate in a themed STEAM workbook project?

The young women who participated in the study were full of lots of ideas and thoughts.
From STEM to STEAM

Some of the young women in the study had an idea of what STEM was. Most of the young women did not know what STEAM was. Once STEAM was explained to them and how the A brings art into the disciplines, their eyes lit up in excitement. One of the young women in the study wants to become an artist and once she found out that she could apply her skills in Science, Technology, Engineering, and Math, she was more than delighted to see this. She can use her craft as an artist to draw scientific representations of science, technology, Engineering, and math. These are some thoughts the young woman shared:

I think that Steam has changed my thinking actually breaking up this by realizing how important each individual part of something is and how like. They're all used together to make something great, and I think they all have to like correlate in order to make something work, rather than just using the Engineering science.

One of the participants mentioned some of the thoughts and concerns that the researchers sometimes talk about. One of the issues that came up is how young women feel about STEAM compared to their male peers. The following statement was made by the same participant after she was educated more about STEAM by the researchers. This was an answer to the question, how has your thinking about STEAM changed after working on the workbook:

I don't know how to word this. I don't know how to explain it. And it doesn't seem as like foreign concept anymore. Like when you learn about steam like oh, science, you know, what are you gonna do with it? I'm not smart. I don't know how that little apply to me, but then, like. When you learn how it, how much it
applies, and a lot of things in your everyday life, it's not as a hard concept to grasp. Yeah. Sure the doing the workbook made it more approachable. Yeah, little bit better understanding what all the different categories are like, have like what they actually like. Everyone has their like a specific a certain idea of the different subcategories, but this just helps kind of explain it a bit more. Does that make sense? Like the Engineering and all that I did really well. How all that worked so kind of helped. Yeah, definitely.

Another participant gave the following thoughts in regard to how the workbook allowed her to see STEAM differently:

Uhm, yeah, OK. Well, during this activity I definitely learned a lot more about, like careers and stuff like STEAM. I learned that knowing salaries is important. I definitely learned that like. Like I wanted a lot more about STEAM in the first place, 'cause before, I didn't really know exactly what it was and now I can explain it perfectly basically and again with like my career and stuff, I definitely changed my thought on like I could definitely use steam as like a career later on if I wanted to, just because I enjoy like science and I think STEAM was cool and it's important. I feel like especially with like. Staying with women is very like it's becoming more popular, but it's still like definitely like there's definitely less women in STEAM careers than men. So I feel like that's also really important. And that's definitely changed my view on like what I wanna do later on in life. …

Well, steam basically the S stands for science, and so this basically has to deal with like all the biological and chemical things that you're learning about and that you need to know to create your product. And then the T stands for technology.
So this basically. Means like you have to know how it works and how the thing you're creating works and what technology you need to know when you used to create your product that you use E is for Engineering, you know how to use the technology and the science and everything else to build your product and then A stands for art and for the art you can either use it to design your product so it is more user friendly. More environmentally friendly, all that sort of stuff. And you can also use it to present your product to like a group of people. Either like on a Zoom call or in a meeting, or if you're making a PowerPoint, or if you're making like a live diagram or model or anything, and then finally M is for math and once you're done using your product and experimenting with it, you can have mathematical data to show and prove that your product actually works.

**Active Learning**

The young women in the study enjoyed active learning utilizing the aspect of project-based learning. They all enjoyed picking their own topic and having the various discussions about Science, Technology, Engineering, Art, and Mathematics.

The various projects the young women selected are described below.

**Saving Sharks**

As mentioned earlier, four of the participants selected sharks for their mini science project. They were all free to come up with their own original ideas but in the end, they all decided to do their project on saving sharks. I asked one of the participants to describe the project and this was her response:
The problem I was investigating is that when fishermen were throwing the nets in to catch fish, sharks were getting caught in them. That was that right? Yeah. And. The solution that we had to come up with was having some kind of net that would like, force the shark away from the fish in the net. So, we had to. put, like a electromagnetic type of device on the net to keep the sharks away.

**Dress Construction**

This participant was interested in interior design, modeling, and acting. As a model, she was very interested in the idea of wearable technology such as a dress. The project entailed looking into wearable electronics that can be used in the assembly of a dress to create eye-stunning garments that world has never seen before. We talked about how STEAM could be used to insert motors, lights, and raspberry pi’s to create a dress that could respond to its environment. She loved the idea of creating a dress that could turn and twist cloth with motors to change its color and shape as one walked around. The researcher also discussed how the dress could pull down weather information from the cloud and have the dress respond by showing images of the current weather.

**Spreading of Infectious Diseases**

The participant was very interested in the medical field and also in microbiology. The topic that she chose to work on was the spread of infectious diseases. The project entailed thinking about a disease, patient zero, and how that disease is spread. The workbook entailed developing a wrist-worn device, such as a Fitbit watch, that would be able to monitor vital information and alert the wearer if a change in blood temperature and heart rate occurred, which may be one of the first signs of a response to an infection. An infection often causes elevated temperature and elevated blood pressure when it first
begins. The idea was if thousands of people were wearing this device, one would be able to create a network of devices worldwide to help alert the community when new infections were detected. Utilizing Data Science, this information could be combined with manufacturers’ records of common medicine such as ibuprofen, aspirin, and cough syrups to find locations where elevated blood pressure and temperature is detected and correlated with local stores having an increased sale in drugs. Through these measures, one would be able to develop a system that would be able to monitor the start and spread of infectious diseases.

**Obsessive Compulsive Disorder**

In this science project, the participant was curious about the manifestation of anxiety expressed as Obsessive Compulsive Disorder (OCD). In this project, the participant looked at some of the main types of OCD which are (1) Cleaning, (2) Symmetry and Ordering, (3) Intrusive Thoughts, and (4) Continuous Checking. Of the four types of categories, it was decided to focus on the cleaning category to make the project easier to understand. In the project, the participant and the researchers discussed what some of the issues with OCD are and how the person can be helped. One way was to help the person who suffers from OCD to be made aware of the frequency of their OCD actions. This entailed the idea of placing tracking devices on common cleaning devices such as vacuums, mops, and brooms. The devices would report every time they were moved and the person with the affliction could learn more about the disorder to help them devise strategies to deal with it and hopefully overcome it.
**Education App**

In this project, the participant teaches at a Voluntary Prekindergarten Education Program (VPK) school and was very curious about apps and coding for tablets and mobile devices. She wanted to see if there was a way that an app could be created that could help prepare and test children to see if they were kindergarten ready. One way to know if one is kindergarten ready is to be able to tell the difference between colors and to know the alphabet. The app that was discussed would help the teacher assess the child’s progress and help them understand where they need to focus learning activities so they would be ready for kindergarten.

**Nutrition and Antioxidants**

In this project, the participant was eager to learn about how certain foods can help make a person focus so that they can perform at their best. When researching focus, it was found out that foods high in antioxidants can help one to focus. The discussions involved thinking of a device that can help one monitor antioxidants in their body and let the wearer know when they should eat certain foods and what foods they should eat so they are at their best.

**Water Pollution in the Indian River Lagoon**

The participant of this project wanted to research ways that one can help the Indian River Lagoon. From sewer runoff to fertilizer contamination and physical garbage from plastic containers, the lagoon often has problems and various ecological issues happen from time to time. The project dealt with a way that one could be proactive and help monitor the lagoon to help understand where manpower and additional resources should be focused.
Monitoring Trains for Civil Engineering

The participant was interested in trains, which is part of civil Engineering. Originally the participant was going to investigate how trains are mass produced, but after seeing footage of a locomotive being constructed, it was quickly realized that trains are not mass produced like cars. Instead, they are meticulously constructed and take up a huge building during their construction. Due to this, it was decided to pivot and instead to look at locomotive construction with a focus on the train sensors instead. With the newly reimagined idea, a discussion was held about monitoring a train and its sensors and reporting that information to a central command. The central command could monitor all trains in the system and detect when trains were having issues. Utilizing Data Science, the central command could identify track issues, train issues, signal issues, and locomotive issues. This would help an operator manage a developing situation while allowing the train system to still function while the other issues was solved.

Learning Based on History

The young women really embraced and enjoyed learning about the women in history. They were all fascinated by the cards provided to them and one young woman indicated in the study that “there needs [sic.] to be women role models” then she paused, thought back to the cards, and realized that there are already women role models in STEAM, and she had never realized that until this point. She then laughed and said: “well I mean there needs [sic.] to be even more role models.” Many of the young women were fascinated with what women have already done in history. They were aware that women existed doing these things but seeing them on the Women in Science cards really brought it to their attention in way that had not been done in the past.
Steampunk

Most of the young women enjoyed the aspect of Steampunk and the Jules Vernian type art and appeal of the turn of the century. Some of the young women had no idea that this artform existed in this type of surrounding. When they noticed that a book was created entitled Steampunk Vixens, they were surprised at how much information existed on the topic. Many of the young women liked the idea of Steampunk while others were more blasé about it.

Bibliotherapy Learning Based on Fairy Tales

Bibliotherapy was introduced to the young women in the study. During Workbook Session One they were told about writing a science fiction story involving their Steampunk character and her quest to discover all she could with her chosen science project. Most of the young women engaged in this activity and wrote small stories about their Steampunk characters. Some of the young women specifically mentioned how they really enjoyed writing the story and used a creative aspect that they had not been able to use in science or STEAM in the past. They discussed how beneficial this was in the workbook activity and some of them indicated that they would continue with it on their own. Many of the young women also indicated that a prolonged engagement with Bibliotherapy and creating science fiction aka fairy tales has a lot of potential for recoding notes and remembering things. It also acts as a way of preserving knowledge. Examples of Bibliotherapy in the workbook include:

Rosalind is a marine biologist and businesswoman. Her animal companion Elliot the polar bear travels the world by boat. Their boat is a rundown cruise ship that they rebuilt into a fancy steamboat. They
decided to live on a boat, so they travel around the world and help
animals, especially sharks, because their old town has caused a lot of harm
to them (because of the stereotypes around them).

**Data Science**

Most of the young women in the study did not know what Data Science was.
After it was explained to them, their eyes lit up and they realized how Data Science can
be used to help find ground truth in data and to help let stakeholders know more about
results and need for funding or continued engagement. They were all very fascinated at
how Data Science can also be used with Math to create compelling visuals to help with
project buy in and to help win support for various efforts. Many of them were able to
relate to Data Science with their science fair projects that they do. In the science fair
projects, they use Data Science to help make compelling arguments to judges so that they
can win a placement in the science fair. One of the participants had this to say and when
one would use Data Science:

Either like on a Zoom call or in a meeting, or if you're making a
PowerPoint, or if you're making like a live diagram or model or anything,
and then finally M is for math, and once you're done using your product
and experimenting with it, you can have mathematical data to show and
prove that your product actually works.

**Vygotsky**

As part of Workshop 1, the S in STEAM, the young women were told about
Vygotsky and his thoughts about the Most Knowledgeable Other. When they listened to
the ideas of how the Most Knowledgeable Other is there to help one get past a learning block and to help guide them past the blocking issue, out of the ZPD, they were fascinated and drawn into this idea. All of the young women appreciated the idea of a Most Knowledgeable Other, a mentor, helping them to advance their knowledge.

In terms of Vygotsky and the ZPD, it was noticed that the young women did not know what Engineering was. When pressed for a definition, the definitions were vague and unnatural. The participants seemed uncomfortable with the topic of Engineering, or they trivialized the question and gave a superficial explanation of Engineering. After the young women were taught what Engineering is and how it is part of everything, they had a better understanding and curiosity about it. The ZPD of the young women was pushed beyond their normal knowledge, and through the help of the Most Knowledgeable Other, they acquired the necessary knowledge to understand the role of Engineering within STEAM. Once this was understood, the young women were able to discuss Engineering more comfortably.

**Systems Engineering**

Systems Engineering was introduced to the young women, and they were all very fascinated by it. They enjoyed listening to how Systems Engineering brings everything together to help orchestrate a project. Requirements analysis to data collection and analysis was discussed. The participants were also excited to see that one could have a career in the field. They enjoyed seeing the V-model of Systems Engineering and how it too was a framework within the Engineering discipline for accomplishing the development and deployment of a system.
Internet of Things (IoT)

The Internet of Things was a term that many of the young women did not know. Many of them took guesses as to what it was but most were unsure what it was. After educating the young women on what the Internet of Things was, they became excited about such devices and began to explain devices of their own design that would address solutions their project. Examples of such ideas are discussed below.

Internet of Things: Nutrition Wrist Band

One idea was about a wrist band that would be able to measure the number of antioxidants in the body to be able to indicate if one is eating the correct foods for the boost they intend to get. In this study, the idea was that certain foods can help one focus or help other abilities within the body. If one were going to study for a test, they could eat certain foods that would help boost their antioxidant levels to ensure they had the proper nutrition for studying. The device would give a readout and helpful suggestions to help maintain the desired levels.

Internet of Things: Drone Duck Boat

This concept was a drone boat for water pollution. This drone boat would be able to collect water samples and perform some basic analysis of water. It would be able to report these results to the internet and store them somewhere so that the data could be analyzed, and Data Science could be applied to understand trends and concerns. The drone would also record everywhere it had been and take pictures. Additionally, the drone would look for large deposits of garbage within the water system such as cans, bottles, plastic bags, and plastic bottles. The device would send data to the internet to help alert people as to areas where intervention would be needed. This drone would help
create a realistic picture of what is going on day to day in the waterway and constantly report findings to interested parties so that they could formulate actionable plans to address issues. Additionally, the constant water sampling would help see if there are any correlations to intensity, change, and events that occur.

**Internet of Things: Obsessive Compulsive Disorder, and Virtual Reality**

As discussed in the Systems Engineering discussion, the OCD project would be able to use Internet of Things gadgets and gizmos that can report activity and movement within an area. This would help people afflicted with OCD to better understand when and how often certain objects were touched and moved such as brooms, mops, and buckets. Virtual Reality would be used to assist with understanding OCD.

**Internet of Things: Electromagnetic Fences**

Electromagnetic devices would be created that could be connected to buoys or nets that had the ability to create a harmless field that a shark could detect. The sharks would sense these signals and would swim away from them, thus preventing them from getting caught up in fishing nets. The nets could also have cameras and other sensors on board to help report the populations of sharks in the area and to indicate if the technology was effective at keeping sharks away from the area where the sensors are installed.

**Internet of Things: Animatronic Dresses**

This project was about building an exciting and fun dress that was decked out in technology. The dress could light up and move its fabric around using small motors built into the dress. The animatronics within the dress could perform choreographed moves and synchronization to create a stunning dress for the world to see. The dress could
report its statistics to the cloud and could also pull down new programs and weather
reports from the internet so it could help one for the day.

**Internet of Things Education: App for Phone or Tablet**

An app would be built for Android and Apple devices that would allow a VPK
child to assess their progress with learning the alphabet and colors. The app would
provide real time feedback and allow the teachers to understand what to focus on. The
app could also report statistics to the internet so that the information from several apps
could give valuable insight to how the students across the country are learning.

**Internet of Things: Locomotive Sensors for Civil Engineering**

Locomotives are huge strong machines that traverse the world everyday
delivering packages and cargo on the rails they ride on. Sensors can be installed on a
train to help monitor the health of the train and the various instrumentation. Alarms can
be set to detect a buildup of pressure, temperature, and efficiency. The onboard devices
can report this information to the cloud so that there is situational awareness for the train
and its health.

**Internet of Things Infectious Disease Tracker**

This Internet of Things device would either be a Fitbit watch or a device like a
Fitbit watch that would monitor the vital signals of the person wearing it. The device
would collect pulse, blood pressure readings, and temperature and report this information
to the internet. The data would be routed to a processing group that would record the
statistics collected. The system would be monitoring thousands of wrist-like devices
across the globe and would report when it detected a cluster of devices in which
characteristics of a viral infection was detected within the population. This would allow for swift action to help stop the spread of a disease.

