UNDERSTANDING HOW TO INTEREST GIRLS IN STEM EDUCATION: A LOOK AT HOW LEGO® EDUCATION AMBASSADOR TEACHERS ENGAGE FEMALE STUDENTS IN STEM LEARNING

By

JENNIFER NASH

A DISSERTATION PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF EDUCATION

UNIVERSITY OF FLORIDA

2017

© 2017 Jennifer Nash

To Scott and Shelly
for inspiring me everyday

ACKNOWLEDGMENTS

I would like to begin by thanking the members of my doctoral committee and other faculty that I worked with during my program. Studying at the University of Florida with such an elite group of professors has been an honor I am thankful for each day. Although I was challenged throughout the program, I felt a sense of community with the faculty that made the impact of learning even greater. I would like to thank Dr. Nancy Dana, who was an inspiration to my study of practitioner research for many years prior to even entering the program. Having you as my doctoral chair was an amazing bonus to the entire experience. While you continued to push me, you also cheered me on through every step. I will never forget the moment you challenged me to find my passion. I am truly grateful for the opportunity to work so closely together and for everything you taught me. Because of you, I am confident I will continue my work as a practitioner scholar who will always have an eye toward inquiring into my practice.

I also want to thank Dr. Aki Murata for being the co-chair on my committee. I will always remember our initial brainstorming sessions and all the encouragement you gave me as I was starting the research process. I want to thank Dr. Rose Pringle and Dr. Mary Koroly for being part of my journey and providing valuable feedback. Having such a strong group of female educators on my committee was an inspiration for me. I appreciate what each of you bring to your field of study as a strong female role model for other students. I also want to give a special thank you to Dr. Sheryl Howie for her support through the entire dissertation process. Not only did you get me through, but I learned so much from you in the process. I want to thank all the professors whose passion for the CTTE program is so evident and appreciated. I have never had my thinking pushed so far past my comfort zone and been thankful for it.

I also want to acknowledge the “most awesome” cohort #3. I am thankful that I was able to know each of you and work with you. We were a diverse group of educators with a range of

experiences, which created great discussion in our classes. I appreciate that you were there for support when I needed you. I thank you for teaching me so much in our time together and hope we will continue to stay in touch. I appreciate that I have been privilege over the years to work with many amazing educators. I have learned so much and am thankful for the opportunity to have worked with them all. I could spend another hundred pages listing the influence other educators have had on me. I will simply say thank you to all the educators whom I have known and worked with over the years and for all I learned from you. I have been blessed with amazing mentors and role models. I would like to give a special thank you to the three teachers that allowed me into their classrooms as part of this study. I see so much value in learning from what others are doing. I appreciate your willingness to contribute to others and support life-long learning through sharing with me. I also want to acknowledge my LEGO® Education family; I appreciate the opportunity to work with such a dynamic group of people that share my enthusiasm for bringing meaningful learning experiences to students.

Most importantly, I want to thank my family without whom I could not have completed this process. I could not ask for a better support system then my parents. Your unending love and support have made me the person I am today. I want to thank my mom, Debbie, who taught me to approach life like I am ten feet tall. Although there were times I could not believe I was in a doctoral program, I always knew I could do it because, as always, you were right behind me as my cheerleader. I love you for being an amazing supporter and role model who is always in my corner. I want to thank my dad, John, who taught me that all good things start with getting up early, which allowed me to tackle the work associated with this program. There is no one in this world that I am more like, and I am so lucky. I am thankful that you always pushed me to be my best and supported me to be everything that I wanted to be in life. I am also thankful for my big

brother, Johnny, for always having my back and celebrating all my adventures. I always know you are proud of me and that you are there to support me

Above all else, I want to acknowledge the two people in my life that I love and value the most, Scott and Shelly. I cannot thank Shelly enough for being an amazing daughter who, without fully understanding the significance of what I was doing, always supported me and was proud of me. I appreciate your sacrificed playtime and attention so that I could complete homework. I really enjoyed when we could jump in the big chair together to read and do our homework at the same time. I cherish all our time together. I hope seeing me graduate inspires you to put the work in for what you want in life and go after all your dreams. I also need to give a special mention to Lam for the countless hours at my side as I was reading and writing to complete this program. I could not ask for a better sidekick.

Lastly and most importantly, I want to thank my husband, Scott. You are my inspiration to do the things I do in life. You are my everything. I never would have even applied to a doctoral program if I did not have you there every step of the way. I know your support and love will never end. I am thankful every day that I married my best friend. Throughout this process, I always knew you were ready to discuss what I was reading, read my papers, and challenge my thinking. I look forward to returning the favor. I know I will always have you by my side and love you dearly.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract of Dissertation Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Doctor of Education

UNDERSTANDING HOW TO INTEREST GIRLS IN STEM EDUCATION:
A LOOK AT HOW LEGO® EDUCATION AMBASSADOR TEACHERS
ENGAGE FEMALE STUDENTS IN STEM LEARNING

By

Jennifer Nash

December 2017

Chair: Nancy Dana
Cochair: Aki Murata
Major: Curriculum and Instruction

While current educational standards serve to ensure all students have access to quality education that engages them in learning the skills that STEM teaches, there continues to be a gap in female students taking STEM-related classes in high school and subsequently entering STEM related careers. Gaining female learners' interest in STEM during middle school has the potential to address this problem. As an Educational Specialist for LEGO®[1] Education, I am responsible for the professional learning and preparation of teachers as they learn to use LEGO® Education materials to enhance STEM education. Through this study, I sought to investigate ways that LEGO® Education Ambassador Teachers (educators selected as exemplary practitioners by LEGO® Education) engage female students in LEGO® Education lessons to heighten their interest in STEM learning. Framed through the lens of practitioner research, the goal of this investigation was to enable me, through the findings distilled in this study, to improve the

[1] The LEGO® brick, LEGO® Education, and LEGO® MINDSTORMS® Education are registered trademarks of the LEGO® Group.

professional development I offer to teachers by heightening their awareness of the unique needs of female students as well as pedagogical approaches to instruction that help address those needs.

Three middle school Ambassador Teachers from various geographic locations were selected through purposeful sampling to participate in this study. Borrowing from Seidman's (2012) phenomenological interview approach, data collection included three interviews with each participant as well as classroom observation and researcher journaling.

Analysis of data led to the construction of narratives for each teacher, which are presented first, followed by a discussion of ten common practices related to engaging female learners that were apparent across all three participants. These common practices include: (1) creating a culture of discussion, (2) using challenging projects, (3) providing role models, (4) scaffolding building and spatial skills, (5) encouraging stories, (6) planning for success, (7) devising group dynamics, (8) promoting self-efficacy, (9) setting high expectations, and (10) allowing for relevancy and choice. Implications for teachers who wish to purposefully interest their female students in STEM careers are discussed, along with implications for my own practice and actions taken to improve my work as a LEGO® Education Specialist.

CHAPTER 1
INTRODUCTION TO THE STUDY

The U.S. Department of Education (2015) calls for students to be educated in Science, Technology, Engineering, and Mathematics, or STEM areas, to prepare students for future careers where the ability to problem solve using skills in all these areas will be important. There is a high demand for students to enter STEM fields since 20% of jobs in the U.S. are considered a STEM-related field or require advanced knowledge in one of these fields (Tanenbaum, 2016). Additionally, research showed that students need in-depth preparation in math and science during college to be prepared for 90% of the fastest growing jobs (Hill, Corbett, & St. Rose, 2010), and jobs in all fields require the skills that STEM education teaches (U.S. Department of Education, 2015). Students need to be more proficient in applying their knowledge rather than just learning knowledge itself. While the U.S. has seen improvement in setting higher standards and improving the graduation rate over the last eight years (Executive Office of the President, 2015), we struggle to produce students proficient in areas of STEM, with less than 20% of high school seniors interested in going into STEM fields (U.S. Department of Education, 2015). Research showed, however, that all students, whether talented in STEM areas or not, demonstrate a higher ability to think critically when exposed to STEM learning opportunities (Tanenbaum, 2016).

The U.S., in both academia and industry, is now pushing to ensure all students have access to quality STEM instruction in the hope of creating a new generation of STEM educated students to enter the workforce. A recent letter from the Department of Education (2016) indicated that federal funding will be provided to better support more rigorous STEM education for all students. Federal grant dollars are being put toward funding more opportunities for STEM learning, both in and out of school, and preparing more teachers in these areas. This plan includes a focus on underrepresented populations, which would include female students (U.S.

Department of Education, 2015). The goal is for the funding to become an equalizer for schools that currently do not have the resources for strong STEM programming, combating the current irregularities among schools as indicated by the research (Tanenbaum, 2016). It will also become an equalizer for minority student groups that do not currently have access to STEM education and resources. Realizing that there will be a greater focus on STEM education in the classroom, it is imperative to better understand what good STEM education looks like and how to best engage different groups of students in STEM areas. As Basham and Marino (2013) stated, "teachers need a practical understanding of STEM education with an emphasis on how to integrate and scaffold STEM learning experiences" (p. 9). Only then will teachers be able to differentiate STEM instruction to meet the needs of all learners.

Background and Significance of the Problem

While STEM teaching continues to gain focus and is seen as important for all students, not all students are experiencing equal success. Women comprise almost half of the U.S. workforce; however, women still make up a smaller percentage of the STEM workforce (Beede, Julian, Langdon, McKittrick, Khan, & Doms, 2011). Although progress has been made with an increase in the number of women earning degrees in STEM areas, women still represent a smaller percentage of the STEM workforce overall (Hill, Corbett, & St. Rose, 2010). The lack of women in STEM areas presents a significant problem in the field. Having more females entering STEM-related areas creates a more diversified workforce. Milam (2012) pointed out how a male dominated workforce can create linear thinking in the field. Bringing in different perspectives from different groups can open up new ideas. For example, women bring an important perspective to products designed for use by women (Hill, Corbett, & St. Rose, 2010), needs that might otherwise be ignored or overlooked. The dominant group tends to view the world through their own lens, without consideration of what other groups need (Sensoy &

DiAngelo, 2012). Without a female perspective, many products designed for use by women do not meet women's actual needs.

Looking at the data, the percentage of women in different areas of STEM varied greatly depending on the discipline. There were higher percentages of females in areas of biological sciences, but extremely low percentages in areas of engineering. Some areas, like computer science, have seen declines in the percentage of women entering the field over the last 30 years (Hill, Corbett, & St. Rose, 2010). Women who enter STEM fields were more likely to enter areas of social science or medical sciences than areas of engineering, computer science, physics, or mathematical science, which remained male dominated fields (National Girls Collaborative Project, 2016). Similar results were found in the number of women taking courses in these areas in high school as compared to men. Women were taking courses and doing well in areas of biology and social science, but in areas like physics and engineering, the number of women taking courses was not as high. In areas of math, however, girls and boys were scoring more evenly on average (Hill, Corbett, & St. Rose, 2010), with a higher percentage of girls taking mathematics courses (National Girls Collaborative Project, 2016).

These statistics bring into focus the fact that females are capable of success in STEM disciplines, but may not be interested in these areas. Therefore, there is a need to better understand what engages female students in STEM areas in order to better understand how to prepare female students to enter these fields. Buschor, Berweger, Frei, and Kappler (2014) described the need to understand more than just ability level when determining why students choose to study STEM. It is important to consider students' interests, their beliefs in their ability to succeed in math and science, and social issues such as economic status and gender in determining what will involve students in STEM learning (Buschor et al., 2014). Teachers can

then be purposeful in designing STEM learning that they know will encourage groups of students, including girls, to stay interested in the field.