**Scrapbooking**

The study utilized aspects of scrapbooking, which was detailed in Chapter 2. By combining scrapbooking and learning science in informal spaces, the young women were able to engage in the activity and find it a fun and rewarding experience. The interviews showed general excitement when it came to creating the workbook (Moyer, 2015; Moriwaki, 2012).

**Textiles and Puppets**

The puppets that were used in the study were also a great success. The idea of puppets came from my own background of a liking of stuffed animals and puppets. The young women all embraced the idea of their puppet and enjoyed collaborating with them. The young women named their puppets Gale, Scott, Elliot, Thunder, Cheshire, and Rose, to name a few. Figure 5: Meet Gale, introduces Gale as one of the sidekicks in a workbook.
The following text is of one of the participants writing about her Steampunk character’s adventures in STEAM. This part is when the puppet sidekick was introduced.

Figure 6: Excerpt from Katherine's Workbook Regarding Scott the Sidekick, shows the story written by the participant. The story is rewritten here. The participant wrote:

Scott is a fairly young wolf living in a forest not too far from London. He meets Katherine when she is taking one of her daily walks through the outskirts of the forest. She is looking in her journal filled with her observations from her excursions from the previous night when he spots her. Both his acute lankiness at that moment and his curious nature draw him to her. When she looks up, she is momentarily startled by seeing a wolf staring back at her from a few feet away. She politely says hello and is surprised to hear him reply. They introduce themselves and get to know
one another, by the end of their conversation they have come to know a lot about each other. She tells him what she’s been up to, and he asks if he can tag along to which she replies yes. From then on, they are inseparable.

Figure 6: Excerpt from Katherine's Workbook Regarding Scott the Sidekick

The young women found working with the puppets fun and exciting. Many of the participants sent pictures to the researchers of their various puppets doing things such as cleaning (for OCD), eating (for nutrition), building (for civil Engineering).

Thoughts About Men and Women in STEAM

One of the questions asked to the young women was: some say that STEAM fields are predominantly geared towards men. What are your thoughts on this topic and does it dissuade you and why? The answers that came back from the participants were quite exciting. Most of the young women said that they could see how people have that perception, but they saw it as a challenge, and will go into STEAM and prove that it can be done. They believe that women are strong and just as smart as men and they can do it. This attitude was extremely exciting to see because it fell in line with the whole idea of
Rosie the Riveter and the tag line “We Can Do It!” (Milgram, 2011). The participants words were:

Like I when I first thought of steam as a girl, I did not know what it meant, like at all. I just thought steam, like maybe out of the air or whatever, like steam like that. But then. Once I realized what it was. Yeah, but men probably already know what it means. 'cause they were, they're probably like, been taught about it before we even did. So, yes, geared toward men, I would say. But it doesn't mean we can't learn more about it and it. It just means that maybe boys might know more, but that doesn't Mean Girls can't learn it.

Another participant supported Rosie the Riveter’s stance on this question:

Um. I think actually it would make me want to be in steam even more because it's challenge more of a challenge. 'cause, you're like I'm the only girl I gotta represent, you know?

Someone else in the study stated that they would be more motivated to do it:

Well, I feel like it's probably true, but it doesn't dissuade me 'cause I feel like. That would make me wanna like do it more.

How Would You Get Women Involved In STEAM?

The researchers asked each of the participants question Q6A which was: Explain how you might change things to make women more eager to join STEAM fields. The following are portions of their responses.

Participant 1:
I don't know. Maybe. I have no idea. I don't. Here. Maybe having like teachers explain it in a more interesting way 'cause whenever I've learned about it or like then it's been introduced on like my teachers and stuff. They don't really make it very enthusiastic, so nobody wants to listen.

Participant 2:

Um I feel like we don't really like in the media and stuff like what you're surrounded with and everyday life you don't really see a lot about steam. So it's kind of like You don't really really know all about it. I think a lot of women have with their certain idea about what STEAM is, that isn't Necessarily what it truly is. Usually when you think of steam you think of Male-dominated you know I think also just. Having more examples of women in STEAM Would i think definitely encourage like younger girls. Look more into it and having more. Activities and More information out there for people who don't know. Yeah. ... Maybe like. like a lot of people start social media pages. So like i feel like if you had someone. I don't know how to word it I don't have the full concept in my head that i can feel. If you had something that was more like. Art like using the art of something till like draw people in. like gradually add more things to it Make it like fun to learn about STEAM.

Participant 3:

Probably tell them more about STEAM. I didn't know what it was and I believe that some woman. I Haven't seen or know about STEAM and know what it is. Because nobody has been talking about it like. I've
never heard one person say. My school at least anything about steam except. Boiling pot of water washing machines. Go. No one talks about it.

Participant 4:

I feel like you could like introduce it at a younger age. When I was younger, I went to an elementary school where we had STEAM workshops used to go to when that whole thing but i feel like right now it's very worse. Because they need. They're trying to make you feel like it's an equal field and all that and it could be a quite possibly it could be what the problem is now is that. And i feel like this whole thing is just like forced. The big block lettering for second grade and it's the steal if you know all those texts things. And the other thing too is a lot about art and boring in the way things look but aren't also relates back to.

Participant 5:

Well. Um. I know a lot of like girls like to be creative and express themselves. So uhm. Just giving them small projects and like kind of like many things to do for each part of steam and they get to just feel free to do whatever they want to do or if they feel like they would like to do with it and maybe that will get them like interested and it would be like, Oh yeah, I remember. Yeah. I wanna do this 'cause. I remember I was able to express myself. And because of that. Corrected that. Oh. I don't really know. Like I like to do a lot of things like each thing individually and separately. So uhm, I don't which, like most people, I feel like go to the
arts, so maybe something from arts like dance or plan to make their own music. Like, oh, that's. I just bought something while I was talking, like on the computer. That would be like technology and arts, like making their own music on the computer.

Participant 6:

So I would definitely use something in this way instead of just assigning science projects in school, making it mandatory. I would almost kind of give someone maybe like a journal and basically starting at a younger age because when kids get to like an older age is about like what's fitting in. And like, typically we have all these, like, stereotypes in schooling or like. Women become like nurses, and they'll become like bakers and things like that in the men will go into more of this field if, like that's just kind of a stereotype. That's kind of almost for. In workbooks that kids get where they see the men doing that area and the women doing the other area, but I feel like just starting at a young age we should embrace like everyone in this same area where anyone can do anything no matter like what and just kind of starting at a young age would definitely be it. And then maybe doing or making it more entertaining like the workbook, more colorful maybe, like videos. Just things that make it more fun for kids that they actually want to like grow up See themselves working in a lab for fun instead of like wanting to be like an astronaut or crazy thing to like. Kids say like a Princess or anything, and P kind of like making signs, a wow factor at a young age just as much as being like a famous person.
Participant 7:

In high school to give women a different outlook on STEAM so that they have some of these slots that you now have. Um, yeah, definitely. I mean. High school is kind of just. Boring. It's like always, just like worksheets and stuff like especially in like my math class like my I have one science teacher and he's great and he like we do labs all the time and I just definitely like, he's a teacher who made me realize I like science so much. It's like, definitely like. We do senior projects at my school so you can like, it's like a community service project that you have to do when your senior and so like you can pick like the AP research class like the regular class. And then there's like science research. So I did science researchers 'cause I heard it was the easier path and I started doing it last year just so I had like, a hang on things of what I was doing. And I actually really like it. And I'm in it this year and it's like my favorite class. And then I have him for another class in that class. We just do labs all the time. It's so much fun. 'cause. It's like I'm definitely a visual learner. So like. And I feel like a lot of people my age are also visual learners just because we've grown up that way, especially with, like all the new technology and stuff, just reading stuff on black and white paper, it's just so much more like boring than watching a video or doing something hands on. And it's like my like kids my age, just learn better that way. So like doing labs and stuff like that instead of just doing, like, math worksheets. It's just like, makes learning so much more fun, especially with like steam classes. It's like I
feel like if more teachers did like hands on stuff, but I understand is like slightly harder to do in math, but 'cause, like the science, there's like labs and like chemical things that you can do where you're like, physically doing a lab. And then in math, it's like a little bit difficult 'cause you have to learn formulas. But I feel like there's like videos and instruction that could be like not just on pencil and paper where it's. Yours doing worksheets. Yeah. And like that goes for men and women too. But I mean, like, women specifically, I feel like women are more like. Not more creative than men, but they like more colorful, like glittery stuff. Like I like that just makes like a little bit more sense. Like, I feel like especially with me like, I definitely like more colorful and glitter E like stuff like I have an opportunity to make a project. Blurry and colorful. I'll do it. I enjoy doing it so. Yeah, that's like the same thing with the workbook like it's hands on and like I can decorate it the way I want to and it's like fun to do.

Participant 8:

I'd probably try to limit or change the stereotype that steam is more focused towards men, because for some people it might be like a determination kind of factor. Like I can get in there and I can. Do this because I'm just as capable. But for other people, it's like. It's kind of destructive of the idea. It's like it's such a male dominated field that it would be more difficult for me. And like it's a big it's a bigger challenge than going for something. … Well, with a lot of. Like women going into
steam. Trying to change it, I would probably try to like. Showcase more of the women who did go into Steam talking about the like steam, why they went for it, why they enjoy it, and how it's not necessarily such a male dominated field because women are just as good as men.

What did you think of the workbook idea? Participant 8:

It's I like doing things like on paper. Because not necessarily like keeping everything just out like in your head. It's not always as easy as having everything written down, so you can like look at it, go back through it. See connections between different things like being able to do something creative on paper. It's always been something that would like help me because I'm more like artistic. I like drawing and painting, doing stuff. On paper creatively.

Did the workbook help with goals? Participant 8:

Yeah, 'cause. I've usually been like a. Like immediate response kind of thing. Like if I set a goal I wanna get it done. I wanna work on it and like succeed in my goal in a shorter amount of time. But like with the workbook, we've been doing the lessons like throughout. All these different. Times like so, you slowly build on it overtime. So it's like seeing the bigger picture instead of like. Setting your goal and getting it done as soon as possible.

Participant 9:

Um. Well, I think. If we can just get a few women to join STEAM fields, then it will kind of have a domino effect and like the more women that
joined, the more we want to join because it's not such a male dominated field. Jobs or whatever 'cause I know now. There's times where it's only one woman ton of men, and it kind of just discourages me because. If you wanna show that you're good enough at the same time, your ideas can be completely tossed out the window. So say something like fashion design. I think that looking kind of like means that and like. Just maybe explain this thing isn't how that certain thing really sustained, because I think that anything else are compatible in some way or another. To steam, so like fashion like there's like, let's the art. You have to have math like and measurements and like how big you need to make something the engineer. I mean I don't really know if someone is considered Engineering, but I think in a lake would be. And then technology, just how sewing machine works, how you can use it to build that and. Well, I don't really know how you would do that for like everyone, but I know like if I have friends or something that are interested in something, maybe I could find a way to really get to see if you wanted to be in STEAM in general.

Participant 10:

Well. I'm not sure if I would change much.'cause I feel like. The fields just something that like you either are interested in or you aren't. Maybe. Get more information out about it.

For this part of the conversation the participant and the researcher were discussing things that could be done to make STEAM more fun an appealing. There was talk about adding cool things to the room and making things interactive. Participant 10:
Make it look appealing. … Well, if you're using like posters or something you could use like lots of colors. And. Just make it like. Match and Look Cool.

What if we gave you $100,000 to design the room?

Put expensive stuff in it.

There you go. So, you want to make it attractive? Participant 10:

You could have a cool door that people want to walk through like one of those skinny doors. … I would just have like tables out. Maybe like? Like information and like interactive things like you have to like click stuff To get information from it. I think that would be interesting to people.

On the topic of cool things, the researcher mentioned that recently they saw an exhibit in a war museum that used mannequins. The researcher asked what the participant would think of that. The idea of using mannequins to show women partaking in STEAM fields. The idea of also using historic mannequins was conveyed in the context. Participant 10:

I feel like having the mannequins set up toward you so you can like see them, like, see them for yourself. Feel more inclined to like to learn about it, especially if you can relate to them.

Participant 11:

I would say I was exposed to it around 6th grade or like fifth grade. I know that my mom wanted me to do some type of club or something over the summer because that was before I was allowed to do online schools during the summer and. I think we're talking about doing a coding club
once because I'm really into gaming and stuff like that. So like I play Minecraft and I like to build different things and I guess just going down that tract and being able to pick apart the different things to be able to put it back together was intriguing to me. So like I did a lot of. Little coding games and I did a lot of like building the robots you seen like the kids at the store or like stuff like that. So I'm doing a lot of hands on stuff was kind of helped me stick to that kind of thing. And how I did learning about it so yeah. … Well, it's kind of hard to like say it in like if you were in a friend group and trying to get them to do it, but like in school settings, I guess setting up a club and being able to spread the word about it to try and get people to come. Like school rallies and stuff like that would be a good way to set that kind of thing up, because you'd be able to show off what you're doing a little bit more. And I know that. Grabs people's attention. But I would say it really just depends on what they are interested in and how you can apply. What they're interested in in Steam to see if they can take that connection and kind of involve it with it.

The result of the conversations with these young women gave a glimpse into their realities and lots of ideas emerged.

**Research Question 3**

1. How does working on the STEAM workbook help young women understand or see potential career opportunities that they might not have known about?
During the various interactions during the three workshops, the researchers discussed with the participant ideas and thoughts about careers and fields of study. During various discussions, a career or field of study was mentioned to peak their interest. In workshop three, the participants were directly asked about a field of study and career. This question when asked illuminated the ideas and thoughts that young women are forward looking and are planners. Each of the young women seemed to have their life, or at least their next few years, laid out before them. Two of the participants indicated that they would go off and get jobs straight from high school. The jobs they would pursue would be an airline attendant and a retail worker. The young woman who indicated that she would become an airline attendant is doing this to help save up money to help with family, school bills, and other such expenditures. The young woman who wants to work in retail is choosing to do so to also save money. Her career plan involves working for a few years to save up money and then to pursue a degree in art. In the case of this participant, the revelations of STEAM and how it may apply to art was fascinating to her. She now realizes that art is part of STEAM, and this can open doors in her life that she had not considered. The conversation that took place discussed ideas of utilizing art to help scientists draw up some concepts that need to be documented. Other discussions included talking about creating museum exhibits and apps that all utilize art. The conversations allowed the participant to now consider STEAM or at least get a minor in a STEAM field to augment her skills in a way she had not imagined. Another young woman discussed how she was going to be a lawyer and then, after working on the workbook, added that she might consider becoming a forensic scientist. Her thoughts about a career in Workshop 1:
I get a bachelor's degree first. Then I would go to law school. I really know I want to be.

Her thoughts on a career in Workshop 2:

Another thing I like. I forgot about I like forensic science too. Do stuff at crime scene. Like figure out what happened. What happened like how the situation played out? Blood splatter was there a struggle? How someone got stabbed? You figure out life. If they were using. Defending themselves throw up running away. If they like showed signs. Struggle. Stuff like that.