Purpose of the Study and Research Questions

The literature shows a continued need and recent push toward STEM learning for all students. However, it asserts that females are not entering the same STEM areas as men, possibly due to a lack of interest in areas such as engineering, physics, and computer science. Additionally, females are not taking courses in these areas during high school. Therefore, it is necessary to consider ways to spark interest in female students prior to high school in order for them to be motivated to engage in these areas and find success. Shapiro, Grossman, Carter, Martin, Deyton, and Hammer (2015) showed that girls in middle school were already considering potential career paths. Understanding what engages female students in STEM areas during and prior to middle school could help prepare and attract them specifically in STEM-related areas.

In my own context, I work with educators by providing professional development, model teaching, and support in implementing new teaching practices and curriculums into the classroom. As an Educational Specialist for LEGO® Education, I work specifically with educators interested in implementing LEGO® Education manipulatives and curriculums into their classrooms. LEGO® Education's main focus is around STEM teaching with various learning solutions for students in pre-school through high school. I am able to work with educators throughout the U.S. with these learning solutions to better prepare their students in STEM areas. For the purpose of this study and in my context, STEM learning is the integration of science, technology, engineering, and math with 21st century skills such as critical thinking, collaboration, communication, and creativity. Through working with a variety of educators to change their teaching practices and implement STEM teaching methods, I have the opportunity to influence

many students and to open up more interest in STEM-related fields for those students. Therefore, I have the opportunity to influence the way educators implement LEGO® Education teaching practices to inspire more girls to be interested in and excited about STEM.

Additionally, I work with the LEGO® Education Ambassador Program teachers, which consists of 32 educators in pre-school, elementary school, middle school, high school, and at the university level, that represent model educators for LEGO® Education. The ambassador educators are located throughout the U.S. in a variety of classroom types, including rural and urban schools, high and low poverty schools, and public and charter schools. These educators use a variety of LEGO® Education curriculums and manipulatives in their classrooms to educate students in an inquiry-based environment. They provide a look at how the LEGO® Education manipulatives and curriculums are being used in a live classroom. Their classrooms also provide a window into how students are working with and reacting to the materials. By studying the actions of the ambassador teachers, I was able to discover where they are finding success in promoting STEM with female students to better inform my own practice.

The purpose of this study was to investigate ways that ambassador teachers engaged female students in LEGO® Education lessons to heighten their interest in STEM learning. The study looked at a small group of the ambassador educators working in middle schools to investigate how these teachers encouraged girls to participate in STEM activities. The research question and sub-questions that guided my study are

- How are the STEM-related lessons delivered by LEGO® Education ambassador teachers fostering the engagement of female students in STEM areas?
    - How do ambassador teachers purposefully try to interest female students in STEM learning?
    - What characteristics of the LEGO® Education STEM material do teachers perceive to be conducive to engaging girls in STEM?

Significance of the Study

The U.S. Department of Education (2015) continues to call for students to be educated in STEM areas in order to prepare students for future careers where the ability to problem solve using skills in all these areas will be important. However, there continues to be a gap in the number of females entering STEM-related fields. Men still represent a higher percentage of the STEM workforce than women, even though more women are entering into science and engineering fields today than in previous years. In order to close the gap, females need to be exposed to STEM areas in school, and educators need to find ways to interest female learners.

The company I work for, LEGO® Education, creates learning solutions to engage students in STEM experiences. LEGO® Education teaching solutions provide manipulatives for use in the classroom by providing unique combinations of the familiar LEGO® brick in sets designed for classrooms. All sets have curriculum designed by teachers to meet national teaching standards that provide insight and lesson plans for the teacher to use. Many sets also provide digital components such as programming software. While my company is grounded on the belief that every student can succeed through engaging in playful learning experiences in the classroom, the company has not yet focused specifically on female learners in science and how our materials might work to interest female learners in STEM fields. My work in this area can help inform my company to support future development of educational materials that will match the needs of female students and keep them interested in STEM areas.

In addition, I provide professional implementation support for teachers across the nation on the use of LEGO® Education materials. Currently, my work does not focus specifically on the potential LEGO® Education materials might have for engaging female learners in STEM. I conducted this study to inform my own practice as a leader of professional learning for teachers. Using what I learned from the ambassador teachers in this

study, I will take action to improve my own practice to support other educators related to engaging female students in STEM learning.

As a student in the professional practice doctoral program in the Curriculum, Teaching, and Teacher Education Program at the University of Florida, this capstone project was designed to provide personal relevance to my own educational practice. According to Archbald (2008), the capstone project experience in a professional practice doctoral program should focus on responding to a local problem of practice. In my context, my problem of practice focuses on how to capitalize on the position I hold within LEGO® Education to raise teachers' awareness across the nation about the importance of engaging female learners in STEM learning early in their education and illuminating specific strategies for doing so based on what I learn from this study. Scholars, such as Auerbach (2011), who write about the capstone project experience for professional practice doctoral students suggest the study should focus on answering the question, "How do you want to change your corner of the world?" (p. 69). I engaged in this study to change the ways professional learning and implementation support is offered through LEGO® Education to better illuminate the role our materials can play in engaging girls in STEM learning and STEM-related fields.

Relevant Literature

The purpose of this study was to investigate ways that ambassador teachers engaged female students in LEGO® Education lessons to heighten their interest in STEM learning. To understand what the teachers were doing that was effective in interesting females, it was important to consider the literature that examined how female students engage in STEM learning and what barriers exist that prevent them from entering STEM-related fields. First, I will establish a description of STEM learning and then look at the research on girls in STEM.

Description of STEM

One practical definition of STEM education is that it integrates knowledge from science, technology, engineering, and mathematics to solve real world problems. According to Weld (2017), STEM learning allows teachers "to integrate concepts across disciplines and to put kids in the driver's seat as active learners" (p. 2). The collaborative problem solving and critical thinking required of STEM learners is important to many of today's career fields. However, despite this knowledge and the fact that the concept of STEM has been around since the 1990's, STEM has only recently received emphasis in the educational community (Sanders, 2009). STEM education has gained momentum over the last decade due to evidence that there would not be a workforce large enough to fill future STEM-related positions (Brown, Reardon, & Merrill, 2011). As a result, there has been a push to bring more students into STEM-focused educational programs. With these programs, additional benefits have occurred from exposing students to a more STEM-based curriculum, including the development of critical thinking and problem solving skills. As a result, momentum has grown around all students having STEM-based experiences and being prepared for jobs that are related to areas of STEM.

Interestingly, Brown et al. (2011) found that there is still a large number of educators who do not know of or really understand STEM education. Tanenbaum (2016) reported the same finding among the public. With a strong push for STEM learning, it is important to know what is expected in STEM education. Participants in the Brown et al. (2011) study who showed an understanding of STEM still had a variety of definitions for it, emphasizing the need to really define STEM education and its goals. Sanders (2009) made a similar claim that STEM is just a generic term that is not clear even to people using it.

Although there is not one agreed upon definition, there seems to be consensus that STEM education is more than just teaching science, technology, engineering and mathematics.

According to Tanenbaum (2016), STEM "can instill in students a passion for inquiry and discovery and fosters skills such as persistence, teamwork, and the application of gained knowledge to new situations" (p. 10). Brown et al. (2011) furthered this idea by adding the benefits of "increased problem-solving skills, critical thinking, and analytical thinking in students" through STEM learning (p. 5).

Understanding what students should gain from STEM education is an important step to ensuring educators are preparing students for the future in an appropriate way. Sanders (2009) furthered this point by looking at the reform efforts in STEM areas and showing that while we know there is a need for STEM educated students, the field does not yet know how to structure that education. The Office of Innovation and Improvement confirmed this point by acknowledging confusion even among educational leaders as to what STEM education constitutes (Tanenbaum, 2016). What is known is that numerous students are not interested in these areas early on and choose to take less demanding courses when possible (Sanders, 2009).

Brown et al. (2011) suggested that STEM involves more than just the areas of science, technology, engineering, and mathematics that the acronym represents. STEM teaching is about integrating all these subjects and connecting them to real world issues. STEM education should involve students working collaboratively, learning perseverance, and completing tasks or projects that require an application of knowledge (Tanenbaum, 2016). Learning through an inquiry approach, where students use their skills to uncover new knowledge, is at the essence of STEM learning. Therefore, the premise behind STEM education is that areas of science, technology, engineering, and math cannot be taught separately because in the real world these areas are working in tandem (Sanders, 2009). As a result, students should be using the STEM

subject areas in combination to learn how these areas intertwine and what skills are important across them all.

Girls in STEM

STEM learning engages students in different ways. Knezek, Christensen, Tyler-Wood, and Gibson (2015) found that boys and girls are interested in STEM for different reasons. Girls wanted to make an impact on the world or society, which means they considered career choices based on the type of impact they would make in that career. Bamberger (2014) studied how gender definitions determined who enters different types of science careers and found that girls tended to see the application of science to their lives differently than boys. As a result, girls were more likely to go into fields such as biology as opposed to fields like physics. Reports from the U.S. Department of Commerce supported this finding by showing that over the last decade more women are entering STEM fields, but in areas of physical and life sciences as opposed to engineering (Beede et al., 2011). Based on the current research, it is not due to their ability that girls are *not* entering STEM fields, but rather the way they see themselves engaging in STEM careers (Knezek et al., 2015).

Knowing that females have the interest and ability, some people question if it is a matter of role models in STEM fields that keep women from entering these areas. Milam (2012) cited several literature sources that showed the positive impact of role models for female students. The article called for more role models for girls at an earlier age. Hill, Corbett, and St. Rose (2010) also saw the need for role models in STEM to help girls know how to acknowledge and overcome the threat of stereotypes. Currently, there is a push from various organizations to create positive role models for girls in areas of STEM through popular media to give a broader view of women in STEM for society. Tanenbaum (2016) cites the example of Disney working with NASA and Google to develop shows like *Miles from Tomorrowland* to engage kids early in

STEM career options, including an emphasis on strong female role models in prominent STEM roles. The mother in the Disney series, for example, is the captain of the spaceship, and the sister does scientific research to solve the problems they encounter.

Bamberger (2014), however, found that exposing girls to positive female scientist role models did not always have a positive influence on girls believing they could succeed in STEM areas. In this study, girls were able to visit science labs to see and hear from females working in STEM-related jobs. Students who did not feel they could succeed in STEM areas explained that it was "hard" and "complicated" because of what they saw when visiting the lab (p. 556). The study showed that girls, in general, felt confident in the abilities of females to work in STEM areas, but not confidence in themselves individually to be successful. Nieto (2013) warned that the development of these negative identities can worsen, causing students to believe they are unable to change their abilities. Educators play a vital role in supporting students to keep a positive mindset and to not promote negative identities.

Additionally, self-efficacy was found to be an important factor in the success of girls in STEM areas. Milam (2012) defined self-efficacy as the student's belief in his/her own abilities. Students who could overcome biases and believe in their own abilities could succeed in STEM areas regardless of their background or minority group. Milan recommended that students need to disregard biases and focus on working hard to succeed in all STEM areas. Hill, Corbett, and St. Rose (2010) supported the need for self-efficacy in their recommendations for educators to demonstrate that girls and boys are equally capable of completing STEM tasks. Educators must stay alert to implicit biases that exist, even ones they are not aware of, and work to counteract those biases (Nieto, 2013). If girls do not feel they are at a disadvantage, they might better assess their actual abilities and gain self-confidence. Building this confidence at an early age

helps female students develop efficacy in STEM subjects and combats the negative stereotypes (Milam, 2012).