One by one the researchers asked each participant about the careers they plan to go into. Various answers emerged from the group. Some of the careers mentioned included: Artist, Model, Interior designer, Actor, Marine Biologist, Educator who can write apps, Food nutritionist, Veterinarian, Medical Doctor, Engineering Architect, Lawyer, and Crime Scene Detective. Most of the women barely had a working definition of salary. They knew salary was important, but the numbers shown were not necessarily meaningful to them. This made sense because money does not really have an effect on one until one has to operationalize money such as paying bills and acquiring things. The young women were fascinated at the different salary ranges and will consider the larger impact it may have on their life. Now that the young women have a better understanding of STEAM, some of them may make some life changing decisions regards the fields of study they may pursue based on career and salary.
Hawthorne Effect

The Hawthorne Effect is recognized as participants in a study behaving differently when they are observed versus when they are not (Bracht & Glass, 1968). The traditional example of the Hawthorne effect dealt with factory workers being more efficient and producing higher yields when researchers, aka observers, were present observing the employees working. In this study, there was a small aspect of the Hawthorne Effect but in the opposite direction. When the initial interviews began with participants and the researchers, it was noticed that some of the participants were shy. To combat the Hawthorne effect, in this case, the shyness, the researcher utilized the puppets named Harry and Victoria to help break the ice and make the interaction more open and fun. The puppets worked as a great icebreaker and helped the participants to see the study is fun. The use of puppets itself was an unexpected and emergent interaction that came about. Originally, the puppets were being used to help facilitate interactions and work on the Steampunk workbook, but the additional outcome of the participants becoming more lighthearted using Harry and Victoria really helped to open the participants up and talk more. The puppets were also used to help with communications between the participants. A picture of Harry was sent to participants to help set up study times and to also remind them of established appointments. It was noticed that when the researchers texted a young woman with just text, often a response was not received. When a message was sent with a picture of the puppet Harry, the participant seemed to respond to the text message.
Trustworthiness and Credibility

The provided narratives expressed in the results have been carefully curated, coded, and analyzed to maintain trustworthiness and credibility. The results provide insights in the young women’s thinking regarding STEAM as well as various careers they would consider. To maintain the trustworthiness and credibility of the research, the following actions were performed, as described below.

Trustworthiness: Truth Value

To ensure truth value, genuine and authentic work took place in recording and capturing the thoughts and emotions of the participants in the study. Member checking was utilized to ensure the captured data accurately reflects the thoughts of the participants (Guba E. G., 1981).

Trustworthiness: Applicability

Findings that are discovered are relevant to the activities that the participants engage in. Discoveries and notes were taken as timely as possible to prevent the decay of idea or thought. Thick rich description was captured to ensure the emergent ideas and thought patterns were collected correctly (Guba E. G., 1981).

Trustworthiness: Consistency

This was maintained by providing sequences of events that took place in the study so a reasonable person can see the clear intent of the process (Guba E. G., 1981). All the participants were given the same questions to answer. The workbook itself offered consistency because each participant was given a replica of the workbook. It was
presented in a specific way and came inside a kit that was prepared in the same manner as everyone else’s. The study can be repeated because the interview questions can be asked to new participants, and they can follow along with the workbook. Some of the interviews were also observed and constructive comments were taken into consideration.

**Trustworthiness: Neutrality**

This was done by removing bias as much as possible and letting the data speak for itself without the need for or interpretation of the researcher (Guba E. G., 1981). The researchers behaved in a similar manner for each participant and remained neutral on the topics the young women chose.

**Credibility: Persistent observations**

Constant observations were made by all members of the research team. The inquiry showed that enough time was spent observing the workbook creation and allowing for the naturalist inquiry to express itself and to be captured (Guba E. G., 1981). Video recordings of the interaction were available so that the researchers could look back at the video and ensure the information was genuine. The video also captured the facial expressions and body language of the participants, which helped to identify if they were excited or not by the topics being discussed.

**Credibility: Peer Debriefing**

Ideas and thoughts of the study were shared amongst the researchers to find the truth. The peer debriefers, the researchers and assistants, acted as a jury to ensure the logical thinking and that parts of the study were sound (Guba E. G., 1981). Before the workbook kits were distributed to the participants, a trial run was conducted with the
researchers. They received a complete kit for the workbook and were able to experience what the Steampunk journey was like for themselves. They provided helpful feedback, which was incorporated into the workbook kits and study.

**Credibility: Triangulation**

This was performed by examining several sources of data such as the interviews, journal notes, memos, the workbooks, observations, member checks, peer debriefing, and peer observation. The different methods were pitted against each other to find the truth in the data (Guba E. G., 1981).

**Credibility: Member checks**

The researchers reached back to the participants and asked if some of the items that had been collected provided a reasonable check and balance to what was observed. Word Clouds were produced and then shown and discussed with the participants. The participants were debriefed on how the Word Cloud was produced and they were given an opportunity to discuss the Word Cloud. All the participants agreed with the captured insight of the Word Cloud and the discussions surrounding the participants’ thoughts and topics. Various parts of the conclusions were shared with some of the participants, and they agreed with what was found. Member checking validated the notes that were collected to adequately capture the observation (Guba E. G., 1981).

**Credibility: Focus Group**

A focus group was performed where the participants were asked similar questions to those they were asked in their individual interviews. The group of young women
repeated statements collectively that matched statements collected from the individual interviews (Charmaz, 2006).

Credibility: Purposive Sampling

An essential part of grounded theory and of qualitative research is to formulate and follow a framework for arriving at ground truth and subsequently grounded theory. To this end, various research papers were consulted to choose the best framework and attributes to achieve the end goal. This population was specifically chosen to yield the result that would help answer the research questions (Charmaz, 2006; Guba E. G., 1981; Chun Tie, Birks, & Francis, 2019; Patton, 2002).

Credibility: Constant Comparative Analysis

As each participant was interviewed, the researchers were able to review notes from the previous participants and draw up some ideas and new thoughts about the holistic picture that was appearing within the data. Constant reflection on the data along with memoing helped to keep track and focused on what was emerging from the data. This allowed for theoretical sensitivity and the ability to perform theoretical sampling too (Chun Tie, Birks, & Francis, 2019).

Salary

Most of the young women in the study did not know salaries of working adults. This was not a surprising revelation but when the participants were walked through the various salaries of STEAM fields, many did have a realization of its possible effects on their lives. They were able to take away from the experience that they should understand some of the results of the paths that they may choose after high school and college.
Emergent Themes and Framework

The emergent idea that came out of this study was a new framework and acronym that one should consider when designing STEAM projects for young women. The framework is as follows and was designed from the emergent themes from the study. All the aspects discussed were important to demonstrate that the study remained authentic, credible, and trustworthy. To this end and as described above, the following theoretical framework emerged from the study. The framework entails prepending a new acronym to the front of STEAM and this acronym is directly geared toward young women but most likely could be generalized for young men too.

DRESS FOR STEAM

When analyzing the data from the study, it was apparent that various divergent themes were emerging. Due to the nature of the study, it was seen that the insights that the young women were giving would not comfortably fit into one generalized aspect unless those emergent ideas were considered a framework to capture the emerging thoughts. When coding the data and looking for these between all the participants, several themes kept coming up repeatedly. They themselves were being expressed in different ways from one participant to another but when one looks holistically at all the conversations and the various thoughts about STEAM, a larger picture was being created. This picture was a new framework that is specifically tailored to women in STEAM. Themes that kept emerging were things such as design, relate, educating, scrapbooks, social media, forward looking, options, and role models. These themes all were important, and all the young women were saying the same things in different ways. After much thought, it was realized that instead of a single emergent idea, we had discovered
an emergent framework that needs to be added to STEAM. This new framework encompasses everything that the young women were saying is a fun way to express what was learned. The new framework is DRESS FOR STEAM. Table 8: Theoretical Framework DRESS FOR STEAM, details the breakdown of the acronym.

<table>
<thead>
<tr>
<th></th>
<th>Theoretical Framework DRESS FOR STEAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Design</td>
</tr>
<tr>
<td>R</td>
<td>Relate</td>
</tr>
<tr>
<td>E</td>
<td>Educate</td>
</tr>
<tr>
<td>S</td>
<td>Social Media</td>
</tr>
</tbody>
</table>

**D (Design)**
The design of any project must be exciting and address the interests of the young women.

**R (Relate)**
The experiments for young women need to be relatable for them. One cannot design a project with the notion of one size fits all. Instead, one needs to realize that the project needs to be flexible and customizable to the interests of young women individually and not as a whole.

**E (Educate)**
Going into the study, there was an impression that the young women already knew what STEAM was. It was surprising to find out that most of the young women in the study did not really understand what STEAM or STEM was. They had known of the letters but did not know what was behind the letters and what they represented at a deeper level. After working with the young women and educating them all on STEAM, they understood deeper what it meant and what it means to them.

**S (Social Media)**
Social Media utilizing interactive platforms such as Instagram, TikTok, and YouTube would be helpful to entice and engage the young women. It is a tool that is already part of their “backyard,” which is something they are already eager about and familiar with.
All of the young women in the study enjoyed working with the scrapbook. They were drawn to the excitement and really enjoyed working with their hands and gathering thoughts and ideas together in a book they were in control of. They enjoyed the freedom and free nature to explore however they wanted. They even expressed that they would enjoy doing a scrapbook/workbook for a prolonged period of time.

Surprisingly, all of the young women who discussed their future plans had already made up their minds, at least at the start of the study, of what they want to do when they graduated high school and college. This indicated that the young women had been planning for a while and thus forward looking at their life, plans, and careers.

Young women enjoy having options and deciding things that they are interested in. They would like the freedom to choose for themselves what they would like to do.

Young women and women need to be thought of as part of the norm. We need to make women doing things a part of normality and not just blindly celebrate monumental achievements. For example, a women president should be thought of as a normal occurrence and not some huge historic event.

Science, Technology, Engineering, Art, and Math
Design

One commonality that existed between all the participants was the design of future workshops. They clearly indicated ideas that would make interacting with young women much more successful. The ideas conveyed was early intervention, prolonged engagement, fun, entertaining, enthusiastic, and project based. All these thoughts and ideas deal with the design of a study. The more appealing one makes the study the more opportunity it will succeed.

Relate

As the study was conducted one was able to see that the young women were very chatty and excited to discuss topics that they could relate to. The experiments for young women need to be relatable for them. One cannot design a project with the notion of one size fits all. Instead, one needs to realize that the project needs to be flexible and customizable to the interests of young women individually and not as a whole.

Educate

One of the insights that emerged from this study is the realization of that many of the young women do not know what Engineering is. This revelation came about through the various discussions held with the young women and their lack of knowledge when discussing Engineering. When one thinks of the exposure one gets in school one, can see that from an early age, there is an emphasis on Science, Technology, Arts, and Math. When one looks deeper at classroom activities and instruction, there is very little mention or formal instruction of what Engineering is. Another aspect is that of the science fair.
Young women are encouraged to join the science fair but unless they specifically choose an Engineering project, they are not exposed to Engineering.

In the original pilot study, one of the young women specifically told the researchers to not focus on Engineering. At the time, this seemed like an odd thought. The thought was written down but was not investigated further. At the time, the young women said that Engineering is stressed enough and does not need to be explored. After interacting with many of the young women and realizing they do not know what Engineering is, one can only speculate that the thought of not focusing on Engineering is due to a concern of not understanding much information about it. After being educated on STEAM, one participant said the following:

I understand the concept of steam more a lot. More than I did before this.

I got to see the manufacturer of Trains. I understand more about it. I like it a little bit.

Another participant had this to say:

So Steam is an acronym. That kind of encompasses a large like array of topics or meals. And there's science, technology, Engineering, art and math. And you can not like apply them to pretty much anything. Like, science kind of helps us figure out what's going on behind the scenes. Helping work technology helps us. I mean we can, it helps to record or like visualize things. Engineering the hearing out the process. Everything. Art making things look pretty and now. Like showing all the data.

One of the participants described STEAM as the following in the first workshop:
STEAM is just like. I don't know like a science program like how I describe STEM. OK. Well, I know what they are, but I don't really know what the purpose is.

The same participant gave this description of STEAM in the last workshop:

Well, I understand the concept of STEAM more a lot. More than I did before this. And I learned about, manufacturing trains. So. I mean now that I understand more about it. I like it a little bit more now. But I'm still not sure if I'd wanna pick up a career in STEAM. … I mean science and technology work a little bit hand in hand. Considering. But like you used science. It's like make the technology. In the technology like helps you figure out. [Engineering] is used to like to put it all together. In art would be like. How do you put it together in like the most? And then Science. Those both work together too. Yeah. [How does the math help?] It helps you figure out like how much. I know how to do it. I could. Just help, looks like this is just.

Scrapbooking

As mentioned in the literature review and in the study methods section, young women are excited with projects such as scrapbooking. In this study, no one rejected the idea of the scrapbook. They all seemed genuinely excited about it and wanted to work with the book. This spoke of many positives about the workbook such as a way of remembering their journey or ways that they can document what they learn. They talked about how they love to write in color, and it gives them a chance to make their notes look all pretty. They loved the idea of cutting out articles and things that they see and pasting
them into the scrapbook. A scrapbook can show and demonstrate one’s lived experience.

One of the participants said the following:

Not more creative than men, but they like more colorful, like glittery stuff like I feel like that just makes like a little bit more sense like I feel like, especially with me like I definitely like more colorful and glittery like stuff. Like if I have an opportunity to make a project. Glittery and colorful. I'll do it. Enjoy doing it so. Yeah, that's like the same thing with the work book like It's Hands on and like I can decorate it the way I want to. And it's like fun to do. … Like that doesn't go on a Saturday and like build a bridge like I don't know why it just doesn't sound like very fun to me. I don't know and I feel like most girls are kind of the same way like I feel like a workbook is definitely more like. Interesting to girls like oh I get to make a little sketch with pictures and stuff in it. Yeah yeah, definitely understand what that the workbook came about.

One of the participants talked about how scrapbooking helps with expressing the A in STEAM:

People like Scrapbooking is a good idea or like getting it in a way of like arts or like.

Social Media

Social media and scrapbooking almost go hand in hand these days. Platforms such as TikTok, Instagram, and YouTube provide a digital representation of pieces of people’s lived experiences just as scrapbooks do. Virtual reality and augmented reality is beginning to be seen in our urban landscape around us and it is most likely the next area
where people will come together and share ideas. The young women enjoyed the videos that were shown to them in the study and the idea of making short videos (where the time duration is 30 seconds to three minutes) was very appealing to them. The emergent idea is for the young women to make videos of each other doing things such as working in labs and doing STEAM related activities. As their friends see these videos, the young women in essence will become role models. The role model will be of an everyday person one can relate to who is having fun with Science, Technology, Engineering, Art, and Math. Additionally, videography is also an art. This next quote from the participant highlights how social media can help with creating role models.

…And then maybe doing or making it more entertaining like the workbook, more colorful, maybe like videos. Just things that make it more fun for kids that they actually wanna like grow up an See themselves working in a lab for fun instead of like wanting to be like an astronaut or crazy things. Or like kids say like a Princess or anything. It be kind of like making science a wow factor at a young age just as much as being like a famous person.

In the study another participant discussed how social media could be used to help draw people in; to make it more fun and approachable:

Maybe like? Like a lot of people start with social media pages. So like, I feel like if you had someone. I don't know how like. I don't have like the full concept in my head, but like I feel like if you had something that was more like. Obviously like using the art of something to like draw people in and like. Gradually, like add things to it, so then make it look fun to learn
about. Like, I don't know how to. Articulate what I'm trying to say, but
like making it. Looks more like fun. I don't know how to explain it.

**Forward**

Surprisingly, all the young women who discussed their future had already made up their minds, at least at the start of the study, of what they wanted to do when they graduated high school and college. This showed that the young women had been planning for a while and thus had formulated thoughts and perceptions about STEAM without knowing what STEAM was. Knowing that many of the young women did not know what STEAM is and that they had already planned out their futures was a bit disconcerting and jarring to the researchers. It showed that earlier research is correct that there needs to be intervention with the young women much earlier in their lives, so they know and understand what STEAM is. One of the participants discussed that STEAM should be taught and engaged in elementary school and continuously throughout their school. A forward-looking prolonged engagement would be one way to help expose and help young women consider fields in STEAM. The following text is from one of the participants who was talking about their idea about early engagement:

So I would definitely use something in this way instead of just assigning science projects in school, making it mandatory, I would almost kind of give someone maybe like a journal and basically starting at a younger age is when kids get to like an older age is about like what's fitting in. And like typically we have all these like stereotypes in schooling, where like women become like nurses and they'll become like. Bakers and things like that and the men will go into more of this field. I think that's just kind
of a stereotype that's kind of almost for. In workbooks that kids get where they see the men doing that area and the women doing the other area, so I feel like just starting at a young age, we should embrace like everyone in this same area where anyone can do anything, no matter like what and just kind of starting at a young age would definitely be it. And then maybe doing or making it more entertaining like the workbook, more colorful, maybe like videos. Just things that make it more fun for kids that they actually wanna like grow up an See themselves working in a lab for fun instead of like wanting to be like an astronaut or crazy things. Or like kids say like a Princess or anything. It be kind of like making science a wow factor at a young age just as much as being like a famous person.

The next participant showed that she had really thought things through. She understood that she may need to support herself and save up for college without taking on debt (student loans). She has formulated a plan of how she intends to navigate life:

Still the same thing when I finish school I'm going to work for a while save up money. And then maybe like an apartment or something on my own. Then I’m going to do Community college and get the basic degrees. And then I want to do and university after that. Relating to our I still don't know what exactly I want to do but anything art-related that's what I want to do.

**Options**

Throughout the workbook adventure, one of the emergent messages that came through is that of options or choice. The young women resounded to the idea that they do
not like being boxed in and they want projects where they have more freedom to explore their own interests. If freedom to explore needs to be narrowed down, then they would be happy with having options or choice. In the conversations with the young women, a lot of them agreed that they did not like walking into STEAM activities and having to build a bridge or a robot. One of the participants did enjoy the idea of a battling robot but everyone else would prefer an activity that would be more or less of their own design or one that catered to interests of women. The participant said:

Oh well that was the other thing. In school you have to have certain things you have to do in the project. So being able to have the creativeness come out and like being able to do what I wanted to do and not having certain guidelines to follow I really like that. So to write the story I had a lot of fun with that writing the story because in school we don't really have any time for that.

About Steam Workshops, the researcher asked what could one do to get women more excited about it? The response was:

Things people had to build it was more towards guys. They could have it as you could build what you wanted instead of having to build a specific thing.

**Role Models**

When talking with the young women, it was realized that they seek more role models within STEAM careers. One of the participants pointed out something remarkably interesting. This participant mentioned that she would like to see STEAM careers being more normalized and that everyday people should be setting the example.
The young woman was not excited about making too much of a big deal about women obtaining certain achievements because it makes the action less normal and therefore a perception of it being unachievable. An example she gave was that the first woman president should be normalized and not be this important thing everyone is after. If it happens, it happens, but by trying to make it happen, society is putting an expectation out there that puts pressure on the person doing this. Another way of saying it is that by putting all this pressure on young women to be the first, it may discourage them or turn them away from pursuing the position due to the heightened spotlight that would be on it.

Another young woman in the workshops said that if society were to get more women to join STEAM careers it would have a domino effect and more and more women would get involved. She said:

Well, I think. Just get a few women to join. Steam fields, then it will kind of have a domino effect and like more and more women might join because it's not such a male dominated set of Jobs or whatever. cause I know now. There are times where it's only one woman, like a ton of men. It kind of just discourages you because. If you wanna show that you're good enough at the same time, your ideas may be completely thrown out the window because like it's something.

Another participant said:

I would probably try to like showcase more of the women who did go into steam talking about they like steam, why they went for it, why they enjoy it and how it's not necessarily such a male dominated field. Because women are just as good as men.
The next participant said:

Uhm, I think it's definitely going that story like way long ago that we can't really change it like this. So it's gonna be like a reoccurring problem. People go back to like Civil War area times where like the women were at home tending to the children where the guys were at war. Kind of that area where that was just something that America started with. And like we can't delete the past. So I feel like it's always gonna be like a reoccurring problem. I definitely think that we can encourage women to kind of be the creators for things, and I think that's definitely happening in the world. We're just not really seeing it. Some people aren't really seeing it as much as they should, but there are definitely women in the field that are getting out there and creating new things just as much as men are now. I think it's just kind of been hidden. People are kind of relating to an old stereotype that was created hundreds of years ago. But I definitely think that we could change it by just kind of informing people on like the women in the area that are doing that, but also not making it a big deal.

STEAM

The Acronym of STEAM which is Science, Technology, Engineering, Arts, and Mathematics.

DRESS FOR STEAM Coding Example

To demonstrate the use of the framework from Chun Tie et al. (2019) Table 9: Example of Theoretical Framework Development, shows insight on how the emergent
theory came to be. The example shows how initial coding fractured the data, Intermediate coding extracted core categories, and finally Advanced Coding revealed the themes within the data.

Table 9: Example of Theoretical Framework Development

<table>
<thead>
<tr>
<th>Initial Coding</th>
<th>Intermediate Coding</th>
<th>Advanced Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>I don’t want it forced</td>
<td>Planning</td>
<td>Design</td>
</tr>
<tr>
<td></td>
<td>Design</td>
<td>Something I Like</td>
</tr>
<tr>
<td>I don’t want to do a Project on bridges</td>
<td>Something I Like</td>
<td>Relate</td>
</tr>
<tr>
<td>Dance, Music, Theatre</td>
<td>Something I like</td>
<td></td>
</tr>
<tr>
<td>Marine Biology</td>
<td>My Science Project</td>
<td></td>
</tr>
<tr>
<td>OCD</td>
<td>Something I am Interested in</td>
<td></td>
</tr>
<tr>
<td>Did not know STEAM</td>
<td>Learn STEAM</td>
<td>Educate</td>
</tr>
<tr>
<td>I Didn’t know sharks could</td>
<td>Shark Biology</td>
<td></td>
</tr>
<tr>
<td>I don’t know much about trains</td>
<td>Learn Sharks</td>
<td></td>
</tr>
<tr>
<td>I’m not really sure what they are</td>
<td>Understand Trains</td>
<td></td>
</tr>
<tr>
<td>I like glitter</td>
<td>Scrapbooking project</td>
<td>Scrapbooking</td>
</tr>
<tr>
<td>It was fun putting stuff in the book</td>
<td>Creating workbook is fun</td>
<td></td>
</tr>
<tr>
<td>I enjoyed the freedom of writing</td>
<td>Workbook allowed</td>
<td></td>
</tr>
<tr>
<td>I like to write</td>
<td>Freedom</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Creative Writing</td>
<td></td>
</tr>
</tbody>
</table>
Table 9: Example of Theoretical Framework Development

<table>
<thead>
<tr>
<th>Initial Coding</th>
<th>Intermediate Coding</th>
<th>Advanced Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>I liked the videos</td>
<td>Video Editing</td>
<td>Social Media</td>
</tr>
<tr>
<td>Instagram</td>
<td>Sharing Photos</td>
<td></td>
</tr>
<tr>
<td>TikTok</td>
<td>Sharing Videos</td>
<td></td>
</tr>
<tr>
<td>Facebook</td>
<td>Group Information</td>
<td></td>
</tr>
<tr>
<td>I know what I will be when I graduate</td>
<td>Plans ahead</td>
<td>Forward</td>
</tr>
<tr>
<td>I will be a flight attendant</td>
<td>Knows Career</td>
<td></td>
</tr>
<tr>
<td>I will get a job first</td>
<td>Action Goals</td>
<td></td>
</tr>
<tr>
<td>I want a PHD</td>
<td>Future Plans</td>
<td></td>
</tr>
<tr>
<td>I like doing what I want</td>
<td>Free Will</td>
<td>Options</td>
</tr>
<tr>
<td>I don’t like it being mandatory</td>
<td>Pressure</td>
<td></td>
</tr>
<tr>
<td>I don’t want to be forced</td>
<td>Not Forced</td>
<td></td>
</tr>
<tr>
<td>I’d like to choose</td>
<td>Choice</td>
<td></td>
</tr>
<tr>
<td>Normalize STEAM Careers</td>
<td>Admire</td>
<td>Role Models</td>
</tr>
<tr>
<td>President of the USA</td>
<td>Look up to/Idol</td>
<td></td>
</tr>
<tr>
<td>Get Some to Do it Other</td>
<td>Domino Effect</td>
<td></td>
</tr>
<tr>
<td>will follow</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As one can see from the examples above, the acronym DRESS FOR STEAM was a naturalistic and emergent theme that was produced by this study and grounded in data.

Word Clouds

The following images shown below are the results of the Word Clouds created using Odin’s Eye, the Well of Truth. Each Word Cloud represents the conversation and interaction with each participant. The names of the participants are not shown with the
Word Clouds to help maintain anonymity. Table 10: Word Clouds and Themes shows the Word Cloud with a brief description of the topic it represents.

Table 10: Word Clouds and Themes

<table>
<thead>
<tr>
<th>Word Cloud and Theme</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Table 10</strong>: Word Clouds and Themes</td>
<td>The theme for this workbook was saving sharks.</td>
</tr>
<tr>
<td><strong>Table 10</strong>: Word Clouds and Themes</td>
<td>The theme for this workbook was Building Apps for Education</td>
</tr>
<tr>
<td><strong>Table 10</strong>: Word Clouds and Themes</td>
<td>The theme for this workbook was Obsessive Compulsive Disorder (OCD)</td>
</tr>
</tbody>
</table>
Table 10: Word Clouds and Themes

<table>
<thead>
<tr>
<th>Word Cloud</th>
<th>Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Table 10:</strong> Word Clouds and Themes</td>
<td>The theme for this workbook was Nutrition (Antioxidants)</td>
</tr>
<tr>
<td><img src="image1.png" alt="Word Cloud Image" /></td>
<td>The theme for this workbook was Water Pollution (Indian River Lagoon)</td>
</tr>
<tr>
<td><img src="image2.png" alt="Word Cloud Image" /></td>
<td>The theme for this workbook was Saving Sharks</td>
</tr>
</tbody>
</table>

165
Table 10: Word Clouds and Themes

<table>
<thead>
<tr>
<th>Word Cloud</th>
<th>Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Word Cloud" /></td>
<td>The theme for this workbook was Dress Construction</td>
</tr>
<tr>
<td><img src="image2" alt="Word Cloud" /></td>
<td>The theme for this workbook was Saving Sharks</td>
</tr>
<tr>
<td><img src="image3" alt="Word Cloud" /></td>
<td>The theme for this workbook was Saving Sharks</td>
</tr>
</tbody>
</table>
Table 10: Word Clouds and Themes

<table>
<thead>
<tr>
<th>Word Cloud</th>
<th>Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomedical</td>
<td>The theme for this workbook was Biomedical</td>
</tr>
<tr>
<td>Civil Engineering – Trains</td>
<td>The theme for this workbook was Civil Engineering – Trains</td>
</tr>
</tbody>
</table>

Summary

Organizing 11 young women to follow through three stages of a workshop was a very challenging and illuminating process. Through the various interactions, valuable insight was gleamed when working with the young women. From learning about their topics of interest such as sharks, OCD, antioxidants, education apps, trains, dress construction, viruses, and drone boats, it was learned that these young women have a lot to share with the world. Utilizing qualitative study techniques, software, coding, and memos, the study was able to capture the various insights of the young women that emerged during the study. The theoretical framework of DRESS FOR STEAM can now
augment any study designed at capturing the enthusiasm and engagement to help create new role models of tomorrow.
CHAPTER 5
Discussions, Implications, and Recommendations

Overview

The study that was conducted was intended to see some of the thoughts and insights that emerge from today’s young women regarding STEAM. The study was novel in its design and utilized qualitative methods to investigate the various realities of the participants.

Chapter One highlighted the main thoughts and concerns about young women in STEAM, which was laid out in the problem statement. The study was aimed at capturing thoughts of young women to gain insights into why young women may not pursue STEAM careers. The study also looked to see if something can be done, perhaps an intervention, to alter their thoughts on STEAM so that they may consider it a viable field for their future. The concern is that young women may not completely understand what STEAM is and are making life decisions without this additional knowledge.

Chapter two presented the literature review, which discussed various frameworks and past research about STEAM projects, women in STEAM, motivation, social-cultural perspectives, learning based on history, Steampunk, bibliotherapy, fairy tales, Data Science, Vygotsky, Systems Engineering, project-based learning, Internet of Things, scrapbooking, textiles and puppets, naturalistic inquiry, and grounded theory. The topics mentioned are all the various aspects of ways to motivate young women and are part of the current state of the art field for studies of women in STEAM. The ideas presented were utilized to create the fundamental building blocks of how a STEAM study was to be conducted that is relevant to young women.
Chapter three laid out the methods and procedures for the study. It discussed the pilot study where various groups of people were asked their ideas of what they thought should be included in a STEAM workbook. Those ideas were next incorporated into Phase Two of the study, which was building a STEAM Workbook. The framework from Chun Tie et al. (2019) was used to extract the thoughts and ideas from the young women in the study by utilizing coding techniques, memoing, and reflection. The framework was slightly modified to create an extra process for transcribing of data. Transcription of data is a long process and developing tools such as the one discussed, Odin’s Eye, the Well of Truth, helped to process the data in a methodical and consistent way. The software too was specialized software written in Python that helped with the overall transcription and analysis of textual data. The framework, the tools, the methods, and procedures were all explained so that it would be easy to understand and recreate.

Chapter four discussed the study that enlisted eleven young women into three workshops to build a STEAM workbook. The participants walked through each of the letters of STEAM, the S for Science, the T for Technology, the E for Engineering, the A for Arts, and the M for Mathematics. The study then provided rich thick description of the participants’ interactions with the workshops and their emergent ideas. The young women took a Steampunk journey where they underwent the task of creating a STEAM workbook on topics of their own choosing. The topics the participants chose were saving sharks, dress construction, spreading of infectious diseases, Obsessive Compulsive Disorder, education apps, nutrition and antioxidants, water pollution in the Indian River Lagoon, and monitoring trains for Civil Engineering. The study gained insight into and emergent ideas of the young women’s reality. A holistic view of the world was taken
from the data collected from the young women to ascertain their societal and cultural perspectives. The researchers learned more about the thoughts of young women that may perhaps entice them to want to look deeper into STEAM related careers. The emergent themes resulted in a new theoretical framework called DRESS FOR STEAM.

Discussion

The world around us is ever changing but the fabric of history is woven everyday as humankind ventures to learn more about each other and continue our culture, traditions, and perspectives and move forward. Young women show excitement for STEAM when they are in middle school, but often by the time they graduate high school, the interest in STEAM has waned and no one is quite sure why (Cohen, 2020). This study investigated the realities and thoughts of young women to explore the thoughts and emergent ideas of young women regarding STEAM.

As part of the social-cultural perspective, the young women in the study participated in a collaborative effort to develop a theoretical research project. From the onset of the study, the researchers assessed each participant’s Zone of Proximal Development to understand the types of scaffolding that would be needed for each learner. One by one, individual workbook sessions were organized with each of the participants with scaffolding tailored to that participant. Each participant was provided a deeper level of learning by the customized sessions with the researchers. Through social interactions that were co-constructed with the researchers and participants, the Most Knowledgeable Other was able to create and then slowly remove the scaffolding needed to help the participant out of the ZPD associated with the science project the participant chose. The researchers prepared PowerPoint slides of each topic and researched each
topic to ensure they would be able to provide the support needed to serve as the Most Knowledgeable Other (Karaolis, 2021) (Vygotsky, 2004) (Wood, Bruner, & Ross, 1976).