The individual lack of confidence that prevents girls from entering STEM careers might also be explained by other barriers that exist outside of school. Shapiro et al. (2015) found that girls and boys in middle school already connect different gender roles to certain jobs. Girls saw barriers they perceived as more specific to women, such as taking time off of work for family. McCullough (2011) showed that there are more obstacles for women entering STEM areas, including general biases such as not being aggressive and obligations to family based on societal views that a woman's place is in the home, which continued to hold women back. These implicit biases exist in educational policy, in the practice of educators, and society in general and affect the access some students have to STEM opportunities (Tanenbaum, 2016).

In addition to general obstacles, the review of literature by Shapiro and Williams (2012) found that girls are at-risk for success in specific areas of STEM, including math and science, because of the influence of others. The studies revealed that girls are exposed to and perceive stereotypes throughout their lives from the messages that teachers, family members, and the media gave regarding who should pursue areas of science and math. These messages created anxieties in girls and a belief that they could not succeed in these areas before they had a chance to try. As Sensoy and DiAngelo (2012) explained, "most discrimination is unconscious and takes place whether we intend to discriminate or not" (p. 3). Girls experience biases each day in everyday objects like the toys and games designed for girls versus what is designed for boys (Tanenbaum, 2016). Whether intended or not, these toys can create a biased view concerning the societal roles for girls and the societal roles for boys. Religion or culture was also an influence on how girls viewed their place in society and their abilities in STEM areas. Bamberger (2014)

found that females felt unable to combine a STEM career with having a family due to their religious upbringing. Sensoy and DiAngelo (2012) determined that the biases created an internalized oppression in female students, which caused girls to set lower expectations for themselves in male dominated areas, such as STEM, or girls believed they were not capable of achieving in these areas.

Further bias exists in areas where women have entered STEM careers. Hill, Corbett, and St. Rose (2010) found evidence that females in job roles considered historically male roles were viewed negatively in society. Women in these positions may not have fit in with their coworkers due to the biases that existed, which could create an uncomfortable working environment for females. Further, women might not have been viewed as capable in their work compared to men (Hill, Corbett, & St. Rose, 2010). This negative image created another reason why girls might choose to avoid STEM related fields. No one wants to enter a field where they will not be seen as or feel like an equal. According to Nieto (2013), it is important for educators to consider these concerns and other biases in the classroom to meet the students where they are at that point in time. Teachers cannot make assumptions about the background biases and stereotypes that girls have or have not experienced. Nieto (2013) suggested that lessons be designed to ensure teachers understand where the students are and how to help them move forward without adding additional bias by making assumptions, which means that teachers need to first take time to build relationships with the students.

Despite biases and stereotypes toward females in STEM areas, girls continue to show promise for success in STEM fields. Shapiro et al. (2015) examined confidence levels based on gender as an indicator for career choices. Boys were twice as likely to choose a career in a STEM area as girls. However, girls rated higher than boys in their level of confidence in areas of

leadership. The study also compared girls participating in Girl Scouts versus girls not, showing that girls in Girl Scouts rated the highest confidence levels overall. There was also a higher rate of girls participating in Girl Scouts who would choose STEM related careers versus girls who were not engaged with Girl Scouts.

Additionally, Cooper and Heaverlo (2013) found remarkable correlations between girls' interest in STEM areas and their interest and confidence in areas of problem solving and creativity and design. Their study revealed that girls with a high interest in problem solving had a higher interest in all areas of science, technology, engineering, and math; whereas, a high interest in creativity and design only predicted an interest in computers and engineering. The findings provided insight for teachers to create lessons that use problem solving to engage female learners and help them create confidence in STEM areas.

Girls have also shown that they have the ability to perform in STEM areas. Milam (2012) determined that girls score higher than boys in structured math areas, but do not do as well as boys in areas that require application. She found that girls have the ability to do well in STEM subjects, but struggle in the general application of STEM-like learning. Milam (2012) concluded that female students needed learning opportunities where they could apply their knowledge. Additionally, she found that girls are entering computer science and engineering fields at low rates, with only 18% of undergraduate degrees in these fields going to girls. These findings make sense when you consider Cooper and Heaverlo's (2013) findings that female interest in areas of computers declined as girls got older. Since women were receiving close to half of the degrees in math (Milam, 2012), connecting computer science and engineering fields to math skills may help female students understand the linkages between the discipline and their career choices.

If girls have the capability and the confidence to successfully complete STEM courses, why are female students not attracted to these fields? The findings from these studies indicate the need to understand more about the types of learning that engage female students to keep them in STEM areas so they might build confidence and become successful.

Understanding the barriers, biases, and ways that female students are succeeding in the classroom provides insight for teachers to understand how to approach STEM learning for their female students in the classroom. However, it is also important to consider the experiences females need in order to relate to STEM areas and understand career options. Tan, Barton, Kang, and O'Neil (2013) found that girls in middle school may not have the knowledge-base about science to link science-related fields to career options. The study found that girls were not able to connect the learning in their science classes to the jobs they were interested in pursuing. In addition to motivating girls and exposing them in a positive way to STEM-rich lessons, it is also important to consider how to prepare female students for STEM-related fields.

The literature provided evidence that female students were capable of achieving in STEM areas in the classroom, but there were other factors affecting their abilities to enter STEM-related fields. The literature revealed that educators needed to foster growth in girls' self-efficacy as much as they needed to promote learning in the subject areas in order for female students to be successful. Equally important to helping girls pursue work in STEM areas were the tasks of building relationships and countering biases that existed. The literature helps educators better understand what engages female students in these areas as well as the need to promote that interest from a young age. One potential way teachers may be able to promote female students' interest in STEM at a young age is through the use of LEGO® Education materials.

Study Context: LEGO® Education

As an Educational Specialist for LEGO® Education, I work closely with educators to integrate LEGO® Education STEM curriculum and manipulatives into their classrooms. LEGO® Education's mission is to engage students in playful learning experiences that enable every student to succeed. LEGO® Education's philosophy of learning is designed around constructivist theories of learning, which are based on the idea that students learn best through doing. To support the company's mission, I work closely with educators in a variety of ways. My work can include coaching, model teaching, implementation planning, and providing professional development to teachers. In addition, I work with other educators who also provide these support services to teachers implementing LEGO® Education programming.

LEGO® Education is an international company that creates STEM solutions designed to be used in many countries. In the U.S., curriculum is tied to national Common Core Standards and Next Generation Science Standards. LEGO® Education teaching solutions are designed by educators to bring manipulatives into the classroom supported by standards-based curriculum and digital components. The curriculum and materials are designed to supplement core teaching in areas of science, technology, engineering, and math. There is a focus around truly integrating these subjects in a way that enhances 21st century skills as well as content knowledge. However, there is not currently any curriculum or particular focus around what engages female learners with the materials.

LEGO® Education has STEM-focused learning solutions in elementary, middle and high school. Non-robotic options include Early Simple Machines for the kindergarten classroom, Simple Machines for the elementary classroom, and Simple and Powered Machines for middle school, which also includes Renewable Energy and Pneumatics add-on sets. These sets introduce students to physical science concepts and then expand the learning by connecting how the

mechanisms and machines work with the math skills being taught in the classroom. Robotic sets include WeDo 2.0 for elementary and LEGO® MINDSTORMS® Education for middle and high school. These sets include programming software that teach coding skills with a physical robot, which students design and build. Curriculum for all sets include teacher's resources, lesson plans, student activity sheets, and assessments. In this study, I was able to investigate the use of the LEGO® MINDSTORMS® Education materials and curriculums by current teachers using them in their classrooms.

LEGO® Education selects a group of educators, designated as LEGO® Education Ambassador Teachers, who have demonstrated their ability to successfully implement LEGO® Education STEM teaching and curriculum into their classrooms. These teachers use one or more of the products and curriculums in the classroom, but all used the LEGO® Education teaching philosophies. Studying this group of teachers provided me with a window into how to effectively implement teaching in the STEM areas using LEGO® Education materials. Since my goal is to better inform my own practice in these areas, studying the ambassador teachers provided an understanding of how teachers can implement STEM teaching practices utilizing LEGO® Education programming and engage female students in STEM learning.

Better understanding of what our ambassador teachers were doing helped shape my own practices in working with teachers and in designing implementation support to help educators new to LEGO® Education apply the curriculum and potentially new teaching methods to their classrooms. The ambassador teachers are located throughout the U.S. in various school settings, including elementary schools, middle schools, high schools, and universities. Thus, the study covered a variety of educators in a variety of contexts to see how the curriculum was being used

and what they viewed as being successful for their students, with a particular focus on the ways that ambassador teachers were motivating their female students.

Research Methods

Although practitioner research is more often associated with use by classroom teachers, I felt it was an appropriate way to frame this study as my goal was to inform my own practice as an educator working for the LEGO® Education Company. According to Dana and Yendol-Hoppey (2014), practitioner research is "the systematic, intentional study of one's own professional practice. Inquiring professionals seek out change by reflecting on their practice" (p. 12). I did not study my own practice directly, however, I studied teachers that represent my company. The study of these teachers, in turn, was undertaken purposefully to impact my practice of supporting other educators in their use of LEGO® Education materials. Through gaining examples and general techniques that LEGO® Education ambassador teachers used to successfully interest their female students in STEM learning, I am able to prepare others to implement LEGO® Education materials into their own classrooms with a heightened awareness of how the use of these materials interest female learners in STEM.

With practitioner research as the generic framework to approach the design of this study, I primarily employed qualitative research methodology to explore how LEGO® Education Ambassador Teachers were engaging female students in STEM learning, particularly drawing on the writings of qualitative research methodologists such as Patton (2015), Creswell (2013), Seidman (2012), and Jacob and Ferguson (2012). In this section, I share this methodology by describing the participants and how I selected them, as well as my data collection and analysis approach.

Participants

Currently, there are 32 ambassador teachers who work in a variety of environments, including pre-school, elementary, middle, high, and university classrooms. Teachers were chosen for the ambassador program based on submitting an application expressing their teaching philosophy and ways they have integrated LEGO® Education materials into their classrooms. Teachers were selected for the ambassador program because they had a commitment to teaching using the LEGO® Education philosophy and were interested in sharing their philosophies of teaching using LEGO® Education materials with the company to support bringing hands-on learning to more classrooms. The selection committee, which consisted of educational personnel and marketing representatives within the company, took recommendations from the sales team for teachers who would be a good fit for the program. Teachers were invited to apply based on these recommendations. Classroom visits made the final determination of which teachers were admitted to the group.

To determine which of the ambassador educators were included in this study, I used purposeful sampling to narrow the group of 32 teachers to three to five teachers. According to Patton (2014), purposeful sampling involves "strategically selecting information-rich cases to study, cases that by their nature and substance will illuminate the inquiry questions being investigated" (p. 264). Using purposeful sampling allowed me to deliberatively select the ambassador teachers that would provide insight into the research question.

More specifically, I used what Patton described as criterion-based case selection to determine which teachers were the participants in the study. I developed four criteria that I used to recruit participants. The first two criteria were based on the context of the study.