The study set out to explore the various thoughts and perspectives of young women regarding STEAM. In order to do this, the following research questions were investigated:

1. How do thoughts and ideas about STEAM change in young women by their participation in a STEAM workbook workshop?
2. What thoughts and ideas emerge from young women who participate in a themed STEAM workbook project?
3. How does working on the STEAM workbook help young women understand or see potential career opportunities that they might not have known?

The results of the research questions are discussed herein:

**Research Question 1**

How do thoughts and ideas about STEAM change in young women by their participation in a STEAM workbook workshop?

The young women in this study were very eager and excited to learn about STEAM. While working with the participants it was clear to see that the participants did not have a clear understanding of what STEAM is at a deeper level. The workbook activity allowed the young women to examine, learn, investigate, and understand a fuller depth and breadth of what STEAM is. Mainly the young women’s thoughts and ideas grew and developed the more they participated in the workshop. The young women reshaped their thoughts and ideas about STEAM by learning and understanding what each of the letters in STEAM meant and how those letters relate to their theme. The
young women learned how they could examine the science of their theme and topic that they chose. To provide an example the young women who chose to do their theme on sharks were educated in the anatomy and biology of sharks. They learned about specialized organs within the shark that helps the shark detect electromagnetic frequencies (EMF) and how they use the EMF to detect prey in their environment. The young women learned that they could use the Internet of Things to create a device that can be installed on a fishing net. This device can emit specially designed EMF signals that would agitate the shark and make the shark swim away from the net. The EMF and Internet of Things demonstrated to the young women how they could use Science and Technology together to solve a problem. The young women also designed diagrams utilizing Systems Engineering and Engineering principles in general to describe how the EMF devices on the nets would get power and transmit data. Additionally, the fishing net could also have sensors on it that would detect the presence of sharks so one could see if the EMF device was effective at driving the sharks away. The participants then saw how Art can be used to blend the EMF device into the natural surroundings the shark swims within. Data science was also explored and used to create graphs and plots of where the sensors were on the nets and if they were effective at driving the sharks away from the net. All the participants agreed that they had never thought of STEAM in this way. They were truly happy and rewarded to see how an everyday problem could be solved using STEAM and how the letters of STEAM orchestrated together to solve a real-world problem. The activity really opened their eyes at what could be done. Some of the girls expressed a desire for this type of activity and mentioned they had not been shown this in school. The activities were enriching and rewarding, and the young women
grew a lot in the understanding and curiosity in STEAM. For the other participants, just like the sharks, each participant was able to choose a problem that they wanted to help solve and with STEAM they were able to see how that problem could be solved with STEAM. For each theme selected the young women were able to identify the science that pertained to their topic. They next examined the technology that would be needed to assist with their project. The technology was based on the Internet of Things and provided a way that they could implement a device of sorts within their theme. For water pollution the idea of a boat drone was explored. This entailed understanding the technology needed to create or acquire such a watercraft along with the engineering needed to make it work. For OCD understanding the science behind obsessive thoughts was needed along with understanding what technologies could be used to assist in helping people cope with OCD. For OCD Virtual Reality was explored as a way at looking at a safe place where they can learn trigger factors for their OCD. Discussions were held about using RFID sensors and Apple Air Tags that could be attached to devices such as mops, brooms, vacuums, etc. This would allow the team to see how often objects within a space moved and this would help the person afflicted with OCD understand how often they may engage in activities such as cleaning. This monitoring of their environment could help them learn and maybe realize when they are cleaning too often and allow for self-reflection of the activity. For each project similar lines of inquiry were investigated.

This means that the take away here is they will be able to look at more problems in their future and be able to generalize it to examine and investigate the science, technology, engineering, art, and math that is involved with the theme.
Linking back to the mnemonic developed DRESS FOR STEAM, research question one helped to identify: Educate, Scrapbooking, Social media, and STEAM

Research Question 2

What thoughts and ideas emerge from young women who participate in a themed STEAM workbook project?

As the participants knowledge of STEAM grew and developed, they were able to apply those ideas and knowledge to their very own mini-science projects. One emergent theme that presented itself is that young women like options and it was seen through the selection of their science projects. The young women were allowed to choose any topic they so desired. Many of the participants really expressed that they liked having a choice and they do not like participating in STEAM activities where specific projects are forced on them. They like choosing things that are meaningful to them. They expressed the overall theme that one size does not fit all, and options and freedom of choice is extremely important. Additionally, shown through the selection of the science project topics they chose was that young woman like themes that they can engage with. Young women are drawn to different topics than that of young men. This study cannot prove such a conjecture but suffice it to say one is sure to agree when looking over the various themes herein. The young women showed their emergent ideas and thoughts regarding the topics they chose:

Water Pollution – In Brevard County there is a body of water called the Indian River Lagoon (IRL). The lagoon has experienced many ecological issues throughout time. Such issues include water contamination, algae blooms, pollution, sewage seepage, and fertilizer run off from lawns and yards to name a few. Due to these ecological issues,
there is a vested interest in the residents to see the lagoon once again survive and run with clean water. To this end many resources are vested into the successful outcomes of water cleanup and decontamination of the Lagoon. One of the participants of the study decided to do her project on the Indian River lagoon. When asking her why she chose the Indian River Lagoon one gets answers such: as I want to help the environment. I want to fix the lagoon. I care about the marine life in the lagoon. These are just some of the answers that emerge when discussing the lagoon. When asking the participant what they can do with the lagoon they discussed the idea of a drone boat. A duck boat water drone that can autonomously patrol the lagoon periodically taking samples and alerting humans to the presence of garbage. These ideas were explored with the participant, and they highlight and show the concern the young woman has regarding the Indian River Lagoon. When pressed further one can discover that the young woman cares deeply about the planet and the effects that humans have on it. The idea to help save the lagoon stems from an overall concern that things need to be done to help clean the planet. These ideas and thoughts are some of the emergent themes that came to be from the woman who was working on this project.

**Saving Sharks** – Four young women chose the theme of saving sharks. When asking the young women why they chose this topic they mention ideas and thoughts about: concern for the sharks, wanting to help, and expressing overall sympathy for the sharks. As discussed earlier the young women mentioned the idea of using an EMF device secured to the fishing nets to help push the sharks away so the sharks do not become part of bycatch.
**Obsessive Compulsive Disorder** – One young woman expressed that they wanted to explore OCD. To focus the discussion, it was decided that the research would be focused primarily on obsessive cleaning. People who are afflicted with OCD often manifest it in different ways. One way that it can manifest itself is through obsessive cleaning. Obsessive cleaning can entail washing one’s hands to often where they become damaged or cleaning a space, room, or house often. As discussed previously the participant and the researcher discussed the idea of placing trackers on the cleaning supplies. Trackers could go on the brooms, vacuums, mops, sponges, trash can lid, etc.

The idea of this is that one can map and monitor the signals that come from the devices and to see when they move around often. If one sees a broom move once a day this may be normal behavior. However, if one notices a mop move 35 times a day it would indicate an abnormal behavior and that someone has an OCD issue. When asking the young woman why she chose this topic she echoed the same thoughts as others. She expressed that she wanted to help people and that by looking into OCD she could help people cope with the affliction. She expressed compassion, empathy, and a general sense of caring. The emergent themes that surfaced was that the young woman was interested in aspects of psychology, understanding behavior, being involved in a clinical setting, and overall helping people. The ideas of social worker and clinician was also explored. These emergent thoughts only surfaced while exploring this project with the young woman. In her activities at school these aspects of her own desires are not explored. Only though the interaction of this workbook activity these ideas were showcased in a way that was never explored before. The activity also gave her motivation to work on the workbook and to explore aspects of OCD in a new and novel way. In her workbook the
young woman drew some scenarios and scenes that could be created in virtual reality showing off a kitchen and how that kitchen could have different levels of cleanliness to detect when a particular environment might make a participant uncomfortable. She also embraced the idea of data science by drawing graphs and charts that showed activity that could be monitored. Overall, the interaction with the workbook allowed the young woman to showcase ideas and thoughts with the most knowledgeable other. Thoughts and ideas that were not previously known.

**Dress Making** – The theme of dress making allowed the participant to explore ideas and thoughts regarding STEAM and how it would apply to the fashion industry. The young women is very interested in acting, dance, modeling, costumes and dress construction. Together the participant and the most knowledgeable other explored the ideas of using technology in a dress to make something new and stunning. The participant came up with ideas such as installing motors within the dress that can lift and turn the fabric. Additionally, ideas of illuminating the fabric also emerged. These ideas when discussed with Science Technology Engineering Art and Math allows one to see the whole spectrum of STEAM being applied to garments that can be worn by people. This new novel idea itself demonstrates how some of the thoughts and ideas of young women are unique and different. The science and physics of fabric were explored and how technology such as the Internet of Things could be used to make the fabric move with motors, light, gadgets, and gizmos that can make clothing change appearance and color. The young women expressed fresh and new ideas that can be incorporated in garments. The discussions with the most knowledgeable other highlighted that the young women were engaged in the design and this was crucial in getting her excited in STEAM.
Similarly, to other participants these thoughts and ideas have not been explored in other settings. The workbook allowed the young woman to express and demonstrate these ideas to the knowledgeable other.

**Trains** – The young woman who explored trains was very curious about trains and their operations. Together the most knowledgeable other and the participant viewed several videos of locomotive manufacturing by General Electric (GE) company. The videos showed how trains are meticulously put together and built-in specialized factories to accommodate the size and scale of a locomotive. The researcher and the participant investigated how the internet of things devices can be installed on a train to help monitor the health of the train engine when deployed. Interesting thoughts that emerged from the train project showed us that when constructing a train station, one must also be concerned with where the people who ride the trains will park their car. The young woman was very excited about the physics behind the train. She was fascinated about how the train wheels work to keep a train on the rails. The insight gained was that the young women selected a topic of civil engineering. The outcome is that she selected a project she was extremely curious about but may not choose to follow as a career.

**Infectious Diseases** – The young woman in this study is very fascinated by the medical field. She has done science projects in the past that deal with helping to find ways to dissolve clots within the blood. In this study she and the most knowledgeable other explored how one can detect an infectious disease as early as possible. Discussions were held regarding utilizing data science to help gauge what is going on. How to indicate the onset of a disease within a population. Together the participant and the most knowledgeable other discussed how devices such as a fit bit could be worn by people to
monitor heart rate and blood pressure. When someone succumbs to an infectious disease changes occur in the physiology and these changes often affect blood pressure and heart rate. If several people within a population are wearing devices that can track their heart rate and blood pressure one would be able to see if a subset of a population started to experience similar changes in their physiology at or around the same time. These changes, happening similarly, within a group in a population would indicate that something new is in the environment and that these people may have encountered an infectious disease. Taking this data and mapping it against data that involves sales of medication for fever, common cold, aspirin, and ibuprofen and the like would also be indicators of something happening within the population. Using data science and art, the way these graphs are shown to the public and others, would help to indicate that a disease has entered the population and steps may need to be taken to mitigate the spread of the disease. This exploration of medicine sales and biological readings from people were fascinating to the young woman and she was extremely excited to see how this could be done. During the brainstorming of these ideas the young woman was highly engaged, energetic, and overly excited of how data science and technology of the Internet of Things along with Engineering and the science of infectious disease could all be brought together to help solve a real-world problem. The young woman chose the project of infectious disease because she hopes to be a doctor and is fascinated with how the human body works. She also wants to help people and be part of groups of people that discover cures to help people get healthier.

**Apps for Kids** – One of the young women in the study works at a preschool where they work with children throughout the year. One of the objectives is to see if the
A child in VPK is ready for kindergarten. The way this is done is to assess the child’s ability to know their ABC’s and what color is what. That they can identify colors such as blue, red, green, etc. The young woman was interested in building an App that children can use to help assess what they knew. Additionally, they could compare the results of one child against others. The young woman wanted to know how one could create an app that would meet this need. Together the most knowledgeable other and the participant discussed software engineering and computer science which study and build apps. The young woman was introduced to SCRATCH which is a visual programming language developed by MIT. While using SCRATCH and developing code in SCRATCH the young woman was able to see how exciting programming could be. One comment she mentioned was she didn’t realize how detailed everything would be to create an application. Through her exposure to SCRATCH, she was able to see what is involved in creating software and the types of thinking and skills needed to pursue such an endeavor. She had not had the opportunity to write code and was fascinated at the process. She was highly engaged in the activity.

**Antioxidants to help focus** – The young woman was curious about how foods can affect mood. Particularly she was interested in how foods, and in the case antioxidants, could be utilized to help a person stay focused so that they could study or focus when taking a test. Together the participant and the most knowledgeable other researched and investigated how foods can improve focus and concentration. Together the pair imagined a way that one could somehow examine the antioxidants within someone and then using data science see the ultimate window of when one consumes a food to when it will be most impactful and the duration of this impactfullness. The
young women were very excited at the idea of how foods could interact and help people accomplish their goals. In further discussions she mentioned she wants to be a food nutritionist, a nurse, or a veterinarian. She is very interested in helping people and animals. The idea of a device that could measure the antioxidants in someone’s body would really illuminate to everyone just how food impacts our mood and behavior. The emergent ideas is how we can utilize diet to help people and also to help identify foods that are helpful. This theme of food is another example of how the young women was excited to have options and to choose something that she can relate too.

Many of the emergent thoughts and ideas that were explored came from the selection of their mini science project as listed above. With each project selected each young woman was able to discuss and share unique ideas at solving problems especially when looking at the problem with the guise of STEAM. Examples of emergent ideas are:

While conversing with the young women it was very clear to see that they were excited about STEAM and enjoyed it but were not happy with how it has presented to them outside of this study. The young women discussed way in which they thought STEAM could be introduced and explored by the way in which projects are designed. They mentioned that they really enjoyed the videos (social media) and the scrapbooking aspect of the study. They liked to have the autonomy of selecting things themselves and especially ideas that they could relate to.

Linking back to the mnemonic developed DRESS FOR STEAM, research question two helped to identify: Design, Relate, Forward, Scrapbooking, Social Media and Options.
Research Question 3

How does working on the STEAM workbook help young women understand or see potential career opportunities that they might not have known?