- Teachers who serve as an ambassador teacher
- Teachers who are using LEGO® Education STEM curriculum

The third and fourth criteria, however, were based on the research. Studies showed that experiences girls had in elementary and middle school often shaped decisions to not pursue STEM-related fields; therefore, increasing the number of women in all STEM-related fields might depend on providing engaging experiences that push the nature of learning for girls in elementary and middle school. The research with middle school female students is especially significant because girls are beginning to consider careers in middle school but see barriers to careers in STEM areas. As such, I only included those ambassador teachers who were in a middle school setting in order to better understand the experiences of female students in these grades.

Research also showed that girls have the ability to perform in STEM areas but were not entering STEM-related fields. Therefore, it was important that I chose participants who were actively working to engage female learners in STEM learning and were cognizant of the reaction their female students have toward their teaching. Therefore, the third and fourth criteria used to recruit and select participants for my study were:

- Teachers who teach in a middle school setting
- Teachers who express a strong interest in and commitment to actively engaging female learners in STEM education

Together, the four criteria given provide the rich cases I needed to gain insights into the research questions. The criteria was communicated through an emailed advertisement that a colleague, who works directly with ambassador teachers, sent to those who met the criteria, asking for their interest in participating. The following is the advertisement that was sent to the ambassador teachers:

> Are you an ambassador teacher in a middle school classroom currently teaching with LEGO® Education WeDo (1.0 or 2.0), MINDSTORMS®, simple machines or simple and powered machines (Machines and Mechanisms)? Are you passionate about engaging female students in STEM learning?

> I am currently working on my doctoral research investigating how we engage female students in STEM learning using LEGO® Education materials and curriculum. I am looking for a few interested educators that would like to participate in a study that will focus on learning more about how you use LEGO® Education materials and how females respond.
>
> If you are interested, please reply to this email so I can share additional information. And thanks for all you do to engage students in STEM learning!

Four teachers initially responded to the emailed advertisement for the study. I contacted each to provide them with additional details about the study and investigate their interest for participating. I wanted to narrow the list of four to three based on who would be the best fit for the study. One person dropped out of the list after the additional details were provided, leaving me with three participants. A fifth teacher expressed an interest in participating after the first round of interviews had been scheduled. Due to the timing and having already obtained consent forms to participate from the other three teachers, I thanked the fifth person for the interest, but did not invite him to join the study. So, I had my three teachers to study.

The three teachers that participated in the study were located throughout the United States and represented a variety of demographics. Table 1-1 summarizes the demographic information for each teacher.

Table 1-1. Teacher demographics

Teacher	Gender	Grade Level	Classroom Type	Location
Judy	Female	Middle	STEAM Class	Southeast
Ben	Male	Middle – High	STEM Coordinator Coding Class	Northeast
Jane	Female	Middle	Robotics	West

Data Collection

Once participants were selected and agreed to participate in the study, I collected data to understand how they engaged female learners in STEM areas. The primary source of data collection were interviews. I conducted three separate interviews with each ambassador teacher.

The questions in each interview were open-ended, which allowed educators to share their backgrounds, but also focused to ensure the discussion stayed on topic (Creswell, 2013; Jacob & Furgerson, 2012).

I borrowed from Seidman (2012) to shape the purpose of the three interviews I conducted with each teacher. Seidman suggests a three-interview series format, with the first interview focusing on the life history of each participant. The goal of the questions during the first interview were to help put the participants' experiences in context by learning as much about them as possible in terms of their background experiences related to engaging female students in STEM learning up until the present time. Seidman then gives purpose to the second interview by asking participants to describe experiences related to the topic of study. In my case, I used the second interview to pose questions related to participants' experiences associated with engaging female learners in STEM in both general classroom instruction and more specifically related to LEGO® Education materials. Seidman then suggests the third and final interview should focus on reflection, where participants are asked questions that help them synthesize, articulate, and make meaning of the topic of study.

Although not suggested by Seidman (2012), I wove a secondary form of data collection, a classroom observation, into the interview structure to provide very specific material for the third interview. Between interview 2 and 3, I visited the classroom teachers and observed their classrooms. I visited each classroom for a day to observe the teacher using the LEGO® Education materials with students. The teacher was able to choose the lessons that I observed. Prior to the observation, I discussed with the teacher that I would be focused on one aspect of his or her teaching—how he or she engaged female learners. I held a pre-observation conference with each teacher to determine the focus of the lesson before conducting the observation and taking field

notes. I then debriefed with the teacher based on what was observed. I conducted the observations as a non-participant observer (Creswell, 2013), which allowed me to take notes during the sessions without being part of the lesson. Not participating helped minimize the disruption my presence made in the classroom.

The observations were focused around the teacher's actions more than the students. I wanted to see what the teacher was doing in the classroom and how he/she was using LEGO® Education STEM materials. I focused on how the teacher interacted with the female students and looked for ways the interactions could help me formulate questions for the third interview. Observations also supplemented my interview data by affording me the opportunity to provide rich description and details in the study. I recorded my observations in a digital journal using my iPad. The observation sessions were not recorded and no images were taken.

The first two interviews were conducted through video conferencing using Skype for Business software, which allowed the interviews to happen at a distance but still face-to-face. Interviews had to be completed at a distance, due to the fact that the teachers were located throughout the U.S. Using video helped eliminate the shortcomings of phone interviewing, which Creswell (2013) described as not connecting to body language and non-verbal expressions. Video conferencing also allowed me to record the sessions to review later for transcription and notes. In addition to recording the video conference sessions, I took notes in a journal that I referenced when transcribing the sessions later. The third interview, conducted after I completed the observation, focused on the lesson I observed and other lessons that the teacher used from LEGO® Education. Additionally, the last interview allowed me to ask questions about how the teacher would coach or work with other teachers to use

LEGO® Education materials in the classroom, all of which focused on engaging female learners specifically.

As suggested by Patton (2015), an interview protocol was used to guide interviews. The primary purpose of the first interview was to understand the background of the ambassador teacher as an educator committed to engaging female learners in STEM education and the history of his/her practice related to this topic was guided by the following questions:

- Tell me about why you became a teacher/experiences that led you to become a teacher.
- Tell me about how you became interested in teaching in the area of STEM.
- Tell me about how you became interested in teaching with the LEGO® Education materials specifically.
- Why did you become a LEGO® Education Ambassador Teacher?
- To be selected as a participant in this study, you noted a commitment to engaging female students in STEM learning. What inspired this commitment?
- How did you first become aware of issues related to women in STEM fields?
- Once your awareness was raised, what are some strategies you have learned for engaging female students in STEM learning?
- What does it mean to you to engage females in STEM learning? What do you consider "engaged"?
- In what ways do the LEGO® Education STEM curriculum materials support your commitment to engaging female students in STEM learning?

The purpose of the second interview was to have participants describe their experiences engaging female learners. During this interview, I wanted to understand where the teachers saw girls engaging in both the general STEM curriculum and the LEGO® Education STEM curriculum. I encouraged teachers to share stories and examples during the interview. Understanding the whole picture of general experiences as well as experiences with LEGO®

Education materials allowed me to find areas that the LEGO® Education materials and curriculum could be improved for female learners. The questions in interview two were

- Tell me about your classroom and about the types of lessons you create for your students.
- Describe your experiences teaching STEM and the reactions of the students.
- Tell me about your experiences teaching female learners.
- What goals do you have in mind for female learners in your classroom? What actions do you take to try to engage females specifically?
- What goals do you have for female learners, specifically in the area of STEM learning in your classroom?
- Describe a time when your female students were engaged and a time when they were not engaged. What does engagement look like or how would you define engagement?
- Describe a time when you saw a female student being reluctant in class. How did you respond?
- Describe which LEGO® Education materials you use in your classroom and how they have been implemented.
- Describe a time when you saw a female student fully engaged with the LEGO® Education materials. What was the student doing that made you feel she was really engaged?
- Is there a time when you saw a female student was not engaged or you felt being reluctant with the LEGO® Education materials? Describe the situation. How did you respond?
- If you were working with other educators, what are the main points you would pass on to them to engage female learners with the LEGO® Education curriculum and materials?
- What are the keys to success to get female learners engaged with LEGO® Education?

The third interview with each teacher followed the classroom observation in order to reflect on the experience and understand how the teacher felt the females were engaged (or not) during the lesson. The purpose of this interview was to discuss what happened during the lesson, ask the teachers how they might structure lessons to better engage females in the future, and to think about what professional development opportunities might be useful to teachers in the

future to develop a commitment to female learners. In preparation for the lesson, I asked the teacher to select a lesson from the LEGO® Education curriculum that he/she felt engaged female learners, even if he/she had made modifications to the lesson. I also asked each teacher to share with me the goals for the lesson, including specific goals for the female learners, prior to the observation. For the third interview, I generated specific questions for each teacher individually based on my observational notes and the previous two interviews but also used the following general questions:

- What is your reaction to this lesson and how it went?
- Why did you pick this lesson to share? What about this lesson did you think showcased engaging female learners?
- What goals did you have for the lesson and how did you accomplish the goals you wanted to in the lesson?
- How do you think the female students responded to the lesson? What evidence supports your conclusion?
- In what ways did you enhance/change the LEGO® Education curriculum for the benefit of the female students?
- If you were able to design lessons/curriculum for LEGO® Education, what do you think is important to include to ensure female learners are engaged?
- What do you see as key to communicate to other teachers when using LEGO® Education materials to ensure female learners stay engaged?
- How would you design professional learning opportunities for teachers to prepare them to engage female learners with LEGO® Education materials?

Although the questions and protocol that I describe above were utilized in all three interviews, I asked additional probing questions to ensure I gained the level of detail I needed to create rich descriptions for this study. The additional questions were added on the spot as needed to dig deeper into the participant's responses. Examples included asking the interviewee to elaborate on

a situation or further explain a particular example given during the interview to ensure I could see the entire picture as described by the teacher.