The young women were able to explore a project that they themselves were interested in. Together the participant and the Most Knowledgeable Other visited several web pages based on the theme they chose. The goal was to take the area of interest from their project and then map it to a college degree. Once the college degree was discovered next they searched the internet together to explore what possible career paths and jobs existed within the realm of the degree they chose. Some of the participants were fascinated at the plethora of degrees that were available for their area of interest. Some of them had no idea such degrees existed. For example, some of the participants who chose sharks were excited to see that they could get a degree in Marine Biology or Environmental Studies. They were next excited to see that such jobs as Marine Biologist, Sea life trainer, Marine education, Fisheries and Wildlife Conservationist, Environmentalist, and Ecologist are just some of the jobs they could pursue. They were even excited to think about being an animal caretaker and trainer at SeaWorld. One by one each of the participants explored the area of interest, the possible degree they could earn in college and then the job or profession they could consider with the degree they selected. Most of the participants had never investigated their possible degrees and then linking it to the job they could get. All the young women were fascinated and generally excited to see the paths and possibilities that lay ahead of them. One participant discussed the idea of being a Crime Scene Investigator. They explained how visiting a crime scene would be very interesting to them and the collecting forensic data from the
site. In this discussion the researcher and the participant even talked about role models in media. In this case Barry Allen was discussed who is the Flash in the DC comic world. Other media presence was also discussed, and this highlighted the importance of having and needing role models within their desired industry. More female role models will go a long way in exciting young women about STEAM. Social Media influencers can also help to get young women involved by showing in their media channels how exciting and interesting STEAM is. In part this is where the R for Role Models and O for Options developed for the mnemonic DRESS FOR STEAM. Others in the study expressed how they wanted to become a doctor and explore advanced degrees. Two of the young women expressed that they would like to start working and pursue college part time while they saved up money. The ultimate outcome of this exercise of looking deeper into college degrees and jobs allowed them to see a larger picture of their life and provided them an opportunity to see how they may want their life to unfold as they get older. Many of the young women had not considered this and were very open minded and glad that the degrees and jobs were shown to them. Some of the young women may change their career path and thinking based on what they saw in the interactive session. Table 11: Areas of Interest shows the various degrees that one may pursue along with the possible profession they link to. The discussions also included salary to assist them in understanding how to obtain such information.
Table 11: Areas of Interest

<table>
<thead>
<tr>
<th>Area of Interest</th>
<th>Degree to Pursue</th>
<th>Profession</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antioxidants to help focus</td>
<td>Nutrition</td>
<td>Nutritionist</td>
</tr>
<tr>
<td>Apps for Kids</td>
<td>Computer Science</td>
<td>Software Engineer</td>
</tr>
<tr>
<td>Fashion Design</td>
<td>Fashion Engineering</td>
<td>Fashion Designer</td>
</tr>
<tr>
<td>Infectious Diseases</td>
<td>Microbiology</td>
<td>Microbiologist</td>
</tr>
<tr>
<td>OCD</td>
<td>Psychology</td>
<td>Psychologist</td>
</tr>
<tr>
<td>Sharks</td>
<td>Marine Biology</td>
<td>Marine Biologist</td>
</tr>
<tr>
<td>Trains</td>
<td>Civil Engineering</td>
<td>Civil Engineer</td>
</tr>
<tr>
<td>Water Pollution</td>
<td>Marine Biology</td>
<td>Environmental Engineer</td>
</tr>
<tr>
<td></td>
<td>Environmental Science</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Environmental Engineering</td>
<td></td>
</tr>
</tbody>
</table>

Young women think a lot about their future, and it was evident in the career discussions held with the young women. When asked what you would like to go into when you graduate all the young women had thoughts and ideas immediately ready. One could tell that they have been thinking about this topic for a long time. This is where the term Forward came from when conversing with the young women. It was clear and evident that these young women had long term goals and careers in mind. When asking the young women what could be done to get more women interested in STEAM the prevailing thought that emerged was early engagement. Meaning to introduce STEAM to young women a lot earlier in life such as elementary school.

Linking back to the mnemonic developed DRESS FOR STEAM, research question three helped to identify: Role Models, Forward, and Options.

The results of these questions were answered in Chapter four but suffice it to say, emergent ideas were discovered from the young women who participated in the study. The first question showed us that many of the young women did not know what STEAM is. With appropriate scaffolding and social-cultural interactions, the young women were
educated as to what STEAM is and how the various aspects of STEAM relate to them. The thoughts and ideas show that the young women are eager to learn about STEAM and by working on the workbook, they were captivated with an interactive project that allowed play, social interaction, and growth.

For the second research question, the researchers discovered that the young women are interested in STEAM and have lots of ideas for projects. The projects include saving sharks, dress construction, creating educational apps, analyzing, and detecting the spread of infectious diseases, monitoring waterways such as the Indian River Lagoon for water pollution, helping people who have OCD issues, looking at nutrition that can help one focus, and analyzing a locomotive when running. These ideas and many more were all parts of the thoughts from the young women in the study. It showed us that the young women enjoy STEAM and do not have any issues working with it and the projects they devised. The researchers also learned that most of the projects dealt with compassion, ecology, and health.

The last question helped the participants to see the usefulness and impactfullness of STEAM in their lives. They were able to see potential careers and the salaries associated with those careers. Some of the participants mentioned that due to the interaction, they would consider being a detective or crime scene investigator, but for now, they are focused on becoming a lawyer. Other participants realized that they have many more options than they realized when concerning career paths. They were delighted to see all the vast areas of study and careers available to them with certain STEAM topics. In the end, the participants learned a great deal about career, fields of
study, and potential salaries. The researchers enlightened their minds so they may now research further opportunities in STEAM.

**Conclusion**

After analyzing all the data and answering the research questions it was clear that a key message was emerging from the data. The key messaged needed to be brought to light in an overall comprehensive way. To accomplish this messaging the Mnemonic DRESS FOR STEAM was created from the divergent themes that revealed themselves within the study.

Hamed (1999) states eloquently that qualitative research is the art of taking things away, like how a sculptor removes and chisels stone away to reveal what is hidden within. Initial coding, intermediate coding, and advanced coding are the art to which he refers. The result of the coding process is abstract ideas generalized from the copious volume of textual data to reveal the themes within the data. To this end, the study produced a new theoretical framework, DRESS FOR STEAM, to consider when creating activities, studies, and events to help motivate young women in STEAM.

The research indicates that to engage young women in an activity or project that they will be motivated to complete, one should consider the following:

**Design:** the design of the study is probably the most fundamental and important step that one can do to motivate young women to want to consider STEAM. Everything about the design of an intervention with young women needs to be considered to cater to their wants and desires. Everything from project topic and the types of interactions they receive needs to be enthusiastic, fun, engaging, and socially rewarding to captivate and keep the attention of young women. The design of a study, the scaffolding, must be
carefully and thoughtfully planned so that the desired result can be achieved. To meet this goal, it is important for people to consider topics, such as play, and discussions to ensure the participants achieve the desired outcome. To help the participant, aka learner, acquire more knowledge, the study’s introduction, procedures, and conclusion need to all be planned in such a way that they will grasp and maintain the attention of young women (Vygotsky, 2004; Wood, Bruner, & Ross, 1976).

Gallagher (2005) mentions that teaching novices new topics is often challenging, and we should not forget the amount of jargon often used in any discipline. To that end, when designing projects for young women, it is important to look at problems from different angles. Sometimes a problem must be turned on its head, like that of the Monkey Sort (Gallagher, 2005). Monkey Sort is a Computer Science algorithm that sorts data using randomization. Gallagher (2005) provides this definition of monkey sort and how it gets its name:

I give this algorithm the name monkeysort. The name comes from the observation that if one places infinitely many monkeys in front of infinitely many typewriters, arbitrarily striking the keys, they will ultimately produce the works of Shakespeare, the Bible, the Oxford English dictionary, etc. as one of the random sequences. The trick of monkeysort, or the typing monkeys, is, of course, to be patient. (p. 3)

The monkeysort provides a completely different and novel way of looking at a problem. It allows one to think of a problem from a different perspective and different solution.

The design of any study or project must be tailored to the audience who will engage in it. As noted in this study, a one size fits all is not a good way to design a study
for young women. The study design must appeal to the desires of young women and must be incorporated in such a way that it is rewarding for the participant.

**Relate:** Young women need to be able to relate to the topic that is being demonstrated and taught in STEAM workshops. Topics of study need to be relevant to the young women and they need to see that it is engaging to them. They also need to see how the project can benefit society, such as something that can help people or the environment. Many of the topics the young women chose were topics that can assist people. Examples include:

1. Duck boat drone that can monitor a waterway.
2. Infectious disease tracker that can help detect and create early warnings of disease.
3. Protection and safety of wildlife such as sharks to prevent them from being entangled accidentally in fishing nets.
4. Education apps that can help people learn and grow.
5. Dress construction where women can spotlight their own Engineering skills.
6. Monitoring of trains and locomotives to give real updates on the safety of the train.
7. Helping people with the use of psychology to help detect and treat people with OCD.

The topics all include parts of the tapestry that make up our culture and these science project pursuits attest to how relevant they are to young women. Designing studies and projects that consider these ideas will be beneficial in capturing and retaining young women’s attention. Ormrod (2012) discusses the topic of relatedness and points
out, based on her research and others, that people have a need for relatedness. People need to relate to each other, their teachers, and the subject matter.

Fowler (2012), discusses how students were put in a Hot Seat to stimulate interest in biology. In a way, this is what happened with the participants in this study regarding STEAM. During the interview, sometimes the participant was inadvertently put in the Hot Seat regarding STEAM. This was done accidentally because the researchers had presumed that the participants knew something that they did not know. In some aspect, the participants had difficulties relating to what was asked. To reduce the Hot Seat effect, the puppets, once again, came to the rescue to cool down the Hot Seat and utilized examples to help the participant relate to the area of STEAM that they had a misconception or confusion about. Fowler (2012) indicated that the Hot Seat activity helped the students gain a deeper understanding of biology and make connection from biology topics to more generalized topics in society. The interactions and interviews with the students in the STEAM Workbook activity also made similar connections. Through the interactions with the young women, the researchers were able to make connections to the participants’ own working knowledge and therefore helped the participants relate to STEAM. Without the discussion and interview, they would not have been able to make the connection and then would not have reached a deeper understanding of how STEAM related to their project. The Most Knowledgeable Other, the interviews, and the discussions connected the participants’ new material to experiences the young women had themselves. The interconnections developed helped the participant tie all the different parts of STEAM together so that the concept was relatable.
To captivate young women to take an interest in learning and becoming more knowledgeable about STEAM, they needed to be able to relate to it.

As part of the project, the researchers used puppets to help with the engagement of the young women. Karaolis (2021) mentions that puppets help to build a pathway to relationships. The puppets allowed the researchers to connect with the students and to participate more freely with the researchers. The puppets added a fun whimsical feature, which helped the participants feel more at ease and helped to relate the researcher with the participant. Karaolis (2021) indicates that a puppet creates a safe and trusted space of playfulness that allows the participant and researcher to engage in a fun and rewarding experience. The puppet allows the researchers and the participant an alternative way to communicate and to see the researcher as a buddy (Karaolis, 2021). The participants were able to demonstrate play with their puppets within the study and to relate to each other (Vygotsky, 2004). Figure 7: Puppets in Play Learning STEAM, show the puppets used.
Figure 7: Puppets in Play Learning STEAM

**Educate:** Before this study was conducted, many of the researchers assumed that the young women in the study had a working definition of STEAM. This turned out not to be the case and that young women knew of the acronym, but they did not know much more behind the letters. With many STEAM topics, it is important to not assume that the participant knows about the topic or the framework; instead, it would be prudent to baseline the participant’s knowledge. The baseline of knowledge that can be achieved with an interview is to understand what scaffolding will be needed for that participant. In this study, all the young women needed to learn about what STEAM is and how it is
relevant. As mentioned earlier, Vygotsky explained how learners can push their knowledge to potential knowledge by being helped through a learning block by working with a Most Knowledgeable Other. This person, the role model, helps the learner learn by setting up the appropriate scaffolding to allow learning to take place. In the study, the researchers embarked on learning software coding for education, the biology of sharks, the effects of antioxidants on the human body, the manifestation of cleaning OCD from anxiety, determining how to detect the spread of an infectious disease, the controls, and sensors on a train locomotive to detect anomalies, the creation of dresses that use Internet of Things devices, and an autonomous boat drone for pollution detection. Utilizing education and aspects of Vygotsky, it was seen that one can build the correct constructs within someone’s mind to help them learn and be pushed beyond their ZPD, indicating that learning had occurred (Vygotsky, 2004; Wood, Bruner, & Ross, 1976).

Park (2014) discusses a mathematical framework that was used to help students engage in mathematics. The work by Park (2014) is also generalizable to concepts of Engineering. The workbook study herein showed that young women do not know what Engineering is. Park (2014) mentions how proper learning environments, enriched with experiencing rewards and sense making, are crucial elements for self-concept and positive dispositions for learning mathematics. The framework and ideas used for mathematics are transferrable for participants to learn about Engineering. Just as in Math, it would be crucial to have a proper learning environment, enriched with experience rewards and sense making for Engineering as well (Park, 2014).

**Scrapbooking:** The scrapbooking aspect of creating a workbook was key to the success of this study. All the young women enjoyed working on the scrapbook and
documenting their ideas. They enjoyed the hands-on nature of constructing the book and letting their own ideas shine through. They enjoyed the colorful markers, the puppet they were given, the stencils, the paper, and frankly everything about the workbook kit. They all found it extremely engaging and enjoyed working with it. Young women, especially those in this study, enjoy working with their hands and writing in the scrapbook. The scrapbook also allowed the young women an element of play just as the puppets helped with play.

**Social Media:** As pointed out by many of the participants, social media is the new platform for today’s young women. Research needs to be adapted to consider Instagram, TikTok, YouTube, and other social media platforms as ways of documenting and interacting with the participants. Creating videos that can be shared is a way to interact and reach the minds and attention of young women today. Sometimes videos that are posted to the internet can become viral and it is not always certain why this occurs. Something in the video becomes fun or exciting to watch and people start sharing it with each other. One person shares it on the social media platform and then two people share it, which then becomes four, then eight, then sixteen, thirty-two, sixty-four, one hundred and twenty eight, two hundred and fifty six, five hundred and twelve, and so on and so on until over a million people have now seen and shared the video. The phenomenon is extremely exciting for content creators and their friends that find it fun and enjoyable. When a video becomes viral, the content creator of that video may also become a role model. Besides the possibility of a video becoming viral, which is analogous to becoming famous, the videos also share our lived experiences and culture.
Social media is digital representation of human activity and documents our lives. The content on social media is often fun, exciting, and engaging.

**Forward:** Young women are planners and are forward thinkers. They know the direction of their life and where they wish to take it. All the young women in this study had an idea of what they wanted to do in life for the long and short term. This indicated that these young women have been looking towards their future and making decisions before they even knew what STEAM is. This is important to consider when building a study because one has to see how the study or project would fit into the young women’s plans. It is important to recognize that this is ongoing with the young women and needs to be accounted for in interactions with them. The young women would not change their forward-looking thoughts unless something substantial would motivate them to do so.

**Options:** Young women like to express themselves and be a key part in decision making. Many of the young women in this study do not like it when topics such as STEAM are forced on them. They crave autonomy and the ability to make their own decisions and designs. In this study, the young women were given autonomy to pick and discuss the science project they planned to work on for the workbook. Ormrod (2012) discussed that students must often follow class work that is dictated to them by school districts, yet when the students have autonomy, it increases their self-determinism and intrinsic motivation. Motivating young women to want to seek out STEAM and see the fruitful careers they can have is the aim and goal of these types of experiences. If STEAM is forced upon students, they will be demotivated and possibly turn away from STEAM fields.
**Role Models:** When one talks about role models, people often think of parents, teachers, famous people in media, historical people from our past, brothers, sisters, aunts, uncles, military personnel, police officers, firemen, and many more. People do not often consider their own peers with whom they share classes, eat lunch, and hang out as role models. Role models are important for society and culture. Often role models are people who we vicariously learn from. In Ormrod (2012), in the chapter Social Cognitive Theory, the author discusses how we (humans) learn from observations and observers are reinforced by models. Often in new situations, one looks to someone else who is known to them to act as a role model or someone whom they can learn from. An example of this would be ice skating for the very first time, especially if one is older. When one gets on the ice, the novice would look at others to see how they are getting around the ice. The new skater will mimic the behavior of others to hopefully grasp the skill for themselves. Social media encourages reinforcement using likes and comments. The people that we “like” are essentially role models whose behavior we enjoy or compliment. The intertwined connection between role models and social media is why these two topics within this study are emergent themes. They complement each other. To encourage more women to join in STEAM activities, women need to see more women doing STEAM activities. For more women to be role models, they need to use social media platforms to show themselves doing STEAM activities. A first-place winner of a science fair project can post to social media a video of what she did to research her science project. Additionally, she can post content of herself hanging out with her friends. Here is where we have a role model doing something we enjoy and posting about STEAM. Addressing what the one participant said, if we were to encourage this behavior, creating
social media posts of STEAM activities along with other content such as hanging out with friends, we may create a domino effect and get more and more women involved in STEAM. This is how role models especially tied to social media can work hand in hand with each other to help drive interest in STEAM for women.