As I conducted the interviews, I was aware of the importance of establishing a trusting relationship with the participants in the study. One thing that helped me establish this relationship is the fact that I have met or interacted with many of the ambassador teachers through the normal course of my job. Ambassador teachers often participate in conferences with our company and work with us to provide professional development. Other times, I am able to work with some of the ambassador teachers to discuss how they are using materials in their classrooms to think about implementation techniques. Thus, I have a working relationship with many of the ambassador teachers, even though I do not work directly with the ambassador program. Based on those existing relationships, I worked to create an atmosphere of sharing and honesty. To make sure participants were comfortable talking and were not rushed during the interviews, I scheduled each interview around their convenience. I also used a script to ensure they understood the process prior to the first interview to alleviate any concerns or uncertainties that might have existed (Jacob and Ferguson, 2012). Using a script at the beginning of the interview ensured I did not leave out any important details. I began the first interview by reading the introductory paragraph below:

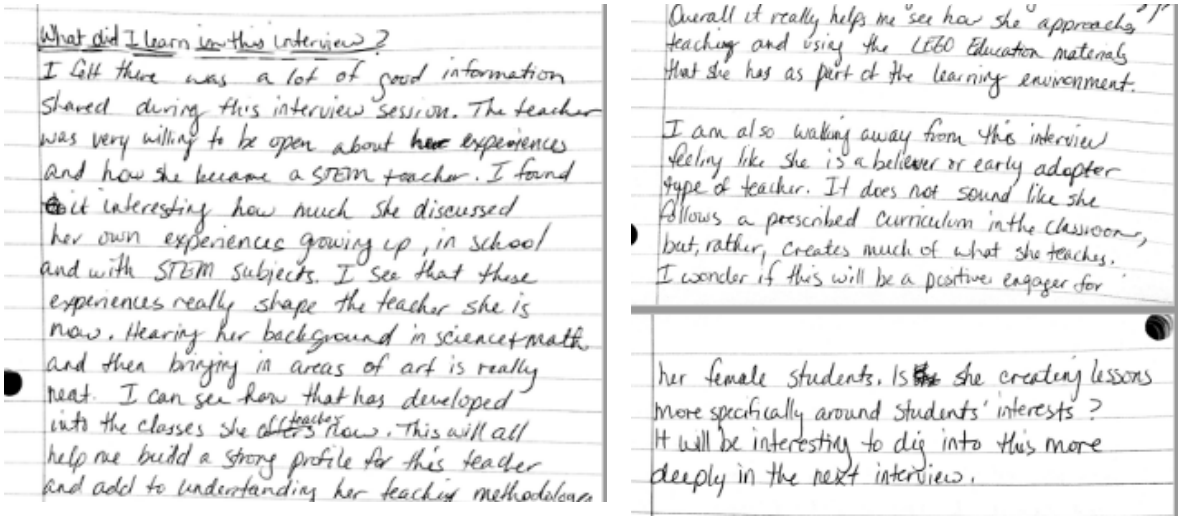
> Thank you for participating in this study. To facilitate the interview, the session will be video recorded as well as audio recorded. Only researchers involved with the study, including the faculty at UF will have access to the recordings of the interview session. The interview is designed to last one hour. During the hour, I will ask you several open-ended questions and provide you time to answer each, which may include silent think time if you find it necessary. I may ask you to "tell me more" sometimes if I am not clear on the full story or explain a certain acronym or term to ensure it is well-defined in the study. I am not looking for a particular answers for any of these questions. Please feel free to answer them genuinely and without hesitation. Are you comfortable with this plan?

I was also careful that any existing relationships and my position within the LEGO® Education Company did not influence the interviewees in any way. Before or during the time of this study, I did not have a position within the company that worked directly with the ambassador teachers nor did I hold any evaluative power over these teachers. It was important that the questions for the interviews be designed and asked in such a way that the educators were comfortable sharing their perceptions and experiences without feeling that I was looking for a certain answer (Creswell, 2013) or evaluating their performance as an ambassador teacher.

In addition to the interviews and classroom observation, I utilized a researcher's journal. According to Dana and Yendol-Hoppey (2014), "journals provide teachers a tool for reflecting on their own thought processes and can also serve as a tool for students to record their thinking related to the project at hand" (p. 109). Following each interview session, I created an entry into the researcher's journal, which acted as a place where I could record my thoughts and reactions to the interviews. While each entry brought additional insight, the questions I focused on answering in each journal entry included:

- Describe my initial impressions of the interview session.
- What did I learn in this interview?
- What ideas did this interview trigger for me as a professional development provider?
- How will this interview influence how I change my practice?

The journal was an additional data source because it helped me capture my own thinking after each interview session and connected what I learned from each interview to the larger study. The journal provided additional support as I analyzed data and could reflect back on my response to each session. Figure 1-1 illustrates an example from my journal entries.



What did I learn in this interview?
I felt there was a lot of good information shared during this interview session. The teacher was very willing to be open about her experiences and how she became a STEM teacher. I found it interesting how much she discussed her own experiences growing up, in school and with STEM subjects. I see that these experiences really shape the teacher she is now. Hearing her background in science & math and then bringing in areas of art is really neat. I can see how that has developed into the classes she teaches now. This will all help me build a strong profile for this teacher and add to understanding her teaching methodology.

Overall it really helps me "see how she" approaches teaching and using the LEGO Education materials that she has as part of the learning environment.

I am also walking away from this interview feeling like she is a believer or early adopter type of teacher. It does not sound like she follows a prescribed curriculum in the classroom, but, rather, creates much of what she teaches. I wonder if this will be a positive engager for her female students. Is she creating lessons more specifically around students' interests? It will be interesting to dig into this more deeply in the next interview.

Figure 1-1. Journal entry examples. Photo courtesy of author.

Data Analysis

Once the data were collected, I began the process of analyzing the data to determine findings. I followed Creswell's (2013) Data Analysis Spiral as a method for conducting the analysis of the data. This process allowed me to organize the data, memo the data, code and classify the data, interpret the data, and then represent the data. These steps followed a logistic path that allowed me to work through the large quantity of data in a systematic way while staying organized.

The first step to working with the data was to organize it by transcribing each of the interviews and notes from the observations into electronic data files. I used software to transcribe the data and then read through the data while listening to the recording to ensure the transcriptions were correct. Additionally, I listened to each interview two to three times while making notes, as I had done during the initial interview. I was able to compare my notes each time to see what main ideas stood out to me.

Figure 1-2 contains an example of my notes from this first step in data analysis.

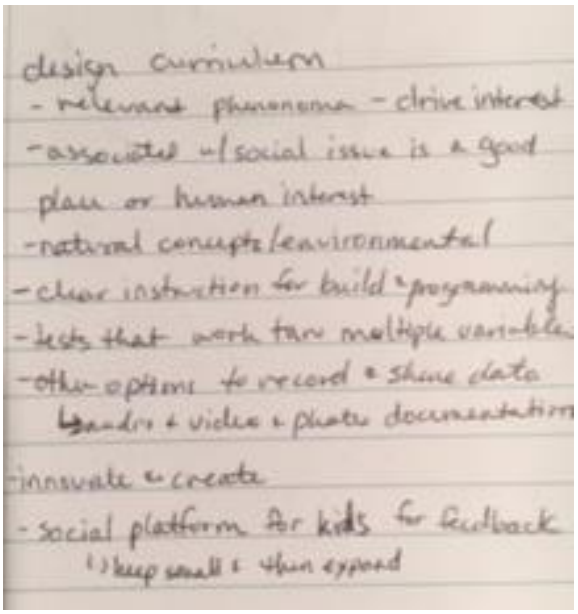


Figure 1-2. Interview notes example. These notes were compiled while listening to the interview transcripts. Photo courtesy of author.

After the interviews were transcribed, I conducted an initial read through of the data to prepare for the process of memoing. According to Creswell (2013), “memos are short phrases, ideas, or key concepts that occur to the reader” (p. 183). Reading and memoing were helpful because they provided me with a more complete image of the data before breaking it into chunks. Memoing allowed me to start organizing the data based on big ideas or phrases that stood out. I utilized my notes taken during each interview and listened to the interviews to support the process of memoing, which helped me further organize the data into a paragraph format that better separated ideas. Through the act of memoing, I was able to get a better sense of what codes might be evident in the data, and it helped me think about ways to develop rich, thick descriptions of my participants’ work as classroom teachers interested in engaging female students in STEM learning.

Next, I began coding the information into chunks, or categories, of information using one word or small phrase descriptors called descriptive codes (Saldana, 2009). According to Creswell (2013), “coding involves aggregating the text or visual data into small categories of

information, seeking evidence for the code from different databases being used in a study, and then assigning a label to the code" (p. 184). I used the descriptors throughout the text so that patterns could be identified as codes were repeated. For this process, I followed Creswell's advice and started with only a small number of codes in order to not overcomplicate the process. Codes I looked for initially included engaged, interested, struggled, succeeded, and expectations. I continued the process, expanding the number of codes as needed with additional cycles of review. The expansion allowed me to create new or different codes from the original smaller list of codes (Creswell, 2013). Some of the additional codes I included upon further examination were risks, story/narrative, grouping, and choice. The act of coding the information helped me chunk the information to identify themes that existed. Coding was an important step in the process of analyzing the data because it consolidated the large amounts of data into meaningful pieces for examination. I conducted additional rounds of coding and categorizing after the initial round to identify where codes might be changed or re-categorized (Saldana, 2009). This process helped me ensure that I did not misinterpret any of the information or overlook any additional codes.

After coding the data, I identified patterns that emerged from the groups of codes. Analyzing codes allowed me to categorize the data into larger groups of information to see what major ideas emerged from the data. Creswell (2013) explained that "themes in qualitative research (also called categories) are broad units of information that consist of several codes aggregated to form a common idea" (p. 186). The themes surfaced as I found patterns in the data by grouping similar codes that shared commonalities, which then created broader categories (Saldana, 2009). The major themes that arose were engaging female learners, engaging female learners with LEGO® Education, and preparing teachers to engage female learners with LEGO®

Education. I was also able to create subcategories depending on the size of the data found within the theme. As Creswell (2013) points out, it is important to keep the number of themes manageable, through categorizing and subcategorizing codes, in order to manage the findings as themes were interpreted. I felt these three overarching themes captured the information well. However, they were broad categories. I created sub-themes under each theme to better organize the information. Figure 1-3 below illustrates the sub-themes.

Theme	Sub-themes
Engaging Female Learners	Creating Culture of Discussion Using Challenging Projects Providing Role Models
Engaging Female Learners with LEGO® Education	Scaffolding Building and Spatial Skills Encouraging Stories Planning for Success Devising Group Dynamics
Preparing Teachers to Engage Female Learners with LEGO® Education	Promoting Self-Efficacy Setting High Expectations Allowing for Relevancy Choice

Figure 1-3. Overarching themes and sub-themes

Once codes were grouped into larger themes, I began the process of interpreting the data to discover what findings were being revealed. Creswell (2013) described the interpretation phase as "involving abstracting out beyond the codes and themes to the larger meaning of the data" (p. 187). The act of moving from codes to themes meant moving from the specific data into a generalization of what the data implied (Saldana, 2009). This phase allowed me to understand what the data were saying in order to draw useful conclusions.

The final step of analyzing the data was to represent the data. Creswell (2013) showed a variety of ways to display the data findings after the analysis was completed, which can include diagrams, tables, and other types of figures. In Chapter 2, I present the data by creating narrative profiles that provide rich descriptions of each teacher. I decided to organize the data by teacher to fully engage each teacher's story individually. Therefore, I created the teacher profiles first to tell a story about who the teacher is and what experiences have shaped the teacher's beliefs. I then looked at how each teacher engages female learners, engages female learners with LEGO® Education, and prepares other teachers to engage female learners with LEGO® Education.

In Chapter 3, I then summarized the findings across all three participants. I found that presenting this information in a table was an effective way to summarize the major themes for the three teachers. The narrative that follows the table in Chapter 3 discusses the connections between each teacher and examines the overlapping ideas within each theme, which provided the implications for my practices discussed in Chapter 4.

Enhancing Trustworthiness

An important consideration during data collection and analysis was establishing trustworthiness. To consider the issue of trustworthiness related to this practitioner research study, I turned to Creswell's writing. Creswell (2013) defined trustworthiness by focusing on validation, which he explained is "a distinct strength of qualitative research in that the account made through extensive time spent in the field, the detailed thick description, and the closeness of the research to participants in the study all add to the value or accuracy of a study" (p. 250). As a researcher, I cannot remove myself from this qualitative study. Therefore, it was important that I carefully consider how to communicate the accurateness of the study to the audience. Creswell provided eight validation strategies to follow as best practices, which added to the accuracy of the study. These strategies are prolonged engagement and persistent observation,

triangulation, peer review or debriefing, negative case analysis, clarifying researcher bias, member checking, rich, thick description, and external audits.

I designed this study using Creswell's (2013) suggestion to employ more than one of the validation strategies to ensure trustworthiness. I utilized four of the techniques in this study. The first technique I used was triangulating the data. As described in the data collection section, the primary source of data collection was through interviews. However, I included an observation session with participants to provide another type of data, which allowed me to triangulate the data. The two data sources provided a way to verify the findings. The second technique I used was rich, thick descriptions to describe the teachers and their teaching. These descriptions should allow readers to make decisions about how the findings can apply to their own situations. The third technique I utilized was member checking. I asked the participants to review the profiles I created for each to ensure the information was accurate and that I had interpreted the information from the interviews correctly. The last technique I used was to provide a description of potential researcher bias in the Researcher Positionality section. This technique allows the reader to understand who I am as an educator and what biases I could bring to the study. Together, these validation strategies added to the trustworthiness of the study.

Researcher Positionality

Throughout this research process, it was important that I remain aware of who I am and what biases I might bring to this project. My gender plays a big role in why I am passionate about the issue of getting more girls interested in STEM areas. Thus, as the researcher, I had to acknowledge the fact that I am a woman working in the area of STEM education. It is because of my gender that, over the past several years, I have studied this issue and been interested in finding ways to engage females in STEM. I want to see more female students be successful in STEM areas.

I have worked in STEM areas over the past 10 years. I began my education career teaching general science in middle and high school classrooms, where I was working with all populations of students. I then moved to a university position where I was working to do STEM outreach in an elementary school, which later grew to include other elementary schools, preschools, middle schools, and high schools in the area. During this work, I began to see disparities in the groups of students who were interested in the individual areas of STEM. The outreach I engaged in included in-school programming where I modeled lessons and worked with other teachers to prepare their own lessons, and I taught after school programing and created curriculum for others to teach. While all students seemed excited to participate in my in-school activities, I noticed that more boys were interested in the voluntary after school programs. I began paying better attention to who was really engaged and who was not in order to better create programs that would interest all students.

Later in the university position, I was able to work more directly with training teachers to do STEM programming in and out of school. This work further opened my eyes to understanding the need to engage all types of students. Working with other educators pushed my belief system further to consider the needs of their students. Through this work, I have seen that different types of students get involved with STEM learning in different ways, and I believe there is a place for all students to be engaged with STEM, which has shaped my own beliefs about what true STEM teaching entails. I feel that STEM teaching should involve a level of integration in the areas of science, technology, engineering, and math rather than teaching them in isolation.

As an Educational Specialist for LEGO® Education, I work closely with teachers using LEGO® Education STEM curriculums in their classrooms, and I am working with educators to

define STEM teaching. I have influence over the materials developed to consider biases that might exist, the training that educators receive as support to teaching with STEM, and the way our mission is messaged out to the educational community. By studying what other teachers are doing, I can better inform my own practice. Chapter 2 describes in detail what the participants are doing to engage female learners in STEM, which is the basis of the learnings discovered in Chapter 3.

Summary and Overview

In this chapter, I have established the basis for my study in which I strive to better understand through practitioner research how to better prepare other educators to engage female learners in STEM. I have described the need for this research, situated in the context in which I currently work at LEGO® Education. I have further described the methods I used to collect and analyze the data from the three participants in the study. The data analysis will be the basis for the rich descriptions provided as findings in Chapter 2, which will lead into the findings across teachers in Chapter 3 and implications for my own practice discussed in Chapter 4.

CHAPTER 2
FINDINGS: TEACHER NARRATIVES

The purpose of this study was to investigate the ways that LEGO® Education Ambassador Teachers engage female students in LEGO® Education lessons to heighten their interest in STEM learning. For the purpose of this study, STEM learning is the integration of science, technology, engineering, and math with 21st century skills such as critical thinking, collaboration, communication, and creativity. During the study, I collected data from three ambassador teachers who teach in a middle school setting and are purposefully trying to engage female learners in their STEM classroom. I conducted three separate interviews and one classroom observation with each participant and kept a researcher's journal in order to answer my research question and sub-questions:

- How are the STEM-related lessons delivered by LEGO® Education ambassador teachers fostering the engagement of female students in STEM areas?
    - How do ambassador teachers purposefully try to interest female students in STEM learning?
    - What characteristics of the LEGO® Education STEM material do teachers perceive to be conducive to engaging girls in STEM?

In this chapter, I create a profile to outline each teacher's background and then share findings about how each teacher engaged female learners in their STEM classrooms, how they perceived female learners as engaging with LEGO® Education, and what each teacher thought was important when preparing teachers to engage females with LEGO® Education and STEM learning.

Judy

Profile

Judy is a female teacher working in a K-8 charter school in the southeastern part of the United States. This is her third year teaching at the charter school. She has been teaching for

over 20 years, with all previous years in a public school setting. She taught many grade levels in both elementary and middle school, but chose to stay at the middle school level because she found the older students "more interesting." She enjoys the variety that teaching provides because, as she said, "I can change it up, I can improve it, I can add something to it" each day (Judy Interview 1).

Judy started as a pre-school teacher. She always knew that she wanted to be a teacher but did not immediately get her teaching degree. She spent 10 years working in a pre-school where she felt that she was merely a caretaker. This experience pushed her to finish her teaching degree, and she is now certified to teach math and science. Only a few years ago, she added an additional certification in art. At the time, she was teaching at the elementary level in a public school. The purpose of adding the art certification was part of her want to create a STEM class for students that would be included in the rotation with other classes such as art, music, and physical education. With an art certification, she thought there would be an opportunity for a STEAM class, which is a STEM class that includes the arts. Although the school previously could not create a STEM class, the additional art certification allowed Judy to become the art teacher. She transformed the art class into a STEAM class that still taught the required art standards, but added the creativity and innovation of STEM. She enjoyed this opportunity, because she was able to expose all students in the school to this type of learning.

When the charter school opened three years ago, with an emphasis on STEM learning, Judy was excited about the chance to teach there. The school's mission statement sets a high expectation for learning centered on problem solving and has a STEM charter for both elementary and middle schools. The school day is 8:00 am to 3:00 pm (Judy Field Notes 1). Judy described the student population as middle and upper class, where she believed students

expected this type of hands-on learning with materials like robotics (Interview 1 and 2). She felt having LEGO® Education products in the school was not a novelty to these students because she found they had similar items in their homes. During my observation, I noted that the school utilized LEGO® Education WeDo in the elementary classrooms and LEGO® MINDSTORMS® Education EV3 in the middle school classrooms (Judy Field Notes 1).

The elementary grades included a focus on integrating career pathways learning in all activities, and all students have a technology class. In middle school, which encompassed grades 6 through 8, in addition to core content classes, students were offered the option to take elective credits in art, graphic art and design, chorus, music, band, and physical education. Students also participated in business and technology classes that included Computers in Business, Career Research and Decision Making, and Engaged Citizenship through Service Learning. There was also an after school program that offered an elementary track that included a LEGO® STEM class and a middle school option to participate on the *FIRST*® LEGO® League robotics team (Judy Field Notes 1).

Judy described the teaching atmosphere as having "more latitude" compared to her previous schools. The class she now teaches is "a course that doesn't even exist, it's STEAM, with science research" (Judy Interview 1). The class allowed her to do more, including robotics and art, and she described the current feel of the class as "maker-like" (Judy Interview 2).

Judy's classes are electives so students choose to take them. The classes Judy currently teaches include STEAM I for grade 6, STEAM II for grade 7, and STEAM III for grade 8. The STEAM courses incorporate the use of LEGO® MINDSTORMS® Education using EV3 robotics. She also teaches four digital arts classes that combine art and technology in projects like video production, film studies, and examining art with technology (Judy Field Notes 1).

Judy felt that many students chose to take these courses because they were fun and "not just sitting and studying something . . . there are a lot of hands-on things to do" (Judy Interview 1). This year, she saw more boys taking the STEAM classes and more girls in digital arts. She said this could be because the girls knew the digital arts class allowed for creativity, but at the time of enrollment, they were not aware of what the STEAM class offered. She attributed the larger number of girls in digital arts classes to girls seeing the "creativity" in the digital arts. She said that "girls feel the digital arts [class] mesh better with them" because of the art component (Judy Interview 2). She felt that would change next year and it would become more balanced now that the girls know what each class had to offer.

When I entered the school building, I could see right into the STEAM classroom through a glass wall in the main office. When observing the classroom, I saw several stations set up for students to work. There were two *FIRST*® LEGO® League competition tables set up, each included a mat and various challenges. There were large round tables with chairs for the students to use as work spaces rather than individual desks. There were several storage cabinets in the room with materials that students could access, and students had laptops that they used as part of their work. Additionally, student projects that were in progress could be seen throughout the classroom. As I observed, there was plenty of space to move around in the classroom so that students could work and access materials with ease (Judy Field Notes 1).

Engaging Female Learners

Judy considered students engaged when they were talking about what they were doing in the classroom. All students had the freedom to talk while they worked in the class because they were working in groups. When they were talking about the work rather than their personal lives or just building quietly, Judy felt students were engaged with the work. She said:

> True engagement is when they're doing it. They're talking about it. They're thinking about it. They're interacting and that's when I know that this is challenging them enough. If you give middle schoolers a chance to talk, they're going to talk. . . . They'll do what I ask them to do . . . but they might talk about other things while they do them. I know that I've got them fully engaged and challenging them when they are communicating, talking, thinking, and performing at the same time. You can see it. You can hear it. Sometimes, I don't even have to look at my class and I know they're engaged . . . because I can hear them and hear what the conversations are. . . . That's how I know they are engaged. Its hands on, minds on. The topic is being discussed and . . . they want to talk about it because they're interested in it. (Judy Interview 1)

Judy knew the value of designing a lesson to ensure that students were engaged and challenged by the task, but not overwhelmed, while allowing for some autonomy in how to solve the problem. Her approach was to listen to the students as they were working to ensure they were engaged. She felt they were really thinking about what they were trying to do. She explained:

> [When] they're thinking about things, [and saying] 'ok if you put something on top of the robots head, what purpose would it serve? How are you going make that work?' [When they say] that kind of thing, or catching each other's mistakes, even like [saying] 'we could do it this way, but if we did it this way, x y or z happens. So maybe we could look at another way of doing it.' You know that kind of thing; so it's the conversation I think that's happening for middle school. I think is really important because they're not going to have a conversation just to impress the teacher. They're going to talk about what they want to talk about. If what they want to talk about is what I want them to talk about, beautiful. I've done my job, they're engaged. (Judy Interview 1)

Conversely, Judy found that when female students are not engaged they become quiet. Boys typically get loud, she explained, which draws her attention to get them back on task. She said girls, however, become quiet and just sit, making it hard for Judy to realize they are not working. It is even harder for the teacher to see when only one person in the group disengages and becomes withdrawn. She needed to find a way to re-engage these students to ensure they benefitted from the project and did not let others do all the work, missing out on the learning opportunity (Judy Interview 2).

Additionally, Judy drew on her own experiences to think about how to reach her female students. She understood the importance of showing students more than one way to approach a problem. She is a female, who as a student was not good at math and science. Judy reflected on her own experiences as a student to determine how to approach teaching female learners.