The resulting phrase DRESS FOR STEAM resonates with other researchers, the literature review, and experiences that fellow educators have had. The message DRESS FOR STEAM is a key take-a-way that provides helpful insight and suggestions for scaffolding and pedagogy to cater to the desires of young women for an engaging experience. By making the study engaging and relevant to the young women one can create a meaningful experience that young women can relate to that will ultimately make them more curious about STEAM. This curiosity will create intrinsic motivation that will result in more women exploring and researching STEAM. The ultimate goal is to provide a springboard to help the young women explore STEAM so that they may consider it a viable career path in their life.

**Implications**

By combining scrapbooking, bibliotherapy, puppets, Steampunk, history, Data Science, Systems Engineering, project-based learning, Internet of Things, and the participants’ own choices, the researcher was able to create a study that captivated the young women to learn about STEAM. The interviews of the young women’s engagement with the STEAM workbook showed us that the women were excited, curious, and eager to learn about STEAM. Each of the projects the young women chose was meaningful to themselves and thus they took a vested interest in its outcome.
For some time now, the acronym STEM has been around in society and has been used to create many workshops that participants engage in. More recently, STEAM was introduced where the addition of Art was added to the acronym. It designates the addition of humanities, creative writing, art itself, and the human experience and design of how one can interact with things in our world. Although the acronym STEAM has been around them, there seems to be a disconnect on how one can learn about STEAM especially with young women.

This research, grounded in truth, has shown emergent thoughts from young women that shows adding a framework to the acronym would be a prudent and wise course of action. By adding the acronym DRESS FOR STEAM to the STEAM acronym, the researchers have now added practical observations that one should consider adding to a STEAM study to make it more rewarding and productive for the young women. The implication is that by using this new framework, DRESS FOR STEAM, there will be more impactful results, additional engagement, and more emergent ideas with young women in STEAM and perhaps change their perception of STEAM so that they may consider STEAM-related degrees and careers.

During many of the interviews with the young women, there was excitement and genuine interest to take these hypothetical science projects that the researchers discussed and turn them into real actionable projects. The projects that were discussed in this study not only help the researchers get a glimpse into the thoughts and realities of young women, it also provides the young women with a solid foundation of a project that they can pursue. The projects discussed with the young women can be operationalized and turned into full-fledged capstone projects in the future. These ideas that were developed
can be taken with them to college and used in classes as the need arises. The young women will not be starting with a *Tabula rasa*, blank slate, so to say (Ormrod, 2012). Instead, they will have a project in the back of their minds that they can always pull out and operationalize.

**Recommendations**

The first recommendation that came from the study is that STEAM needs to be explored and incorporated much earlier in one’s life. As recommend by the research of Cohen (2020), and supported by the statements of the young women in the study, the earlier the young women engage in STEAM, the earlier they will have an open mind to explore and realize that they themselves can do it. One needs to be aware that young women are planning and thinking of things in life a lot earlier than society might suspect. Therefore, it is imperative to ensure the young women have enough knowledge at their fingertips so that they can make the best decisions for themselves before it is too late. It appears that many STEAM interactions or groups miss the boat as they say. The intervention of teaching STEAM arrives too late when the young women have already made up their minds about how they want to pursue interests in life.

The second recommendation is to have a prolonged engagement in the workbook. The participants in this study did express that if they had the workbook longer, they would enjoy filling it out and doing further research. The recommendation is to do the engagement for either half a year, a full year, or for four years during their high school journey. The participants did state that they would love the idea of a journal that they could have in which they could document their study. Additionally, the book could be used as an experience testament that could be referred to during college and job
interviews. A project that spanned four years would be something one can draw from for college interactions, along with job interviews, where the young women would demonstrate an eagerness to pursue and engage in STEAM.

The third recommendation is that whatever activities are designed for young women, they should involve social aspects such as working together. They should involve the discussion of role models and women in history. The study should also limit the occurrence of failure. This study that was designed for the young women had no failure points. The Most Knowledgeable Other created appropriate scaffolding to bridge the gap of what the young women know to what they do not know. The projects were theoretical on purpose so that the young women had a positive experience with STEAM and failure could not happen. When introducing women to STEAM, it is important that they find it fun and exciting and that it involves a certain aspect of play. Building a bridge that could collapse and fall is not an appropriate way to introduce them to STEAM. Testing the bridge in front of their peers can possibly drive them away from STEAM. No one likes to fail publicly in front of their peers. Additionally, with each participant choosing their own project, it allowed the researchers to work with the young women one on one. This ensured no one person took over and it allowed each participant a unique experience.

One thing that should be considered for future engagements with the young women is for Harry and Victoria, the puppets, to have their own Instagram and TikTok accounts. It is believed this would add an extra level of engagement. The puppets could react to the participants’ videos and be their online buddies. One interesting thing that happened during the research is that Harry and Victoria visited the focus group. In the
focus group, the young women were very excited to see Harry and Victoria. They passed the puppets around the table, engaged with them in play, and treated the puppets as their friends that were part of the journey. This was unexpected and awesome to witness.

**Future Research Opportunities**

A study should be conducted discussing young women’s thoughts on technology and engineering. A thought that came about while doing the research is that often it seems that young men may engage with technology sooner than young women. This is evident when one ponders why boys and young men seem to play video games more than girls and young women. It is a wonder why this may be the case. On this thought, it would be an interesting study to create an escape room with technology and engineering as the primary elements. It would be interesting to observe young men and young women exploring the escape room and to document when certain aspects of technology puzzles, scientific puzzles, and engineering puzzles are tried and by whom. The escape room could use customized apps that are not like Android or Apple to see how the participants interact with an interface they have no experience with. Another aspect that could also be considered is to interview young women about video games and Engineering. Video games are a form of play, and it would be curious to understand what young women may be doing if they are not engaging in video games. These questions and their subsequent answers may bring about more emergent themes to help us understand additional thoughts and perspectives of young women. The results may lead to a deeper understanding of why young women may not pursue Engineering.

Another study that one could consider is approaching a school and trying to understand how they could have a class that would specialize in teaching technology and
Engineering – a class much like how Science and Math is currently taught today. It is the thought that young women may not be entering STEAM fields because they simply do not understand what Engineering is and it has never been taught to them. For some young women, Engineering might be an abstract topic that they have no real-world exposure too. Then when going to college, the young women choose fields more familiar to them and stay away from Engineering because it is foreign.

A study could also be conducted where there is a prolonged engagement with the workbook that follows a participant through one year or four years of school. The workbook interaction could be done much the same way as it was done in this study. A prolonged engagement may offer deeper glimpses into the reality of the young women’s minds. The study would give valuable insights as to what we may all do differently to make STEAM careers something fun, rewarding, and engaging to explore.

**Limitations**

One limitation of the study was a threat to internal validity regarding history. Due to the global pandemic of the COVID 19 virus that has been occurring during 2019, 2020, 2021 and 2022, the participants in the study have been (1) limited in their interactions with other participants and adults due to the nationwide quarantine orders and (2) the thoughts and emotions of all participants may be biased toward understanding the virus, which may influence their natural and raw response to other science fields and disciplines.

A second limitation was initially identified but did not happen within this study. The concern was if participants chose problems that are impractical, they would not be able to be discussed or implemented.
A third limitation was reduced in-person group activity and in-person meetups to discuss the workbook topics. Due to COVID 19, in-person interactions were not possible until the end of the study. Sessions were held over Zoom meetings and therefore limited the interaction one would have in person with reading body language and cues from the participants. The puppets helped to reduce awkwardness and make things fun and engaging as was intended in person. A focus group was held at the end of the study and the young women were highly engaged in the STEAM project.

COVID

This study was conducted during the global COVID pandemic. Due to the pandemic, face-to-face interactions were not possible until the fall of 2021. The researchers and participants had to work utilizing Zoom, phone calls, and screen sharing technologies. Although challenges were presented because of COVID, all the participants were great to work with and understood the unprecedented times that we are living in. Originally, it was imagined having various group sessions so that the young women would interact with each other in a more social way. Due to COVID, this was not possible and would have been too difficult over a Zoom call. The original project documented here could be redone once COVID restrictions are removed.

Summary

The young women in the study expressed excitement and enthusiasm when they were set on the quest to build their own STEAM workbooks. Working with the Most Knowledgeable Other, they were able to see their ideas come to life in a workbook of their creation. The young women enjoyed the social conversations with the researchers and each other talking and discussing their workbook idea. From their thoughts and
discussions, the emergent framework of DRESS FOR STEAM was realized. When interacting with young women and creating projects and studies revolving around STEAM, one needs to consider design, relatedness, education, scrapbooks, social media, forward looking thoughts, options, and role models.

The implication of this study is that young women enjoyed the STEAM activities and gained a new perspective and insight on STEAM that they previously did not have. After the young women were educated on what STEAM is and how it could affect their life, they were much more interested in STEAM than previously thought. In many of the participants’ minds, they did not know what STEAM was, at least the deeper meaning.

Future research and recommendations entail creating a study, similar in design to this one, utilizing prolonged engagement and additional social interactions once COVID restrictions are reduced or removed. Further studies should be done to ascertain a young women’s interest in Engineering and to perhaps run a study with an escape room designed for young women and young men to see if any comparative differences exist with the interaction. Lastly, it was demonstrated that play is a useful tool for helping to engage participants. This play can be done with puppets, scrapbooking, and even social media to create an engaging interaction with everyone in the study. Young women enjoy various social topics and helping one another to explore and engage in the world around them. There are many reasons why young women may not pursue STEAM fields of study and careers, but there is plenty we can do to allow them to make those decisions for themselves. Members of society need to do their part by providing opportunities that have a design intended for young women. This would include projects they can relate to, where we educate them on STEAM with a Most Knowledgeable Other, which involves
aspects of social media, scrapbooking, forward looking thoughts, options, and lots of role models so that all of us as a society and culture can DRESS FOR STEAM.
REFERENCES


He, J. a.-T. (2016). Integrating Internet of Things (IoT) into STEM undergraduate education: Case study of a modern technology infused courseware for embedded system course. *2016 IEEE Frontiers in Education Conference (FIE) (pp. 1-9).* IEEE.


Retro VG Media. (2013, June 24). Commodore 64 Australian Ad: Are you keeping up with the commodore [Remastered audio] [Video file]. Retrieved 04 15, 2019, from https://youtu.be/oGMx_Cw0ICc


Singer, D. G. (2003). The role of play in the preschool curriculum. All work and no play: How educational reforms are harming our preschoolers, 43-70.


APPENDIX A. WORKBOOK KIT CONTENTS

The workbook consisted of the following items:

- 1 Canvas Bag From Black or Beige Canvas Tote, 6 Packs Segarty 16x15 inch Canvas Bags with Zipper, 12Oz Heavy Duty Canvas Reusable Grocery Shopping Bags, Plain Bag for Women Kids Crafts Painting Embroidery, Gift Bags Bulk (Amazon)
- 1 Puppet from the 5-Piece Set Animal Hand Puppets with Open Movable Mouth / Zoo, Safari, Farm, Jungle / Rabbit, Sheep, White Dog, Pig and Wolf (Amazon)
- 1 Pair of Scissors from Scissors Bulk Set of 25-Pack, Niurop 8" Multipurpose Sharp Scissors for Office Home High/Middle School Student Teacher Supplies Kit, Soft Comfort-Grip Right/Left Handles, Great For Back to School Gift (Amazon)
- 1 Pack of Crayola 588106 Washable Super Tips Markers, Assorted, 20/Set (Target)
- 1 Pack of Crayola Broad Line Markers, Classic Colors 10 Each (Target)
- 1 Pack of Crayola Original Marker Set, Fine Tip, Assorted Classic Colors, Set of 10 (Target)
- 1 box of 250 sheets of scrapbook paper (6” x 6”) cut from Theodosia Square Paper Pack - 12" x 12" (Hobby Lobby)
- 1 Bottle Elmer's 4oz Rubber Cement Adhesive with Brush Applicator (Target/Amazon)
• 1 Paper Air Balloon Lantern from pack of Hot Air Balloon Paper Lanterns for Wedding Birthday Engagement Christmas Party Decoration Colorful Set Pack of 6 (Amazon)

• 1 Copy of the Parental Permission Form


• 1 Roll from Scotch Contractor Grade Masking Tape, 0.94 inches by 60.1 yards (360 yards total), 2020, 6 Rolls (Amazon)

• 1 Roll of Scotch Magic Tape from pack of Scotch Magic Tape, 6 Rolls, Numerous Applications, Invisible, Engineered for Repairing, 3/4 x 650 Inches (6122) (Amazon)

• 1 Roll of double-sided Scotch Tape from pack of Scotch Double Sided Tape, 1/2 in x 500 in, 6 Dispensered Rolls (6137H-2PC-MP) (Amazon)

• 1 Set of Stencils (1 pack) created by separating the following into 5 packs: Stencil Drawing Kit for Kids, 25 Pcs Plastic Drawing Stencils with 400+ Shapes, Great Birthday Gift for Boy Girl (Amazon)

• 1 Set of Paper Dolls (10 Randomly placed in each kit) from Tim Holtz Idea-Ology Paper Dolls TH Ideology (Amazon/Hobby Lobby)

• 10 Cards of Famous Women in Science from Women in Science: 100 Postcards Cards – March 7, 2017, ISBN 1607749815 by Rachel Ignotofsky (Author)

• 1 Workbook Wrapped in two pieces of cloth

• 1 – Cloth represented old time Paris: DAVID TEXTILES Paris Hot Air Balloons Cotton Fabric by The Yard (1 Yard) (Amazon)
• 1 – Cloth represented old world maps: DAVID TEXTILES Map of The World Cotton Fabric by The Yard (1 Yard) (Amazon)

• 3 Rolls of button sticker dots from UPINS 3000 Pcs Point Dots Balloon Glue Removable Adhesive Point Tape, 30 Rolls Double Sided Dots Stickers for Craft Wedding Decoration

• 1 Battery Tea Light from BEICHI Flameless LED Tea Light Candles with Timer, 12 Pcs Battery Operated Votive Tea Lights Candle for Home Party Decorations, 6 Hours On and 18 Hours Off in 24 Hours Cycle Warm White Light

• 1 plastic box that holds the Women in Science Card and the Paper Dolls

• Photo Storage Keeper, (For organization and to protect them), Case: Length: 4 5/8", Width: 6 5/8", Height: 1 5/8", SKU 149476 (Hobby Lobby)

• 1 6x6 plastic box to protect the scrap book paper: ArtBin 6953AB ClearView 6" x 6" Box Art & Craft Organizer, [1] Plastic Storage Case, Clear (Michaels/Hobby Lobby/Amazon)

• 1 8x11 clear plastic folder to hold paper, permission form, and scissors. YoeeJob 15 PCS Letter Poly Clear Envelopes with String Closure 1-Inch Gusset Side Loading Folders (Amazon)

• 1 small bag of assorted keys (approximately 10) created from 125Pcs Antique Bronze Vintage Skeleton Key Charms DIY Necklace Pendant for Handmade Jewelry Making Wedding Party Favor & Birthday Party (Amazon)

• 1 small bag of assorted gears (approximately 10) created from BIHRTC 140 Gram (Approx 92pcs) DIY Assorted Color Antique Metal Steampunk Watch
Gear Cog Wheel Skull Musical Note Skull Hand Safety Pin Charms Pendant for Crafting, Jewelry Making Accessory

- 1 pen

- 1 Large Key from Makhry Mixed 20 Extra Large Antique Skeleton Keys Rustic Key for Wedding Decoration Favor (Amazon)

- 2 Safety Pins

- Gold or Yellow Yarn to Tie the cloth fabric around the workbook

- 1 Clear Vinyl Luggage Tag with metal connecting ring: Cruise Luggage Tags, 12 Pack Cruise Luggage Tags Clear E-tag Holders Zip Seal & Steel Loops for Cruise Ships

- 1 – Pack of Earthton 50 Sheets Cardstok Pack, 65 lbs, 5 Colors, 10 Each, 8.5IN x 11IN by thePaper Studio, Item #732339 (Hobby Lobby).

- 2 Cloth bags

- 10x Burlap Bags with Drawstring by BHSKJSZ 5x7.5” Party Bags Gift Bags Tags or Wedding and Party Favors, DIY Craft-Extra L (Amazon)

- Cotton Produce Bags - Large 10x12 Inch - 12 Pcs Multipurpose Eco Bags - Muslin Bags with Drawstring - Canvas Bags - Vegetable and Bread Bags - Fabric Sachet Bags - Linen Bag by Leafico (Amazon)

- 1 Workbook : 9”x12” Hardcover Sketchbook Turquoise Blue – Mondo Llama™ (Target)

- 2 Self-Sealing Storage Bags – 2” x 3, Length 3”, Width 2”, 150 bags, SKU 888651 (Amazon)
APPENDIX B. INSTITUTIONAL REVIEW BOARD CLEARANCES

Approval for the participation of the girls was given by the Florida Institute of Technology Institutional Review Board. Participation in the research activity is voluntary. Participants were given informed consent.

Notice of Expedited Review Status
Certificate of Clearance for Human Participants Research

Principal Investigator: Robert Konczynski
Date: February 15, 2020
IRB Number: 20-019
Study Title: Motivating Young Women in STEAM Workbook Survey Pilot Study

Your research protocol was reviewed and approved by the IRB Chairperson. Per federal regulations, 45 CFR 46.110, your study has been determined to involve no more than minimal risk for human subjects. Federal regulations define minimal risk to mean that the probability and magnitude of harm are no more than would be expected in the daily life of a normal, healthy person.

Unless you have requested a waiver of consent, participants must sign a consent form, and the IRB requires you give each participant a copy of the consent form for their records. For online surveys, please advise participants to print out the consent screen for their files.

All data, which may include signed consent form documents, must be retained in a locked file cabinet for a minimum of three years (six if HIPAA applies) past the completion of this research. Any links to the identification of participants should be maintained on a password-protected computer if electronic information is used. Access to data is limited to authorized individuals listed as key study personnel.

Prompt reporting to the IRB is required in the following conditions:
• Procedural changes increasing the risk to participants or significantly affecting the conduct of the study
• All adverse or unanticipated experiences or events that may have real or potential unfavorable implications for participants
• New information that may adversely affect the safety of participants or the conduct of the study.

This study is approved for one year from the above date. If data collection continues past this date, a Protocol Renewal Form must be submitted.
Notice of Expedited Review Status
Certificate of Clearance for Human Participants Research

Principal Investigator: Robert (Robbie) Konczynski
Date: December 5, 2020
IRB Number: 20-118
Study Title: Motivating Young Women in STEAM Creating a Workbook/Digital Content

Your research protocol was reviewed and approved by the IRB Chairperson. Per federal regulations, 45 CFR 46.110, your study has been determined to involve no more than minimal risk for human subjects. Federal regulations define minimal risk to mean that the probability and magnitude of harm are no more than would be expected in the daily life of a normal, healthy person.

Unless you have requested a waiver of consent, participants must sign a consent form, and the IRB requires you give each participant a copy of the consent form for their records. For online surveys, please advise participants to print out the consent screen for their files.

All data, which may include signed consent form documents, must be retained in a locked file cabinet for a minimum of three years (six if HIPAA applies) past the completion of this research. Any links to the identification of participants should be maintained on a password-protected computer if electronic information is used. Access to data is limited to authorized individuals listed as key study personnel.

Prompt reporting to the IRB is required in the following conditions:
- Procedural changes increasing the risk to participants or significantly affecting the conduct of the study
- All adverse or unanticipated experiences or events that may have real or potential unfavorable implications for participants
- New information that may adversely affect the safety of participants or the conduct of the study.

This study is approved for one year from the above date. If data collection continues past this date, a Protocol Renewal Form must be submitted.
Request for Revision

Use this form to report any changes to a previously approved protocol or consent form. Changes must be approved by the IRB prior to their implementation.

1. Principal Investigator Name: Robert (Robbie) Konczynski
   Title of Project: Motivating Young Women in STEAM Creating a Workbook/Digital Content
   IRB Number: 20-118

2. Does this revision increase risks to participants enrolled in the study?
   [ ] Yes  [ ] No  [ ] X

3. Describe revision requested:
   Parents have expressed interest in allowing me/researchers to have face to face interactions. They feel I am no additional risk than what they already experience in the school setting. I will adhere to the CDC guidelines and wear facial coverings when appropriate to do so. Meeting with the participants face to face will be up to the discretion of the parents and the organizers (e.g. Girlscout, dance school, etc.) of any group settings. I will have the opportunity to interact with the participants at a girl scout meeting where precautions for COVID are already in place and they are already in a group setting. Participants will be socially distanced from me following CDC guidelines. Social distancing will be achieved by using large tables and/or sitting outside. I will social distance myself from the participant by sitting on the other end of the table and following the CDC guidelines.

   I am also asking for an extension of the IRB to April 2022.

4. Attach revised protocol and/or consent [highlight all revisions]:
   The protocols and consent forms all still the same except that for some participants I will be in person.
Changes to the IRB: (I could not highlight the sections in the PDF since they are text boxes, my software wouldn’t let me do this)

PART 3, Section 1:

The general purpose of this study is to help the participants build a STEAM workbook. The aim is that by building the workbook they get a better understanding and appreciation for STEAM and careers they could pursue in the future. The information collected is qualitative about their thoughts and ideas about STEAM and careers that they want to pursue. This IRB is seeking approval to conduct a mini science fair with the participants, online via Zoom (due to COVID 19) and face to face following CDC guidelines, where they will select a topic of interest and “the most knowledgeable other will help them research it and inspire them about STEAM.” Zoom meetings will be used to communicate with participants.

PART 3, Section 8:

Zoom calls and face to face meetings will be arranged with the participants based on parental/guardian preference. The Zoom calls will be recorded with the permission of the Participant and the Parent/Guardian. If the session is not allowed to be recorded then note taking will be used. Additional researchers and the Most Knowledgedte other may be on the Zoom call with permission.

Signature of PI: __________________________ Date: 10/4/2021

Signature of Major Advisor: __________________________ Date: 10/4/2021

(If PI is a student)

For IRB Use:

<table>
<thead>
<tr>
<th>Approval</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Approved</td>
<td></td>
</tr>
<tr>
<td>Approved Pending Changes</td>
<td></td>
</tr>
</tbody>
</table>

Jignya Patel, Ph. D.

IRB Approval __________________________ Date: __________________________
APPENDIX C. PARENTAL CONSENT FORM FOR PHASE 1

Study Title:
"Motivating Young Women in STEAM Workbook Survey Pilot Study"

Researchers: Robbie Konczynski and Dr. Samantha Fowler

This is a parental permission form for research participation.
It contains important information about this study and what to expect if you permit your
child to participate.

Your child's participation is voluntary.
Please consider the information carefully. Feel free to discuss the study with your friends
and family and to ask questions before making your decision whether or not to permit
your child to participate. If you permit your child to participate, you will be asked to sign
this form and will receive a copy of the form.

Purpose:
The general purpose of the study is to ask your child questions about STEAM to see if
they can offer insight as to what activities should be created for the development of a
STEAM workbook. The information gained will help us better understand what sorts of
curriculum and rubrics to use to create a workshop where participants will be asked to
create their own STEAM workbook.

Procedures/Tasks:
This study is to collect ideas from the participants about what would be good ideas to
include in a STEAM workbook.
The measurement instrument will be a semi structured interview where the researcher
will ask the participants the following questions. Based on their answers the researcher
will ask follow-up questions to help discover their idea.
  Q1: What would you include in a STEAM (Science, Technology, Engineering,
        Arts, and Mathematics) workbook? I.e. Activities
  Q2: Think about the S or T or E or A or M what would you put in the book to
        address these parts of STEAM (Science, Technology, Engineering, Arts, and
        Mathematics).
  Q3: What would motivate you to get involved in STEAM?
  Q4: What do you think about a workbook being themed in Steam Punk?
  Q5: Would you like a workbook that explores Lightning?

Research Protocol:
Begin
Ask parents if I may ask their child questions about STEAM
Ask parent to sign consent form (this form)
Ask participants, 2 or 3 at a time the questions stated above about STEAM.
Ask participant to come up with a fake name.
Write fake name, age, and grade level on index card or paper.
Ask the questions listed above
Write down their answers
Ask the participants to write down notes too
Collect participants cards.
Thank the participants for their time.
Analyze data

End.

**Duration:**
If you give consent, your child will work with a researcher for about 15 minutes one time. Your child may leave the study at any time. If you or your child decides to stop participation in the study, there will be no penalty and neither you nor your child will lose any benefits to which you are otherwise entitled. Your decision will not affect your future relationship with the researchers.

**Risks and Benefits:**
There are not any major potential risks that may occur to participants during this study. Participants may benefit from learning more about STEAM and thinking about it in a different context than they have before. It will also benefit society because there have been very limited studies conducted to understand what should go into a STEAM workbook. Many studies have been done on STEM but not many on STEAM. Additionally, this would benefit teachers so that they can build better curriculum and rubrics to create an interactive activity of building a STEAM workbook.

**Confidentiality:**
All data collected in this study will be kept in a binder/storage bin for all participants. Only the primary and coinvestigators will have access to the data/binder/storage bin. Informed consent will be obtained from the parents (this form) for their child’s participation. The participants data will be anonymized from the moment of collection and one will not be able to link the data back to the participant. Furthermore, your child's data, which is anonymized, may be reviewed by the following groups (as applicable to the research):

- Office for Human Research Protections or other federal, state, or international regulatory agencies;
- The Florida Institute of Technology Review Board or Office of Responsible Research Practices.

**Participant Rights:**
You or your child may refuse to participate in this study without penalty or loss of benefits to which you are otherwise entitled.
If you and your child choose to participate in the study, you may discontinue participation at any time without penalty or loss of benefits. By signing this form, you do not give up any personal legal rights your child may have as a participant in this study. An Institutional Review Board responsible for human subject’s research at Florida Institute of Technology reviewed this research project and found it to be acceptable, according to applicable State and Federal regulations and University policies designed to protect the rights and welfare of participants in research.

Contacts and Questions:
For questions, concerns, or complaints about the study, or if you feel your child has been harmed as a result of study participation, you may contact Lina M. Majdalany, PhD., BCBA (321) 5057770. Information involving the conduct and review of research involving humans may be obtained from the Chairperson of the Institutional Review Board of the Florida Institute of Technology, (321) 674-8104.

I have read (or someone has read to me) this form, and I am aware that I am being asked to provide permission for my child to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to permit my child to participate in this study.
I am not giving up any legal rights by signing this form. I will be given a copy of this form.

____________________________________
Printed name of subject

____________________________________
Printed name of person authorized to provide permission for subject

____________________________________
Signature of person authorized to provide permission for subject

____________________________________
Relationship to the subject

____________________________________
Date and time

AM/PM
Investigator/Research Staff

I have explained the research to the participant or his/her representative before requesting the signature(s) above. There are no blanks in this document. A copy of this form has been given to the participant or his/her representative.

__________________________  __________________________
Printed name of person obtaining  Signature of person obtaining consent
consent

__________________________
AM/PM
APPENDIX D. PARENTAL CONSENT FORM FOR PHASE 2

Study Title:
"Motivating Young Women in STEAM Workbook"

Researchers: Robbie Konczynski and Dr. Samantha Fowler

This is a parental permission form for research participation.
It contains important information about this study and what to expect if you permit your child to participate.

Your child's participation is voluntary.
Please consider the information carefully. Feel free to discuss the study with your friends and family and to ask questions before making your decision whether or not to permit your child to participate. If you permit your child to participate, you will be asked to sign this form and will receive a copy of the form.

Purpose:
The general purpose of the study is have your child participate and three workshops that are designed to inspire STEAM. Your child will create a STEAM workbook. The information gained will help us better understand what sorts of projects and problems young women are interested in solving.

Procedures/Tasks:
The participant will attend three workshops. Each workshop will teach various aspects of STEAM and have your child use active learning to build a STEAM workbook. Workshop one will focus on the S in STEAM. Workshop two will focus on the T and E of STEAM. Workshop three will focus on the A and M of STEAM. Each workshop is intended to build upon the workbook the participants are building. Each workshop will begin with a small lesson and then the participants will work on their workbook with the help of the adult team.

Research Protocol:
Participant signs up for the study
Participant attends and is invited to workshop 1
Participant attends and is invited to workshop 2
Participant attends and is invited to workshop 3
During each workshop the participant will build on their workbook with the help of their adult team members.
During the process the participant will be asked questions and interviewed.
When the workshop concludes the adult team will Analyze data and look for emergent themes.

Duration:
If you give consent, your child will work with a researcher for about one month. Your child may leave the study at any time. If you or your child decides to stop participation in the study, there will be no penalty and neither you nor your child will lose any benefits to which you are otherwise entitled. Your decision will not affect your future relationship with the researchers.

Risks and Benefits:
There are not any major potential risks that may occur to participants during this study. Participants may benefit from learning more about STEAM and thinking about it in a different context than they have before. It will also benefit society because there have been very limited studies conducted to understand what should go into a STEAM workbook. Many studies have been done on STEM but not many on STEAM. Additionally, this would benefit teachers so that they can build better curriculum and rubrics to create an interactive activity of building a STEAM workbook.

Confidentiality:
All data collected in this study will be kept in a binder/storage bin for all participants. Only the primary and coinvestigators will have access to the data/binder/storage bin. Informed consent will be obtained from the parents (this form) for their child’s participation. The participants data will be anonymized from the moment of collection and one will not be able to link the data back to the participant. Furthermore, your child's data, which is anonymized, may be reviewed by the following groups (as applicable to the research):

- Office for Human Research Protections or other federal, state, or international regulatory agencies;
- The Florida Institute of Technology Review Board or Office of Responsible Research Practices.

Participant Rights:
You or your child may refuse to participate in this study without penalty or loss of benefits to which you are otherwise entitled. If you and your child choose to participate in the study, you may discontinue participation at any time without penalty or loss of benefits. By signing this form, you do not give up any personal legal rights your child may have as a participant in this study. An Institutional Review Board responsible for human subject’s research at Florida Institute of Technology reviewed this research project and found it to be acceptable, according to applicable State and Federal regulations and University policies designed to protect the rights and welfare of participants in research.

Contacts and Questions:
For questions, concerns, or complaints about the study, or if you feel your child has been harmed as a result of study participation, you may contact Lina M. Majdalany, PhD., BCBA (321) 505-7770. Information involving the conduct and review of research involving humans may be obtained from the Chairperson of the Institutional Review Board of the Florida Institute of Technology, (321) 674-8104.

I have read (or someone has read to me) this form, and I am aware that I am being asked to provide permission for my child to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to permit my child to participate in this study.

I am not giving up any legal rights by signing this form. I will be given a copy of this form.

____________________________________  ________________________
Printed name of subject  Printed name of person authorized to provide permission for subject

____________________________________  ________________________
Signature of person authorized to provide permission for subject  AM/PM

____________________________________  ________________________
Relationship to the subject  Date and time
Investigator/Research Staff

I have explained the research to the participant or his/her representative before requesting the signature(s) above. There are no blanks in this document. A copy of this form has been given to the participant or his/her representative.

________________________________________  ______________________________
Printed name of person obtaining consent  Signature of person obtaining consent

AM/PM

________________________________________