> I realized, hey, all that time I wasn't good at math, it's not that I wasn't good at math, I just didn't have somebody instructing me the way that made sense to me…. So, I think that has been very impacting on how I feel about math and science and how I teach it. When I teach math and science to all of my children, I teach them here's one way to do it, if this doesn't work, we can try this way, if this doesn't work, here's a new way, let's keep finding a way that works for you. I work very hard not to do that one size fits all kind of thing because that is, that's the way I grew up with education and how schools work. Had I been able to talk to people more, to have more examples, to have more hands on experiences, doing that would have made a huge difference with my math, and maybe even with what I did. (Judy Interview 1)

As a now successful math and science teacher, Judy realized that she was capable of doing the math that she struggled with as a student. Thus, Judy allowed and encouraged all of her students to try different methods to solve problems. Judy wanted students to find the methods that make sense to them and helped them understand the concepts. She knew the importance of differentiating instruction for a variety of students who learn in a variety of ways, including her female learners. She realized, based on her own experience, that helping students learn how to learn in their own way could open up many more pathways for them in their future (Judy Interview 1 & Judy Interview 2).

Additionally, Judy believed that people engage in things that interest them. She did not view females as any less able to do the work in her class, but that they were not always immediately interested.

> You pay more attention to things that you're interested in naturally. So it's just a matter of capturing their interest and keeping it. It's not that boys are smarter than girls or have better memories or something like that, it's that getting their attention and helping them see that this is important to them, that it can be real for them. (Judy Interview 1).

Judy looked for ways to bring the things that female learners are interested in to the classroom to get them engaged in the work. She designed lessons in a way that allowed female students to drive the direction of how to present the solution. For example, she allowed students to decorate their robot, which engaged female students in particular.

Based on her own experiences, Judy believed that role models play an important part when engaging female learners. She tried to be a role model for students by being "girly" and still showing what she can do as a STEM teacher (Judy Interview 1). She explained:

> I think just me being enthusiastic is a big one. . . . I do know that when I wear a pretty dress and have a little pretty bow in my hair, or something like that, and I teach STEM to the kids, it does attract more girls. . . . I want them to see that you can be excited about math and science and still keep your girliness about you, if that's important to you. . . having that enthusiasm and showing [girls] that you don't have to be [wearing] the big glasses, because that's still what the kids are thinking. You can be a regular woman and still do these things. (Judy Interview 1).

Judy tried to help the female students feel comfortable in the classroom and talk through what is happening to help them see how they were being successful. If her girls could see how other females have been successful, Judy felt they would be more open to engaging in the STEM areas. Judy also viewed it as important for students to see all the different types of jobs in STEM and tried to expose students to a variety of role models in different career fields. The message she wanted to get to students is that "we need different thinkers," which means that there is a place for everyone in STEM roles (Judy Interview 1).

Judy found that mentoring, in which her middle school students could work with elementary students, was a good way to engage female learners. Through mentoring, Judy found a way to provide role models to the younger females while inspiring the older females. She found that female learners were more "nurturing" to the younger students (Judy Interview 1). The females had put a lot of effort into preparing to work with the younger students because they wanted to give them a good experience. The female students become the teachers and, therefore,

learned the material more deeply because they were preparing to teach it. Judy described the effect of mentoring as

> not only giving them that need for nurturing and acceptance, but it is also empowering [females] to feel like they can teach these things and understand these things and pass their knowledge on to somebody else. It boosts their confidence. It makes them feel better when they are doing math and science or when we are doing something complicated. I will many times have them scale it down a little bit, and then teach that skill to a younger grade so that they do feel like, not only can I build a robot, but I can teach robot building to second graders, which is really cool. (Judy Interview 1)

Engaging Female Learners with LEGO® Education

Judy's experience is that female students do not come into the class with the same background in using LEGO® bricks as male students, especially the technic pieces, which can cause them to approach the learning differently (Judy Interview 2 & Judy Interview 3). She worked to ensure all students were able to be successful, which meant scaffolding for the students who did not have the background to design on their own. Judy provided support by getting students started and having materials readily available for students to access.

However, Judy did not find that girls were any less likely to engage with the LEGO® Education materials. She observed that girls wanted to do different things.

> From my observations, they tend to want more thematic kind of things and more backstories. Instead of just build a robot that's going to get [from] point A to point B, it needs to be the whole story behind it and trying to make it creative. (Judy Interview 3)

Judy, therefore, created lessons that were project-based and allowed students to do more than just individual tasks. Through these project-based lessons, girls were able to make choices in the way they presented or shared what they learned and created. They could build a narrative for the robot and the task the robot had to complete (Judy Interview 3).

Additionally, Judy set goals for female learners during the year to strengthen their ability in STEM learning. She said, "I want them to come out the other side with a rich background in

STEM education and engineering and engineering process" (Judy Interview 2). Judy set the same high standards for the girls as for the boys. "I want them to get the perseverance of pushing through" when they encounter a problem. (Judy Interview 2). She sought for her girls to learn how to gain from their mistakes and not get frustrated by them. She ensured that girls became comfortable in STEM through several experiences in the design process, engineering process, and coding using the LEGO® Education materials and other materials. "I want them to love technology and be interested in lots of different things" (Judy Interview 2).

Judy further engaged female learners by setting the goal for them "to take risks" (Judy Interview 2). She found that girls were worried about making mistakes and needed to learn how to learn from their mistakes rather than shutting down when things did not work out. She said:

> I want them to learn something new, to learn how to take risks. I think is very important what I do. Especially [for] females, I have a problem with that, they tend to be a little bit more perfectionist, worried about messing something up and they're less likely to just try something out and see if it's going to work or not. (Judy Interview 2)

In her classroom, Judy saw that female students would dis-engage with the LEGO® Education materials when they reached barriers that they could not easily overcome. Judy felt, it was important to work with girls to learn the iterative nature of STEM in order to keep them engaged in the classroom and see that mistakes are just part of learning. Judy said: "You know they have to go slow and think about what they're doing. I try to take baby steps so that they get small successes instead of [doing] something really big and have it all crash down really hard (Judy Interview 3). Students needed to learn the importance of the step-by-step process by successfully completing one step before going onto another. She viewed this as a stepping stone to becoming more independent learners.

Preparing Teachers to Engage Female Learners with LEGO® Education

In working with other teachers, Judy noticed certain areas that brought success when engaging female students. She learned that it was important to be thoughtful about how groups are made to ensure the skill sets complement each other. Judy found that a group with one partner who is more experienced with building or coding often results in that one person doing everything and the other person being left out. Knowing what prior knowledge and experience students had in building and coding was a good place to start. She suggested:

> Girls don't have as much experience with the LEGO® [bricks] and so they're a little tentative. They just kind of sit back and let the boys do their thing. . . . You know they're just very passive . . . and are difficult to catch if you're not looking for it. I think it is very easy for us as educators to let that go like 'oh well the job is getting done. The group is progressing. Just this one child is just really sitting there instead of actively engaged, but at least she's quietly sitting there and not causing a problem.' You know… as educators that is really a bad on us because just because it's easy doesn't mean it's right. For many of our girls, we're doing them a disservice. . . . I want everybody to participate and do something. I have to watch my grouping. (Judy Interview 2).

Additionally, Judy found that she often needed to help all her students learn to work better as a team. Students did not know how to work collaboratively and tended to divide the work, one person building and one getting pieces or "you build this page and you build this so it is fair" (Judy Interview 3 & Judy Field Notes 1). Judy suggested working with students to ensure both partners are engaged in all of the tasks. She said to her students:

> Let's switch things up and switch roles. Now you are going to build and you can type this up or do the research or whatever. Let's take turns, you do this for five minutes or 10 minutes then switch off with what the other person does. So that they are both getting equal shares. Sometimes to counteract that I will change up my grouping a little bit. If I have a really strong personality or a boy with a very strong personality, I tend to not put him with passive girls, especially if we are doing robots because they tend to hog everything and the girl just sits there and lets it happen. (Judy Interview 2)

According to Judy, understanding how to work together effectively also helps build confidence in female students who may be lacking the experience needed for this type of activity and are not

sure where to begin. Judy added that it is important that roles within the groups rotate so that students "can find out what they like" (Judy Interview 3).

In addition to understanding their skill set, Judy found it necessary to consider how to scaffold lessons. Based on her observations that female learners often enter the classroom with less building experience, and sometimes less confidence, Judy created examples or pictures to share with those students to give them inspiration to get started. If students cannot get started they become frustrated and shut down. With some inspiration or basic building instructions, then students can settle into the project and start working. Judy thought it was important to think about how to walk students through a project to support them, without just doing it for them.

Judy did not, however, use the LEGO® Education curriculum often in the classroom. She described it as "a good starting point" or "inspiration" for her lessons (Judy Interview 3). She preferred to design her own projects around other things they are doing in class and what interests her students. In her experience, the pre-developed LEGO® Education lessons did not easily fit into the curriculum she teaches. In a way, she preferred this approach so that she could give students more choices. She said:

> I can make [LEGO® MINDSTORMS® Education robotics] fit into my curriculum how ever I want to . . . You know just anything you're teaching, it needs a robot to enhance it and make it special and interesting. . . . Maybe make it a project during your unit or at the end. [It's like saying], 'now that we are finished, we're going to take all the knowledge you learned and we're going to wrap it all up into this one project here and you're really going to show what you learned' . . . . I [like] the flexibility to make it my own and make it work for me as the teacher and for my kids to be able to take pieces and make it their own. [For example], if they want to build a spinning top . . . to have flowers on it and have a little personal flare, that's cool . . . . How is it affecting its balance? Those are the conversations that we have. . . that's a personal preference and as long as you know it's getting the job done, editing and going through the engineering process of building a top and testing it and keep going, that's what [I am] looking for. (Judy Interview 1)

Moreover, as the teacher, Judy found that she needed to be the cheerleader. She said she did not allow girls to think they could not do something, but instead helped them see that they can be

successful and supported them throughout the project until they found a solution. She said, "It has to do with just encouraging them and helping them feel like this is something they can do" (Judy Interview 3). She gave this example:

> I try to use lots of encouragement, especially in middle school. Self-esteem can be a real big issue for some of these kids, their changing, their bodies are changing, I have a lot of girls coming in with big jackets on because they are not comfortable with how their bodies are developing. It can be 90 degrees out, that jacket is not coming off. Just to be understanding of that, to be accepting of them no matter what [is important]. (Judy Interview 1)

However, she always holds her students, including females, to a high standard. She would tell them "to take it to the next level" and pushed them to "make [it] more complex" to show what they can do, using rubrics to guide them (Judy Interview 3). She focused on building their confidence and helping girls see that they could do it.

When designing lessons, Judy said to let "[female students] feel like they have some ownership and some choices" (Judy Interview 3). She found female students respond well and engage better when they have choices in the assignment. She said she "doesn't instruct them differently, but encourage[s] them to do things that are interesting to them" (Judy Interview 3). She assigns the task to be completed, but would allow students to determine the storyline or how to present their work in their own way (Judy Interview 1).

> In the STEAM classes, we do a robotic project with them. They have to do a little research on a robot and talk about a robot. Now, they're allowed to choose what robot they want, but it has to be a robot. They are not too excited about it, until they find a special robot or something unique. (Judy Interview 3)

She found this gave them "ownership" over their learning, which means that the students will dig more deeply into the learning (Judy Interview 3). By designing projects that allow for student choice, Judy allows students to bring their own interests into the project.

Finally, Judy suggested that teachers should be open to try new things that might engage female learners with LEGO® Education and be ready to revise. Sometimes students just did not

connect with the lesson so she had to revise and restart the lesson. She found the LEGO® Education materials provided a vehicle for experimenting, and she could easily adjust lessons as needed, but the teacher has to be willing to do so. Additionally, the materials encouraged girls to take risks, which she found necessary. Because of the rapid prototyping ability of the materials, students could easily make modifications and run tests without drastically altering their model. Female students could try things out without taking a big risk. Judy explained:

> I think one of the things that amazes me most about the LEGO® Education [materials] is that with other robotic platforms, you're not building something unique. A lot of times it's like this kit that you have to put together in a special way, otherwise it won't work. It does not work that way with LEGO® Education [kits]. If you can build it, you can make it move. You can turn it into a robot and solve something. I can even tell them, 'you see these bricks and the little mini figure that I stuck on top here? Well watch, I'm going to turn it into a robot.' I just stick an axel at its rear end and make it go; and they're like whoa! I really think it is empowering to take anything and make it move, and that's the beauty of LEGO® is that you can make whatever you want and they are colorful pieces. (Judy Interview 1)

Ben

Profile

Ben is a male teacher working as a STEM coordinator for a small, public middle and high school in the northeastern part of the United States. He has taught in several states throughout his 20 years of teaching and is certified to teach K-8 STEM. He taught math his first year before becoming a gifted and talented teacher in elementary school. He enjoyed this position, which allowed him to focus on an inquiry-based curriculum to teach thinking skills within the subject area. He positioned his teaching approach with his belief that "STEM is a mindset, not a subject" (Ben Interview 1). He said he naturally began integrating a lot of STEM teaching into the gifted and talented classes.

Ben later went back to the regular elementary classroom, but brought these same ideals there as well, and it was in this setting that he was introduced to LEGO® MINDSTORMS®

Education. Ben is focused on integrating technology purposefully into the classroom. He found that robotics provided a good way to bring science and technology together in a way that was easy for the students (Ben Interview 1).

Ben was then recruited to teach at a K-6 private school and structure their interactive science and technology program. He worked with the teachers in all grade levels to integrate STEM teaching practices, including coding components and LEGO® Education robotics. At the time of this study, he was not only teaching courses, but also providing support to other teachers.

For the past three years, Ben has been teaching in his current school. He came to this school to coordinate their STEM program. He teaches computer coding for all students in grade 7 and coordinates the robotics class for all grade 8 students. He also teaches a computer science class at the high school level. He trained the math and science teachers as well as the library media specialist in using robotics and technology in the classroom. All students in the school had access to STEM learning regardless of their background. Additionally, they are currently mapping the curriculum to incorporate robotics into the core science classroom and coding classes. Ben explained that "STEM is about integrating different things and trying to make sense of the world around us" (Ben Interview 1). He enjoyed that he was able to be innovate in his teaching and help others bring that innovation into their classrooms as well.

At his school, the middle and high schools shared the same facility, but were on separate floors. The middle school included grades 7 and 8 and the high school had grades 9 through 12. The schedule required students to complete core subject courses, have experiential learning courses, and elective courses. The experiential courses were 30 days long and divided into both required and choice classes (Ben Field Notes 1). There were three experimental classes required for students in grades 7 and 8. The computer coding class that Ben taught was

one of the required courses for grade 7 students. There were also four options for each grade level in which students chose three of the classes. The Intro to Robotics course is an option for grade 8 students. Other experiential class options were either related to STEM or Art. The elective class options included Spanish and Music related courses (Ben Interview 1 & Ben Field Notes 1).

The school's mission was focused on preparing students through stimulating experiences for a world that continues to change. The school allowed students to bring their own electronic devices to school, which meant students could bring laptops, phones, tablets, and other devices to use for school-related work. The school also had several club options for students to attend in a variety of areas (Ben Field Notes 1).

Engaging Female Learners

Ben defined engagement for his students as being "locked in" (Ben Interview 1). He used this term to describe students who are focused and committed to what they are learning. He considered students engaged when they were talking about what they were working on and asking questions.

> I love seeing the kids who are not asking questions of how I would do something, but puzzling with the problem to make sense of it. Rather than saying, 'how do you do that?' [I want students] who say, 'you know I'm thinking that I want to do this. I think that it looks like this, but I'm not quite sure how to do it.' They are actually puzzling through the process. [There is] a lot of talking with each other surrounding the actual subject. (Ben Interview 1)

He created a classroom environment where all students can openly talk. He explained that when he heard students talking about the work and not personal matters, he knew they were really invested in the learning. He said he worked to engage students from the beginning through setting up a problem to solve, and to add depth to the investigation, he makes sure the lesson is continued. He explained:

> It's really modifying [at the end of the lesson]. It starts out with a good concept and we want to take it a step further. It is nice to be able to have that opportunity in the software . . . . And get some additional data, so that we're not just proving one concept, but we're analyzing two things against each other to make it a little bit more well-rounded. (Ben Interview 3)

According to Ben, "setting clear expectations" and creating an open environment resulted in maximizing engagement. (Ben Interview 1).

The absolute key to engaging female learners, according to Ben, was "a real novel problem to work with" (Ben Interview 1). He felt his female students responded to having a problem to solve, especially if it was a real problem with which they can connect. He explained:

> The real engager is a real novel problem to work with. I think that is probably one of the best [engagers]. Thinking back to the machines and mechanisms kit, there would be a particular issue to try and solve. . . I don't know if it was the emotional buy in with it, but . . . it definitely provided a rallying cry and something that I tried to replicate in what I do. So when developing activities, it's based on, you know, this type of real world thing that you have experienced. We're trying to either replicate that with programming or engineering . . . and that tends to provide value (Ben Interview 1)

His goal was that all projects provided this initial connection in order to get female students interested in the project from the start. If he was able to make the problem "personal and relevant," then students had a reason to work on it. (Ben Interview 1).

For female learners, Ben observed a connection to anything "associated with a social issue, human interest piece, nature, natural concepts, or environmental concepts" (Ben Interview 3). He felt that females liked lessons that involved an impact on societal issues. He either tried to structure the lesson to include these issues or left it open-ended enough that students could incorporate issues on their own.

Ben observed that females were "more reflective on the process" in the beginning rather than just diving right into the project. (Ben Interview 1). He shared an example from his *FIRST*® LEGO® League team.

> I was thinking [about] my *FIRST*® LEGO® League team, our girls were more reflective on the process. . . .The boys were quick to dive right in and clean up the mess as it comes along. The girls were more planning . . . and methodical. (Ben Interview 1)

In general, he saw this was how female students approached problems to solve. As such, he allowed time for girls to plan and work toward their solution in their own way.

Additionally, he shared the example of a female eighth grader that took a leadership role for the *FIRST*® LEGO® League team. He said that she was strong in this role because she was willing to challenge other group members, including the boys. He explained:

> The person that ended up being our strategical lead for our group was one of our eighth grade girls. She was exceptional, because she was able to take methodical process and be able to turn it back into [the project]. Because she was an older girl, she felt like she had the gumption to go against some of the boys and say, 'well hold on I actually think . . .' [They] actually moved through it like an engineering design process with this. (Ben Interview 1)

He saw that because she was confident in her knowledge of how to solve problems, she questioned the team's approach and stopped to think about what they were doing at each step rather than just pushing ahead. Ben also observed that female learners often take more away from the lesson in the end because they are methodical about the way they approach learning and do not just go through the motions of getting the assignment done. He noted that they want to do it right from the beginning.

Ben also believed it was important for female learners to see that they can be successful. He shared the example of a girl who was asking questions in class and he praised her that she was asking the right types of questions. He described the situation:

> There was a girl recently in my experiential class. She was asking me a question about something and I said, 'You were asking me the exact right type of questions and I can tell you have really been thinking through and using these strategies that we have been talking about, [including] the programming and being able to start to break down your work. You've got a future with something like this.' Her eyes lit up and I said, 'you can totally do all this stuff. . . .' Her eyes lit up and she smiled. From there on forward, she was the hardest worker in our class. (Ben Interview 2)

According to Ben, this small praise helped build the student's confidence to do the work. The motivation the female student received from hearing that she was being successful motivated her ability to thrive even more in the class.

Engaging Female Learners with LEGO® Education

Ben recognized the value in LEGO® Education because female learners were excited about working with the materials and programming. He observed the value in how students can quickly complete projects and easily go through the iterative process of design engineering (Ben Interview 1). From what he observed and from what he heard from other teachers, students were engaged because their hands were busy and they were thinking the entire time (Ben Interview 3). He explained, however, that females interact with the materials differently than the boys.

> Our girls are doing a better job of thinking through the planning of the organization, particularly in the code. Boys tend to do well with the spatial/relation pieces and building everything and putting it together with their code. When [boys] put stuff together, it's just a little bit more railroaded . . . . The girls tend to be a little bit more efficient as far as what they are trying to do. (Ben Interview 2)

Regardless of how the students naturally interact with the materials, Ben pushed all students to "scale it up" and set high expectations for both male and female students (Ben Interview 2). He said that to get a grade of 100%, students had to do the work and be innovative with it as well. He held all students to that high expectation, even when they struggled to ensure they understood the important concepts from the lesson. Ben shared an example of where he noticed all students struggling.

> The process of getting data was not an issue for them, but it was in trying to extrapolate that information to really be able to make meaning from it because it wasn't fully lining up with what we were expecting it might be. (Ben Interview 3)

In this example, Ben referred to the data that students were able to obtain through one of the investigations in the science curriculum. He valued the sharing of ideas and outcomes to help female learners, or any other student that is struggling, to connect with the content behind the lessons to ensure they had a high learning value. As he shared, students were able to do the work and gather the data, but this is not where he sees the value of the learning. He looked for those connections from students, for them to "make meaning from it" and always made sure there was a way for them to report their findings (Ben Interview 3).

When considering what parts of working with robotics and the lessons that best engage his female students, Ben found that girls enjoy the creative aspects most.

> It's interesting to me how robotics, it used to kind of feel like it's a make driven thing. I find the girls really enjoy the programming aspect of it and the creativity piece and the problem solving piece more so than the actual engineering and mechanical piece. I think that the problem solving mindset, I see girls really enjoying that and the creative outlet with it, like the lateral thinking that you see our girls have. (Ben Interview 2)

As a result, he structured the lessons to provide more direction in the building and coding, but allowed students some autonomy in the way that they presented and shared their solutions. He found that female learners were particularly good at and enjoyed creating audio, video, and photo documentation of their work.

Additionally, Ben observed female students disengaging when they could not see the relevance to their learning. He shared the example of a female student that was interested in fashion design but could not see the connection or need to learn coding. She had not bought into the course in general, let alone the lessons. He tried to make a connection for the student by saying:

> If fashion is your goal, you're going to have to get to know how to think about all these different possibilities that are going to happen in your business or with your fashion. [Think 'How] much fabric of any size 6 I need? What are the numbers of people that I have that are going to use these different sizes?' [I want you to see] the thinking and logic and how to code things like this so that in the future you can use these same pathways, these same ideas. (Ben Interview 2)

Ben found that it was important to help female students make the connections with what is relevant for them to be invested in the learning. He used this opportunity to allow this student to embed her own interests into the lessons and helped her see connections to what she was learning about the fashion industry. Unfortunately, the student continued to struggle, so Ben decided to involve a role model for the student.

> [I brought in] a high school student, a girl, that works on some of our other programs. She's a very strong student. She's going to school as an engineer this coming fall. I invited her in. She started working more with a few targeted students and this girl in particular. It helped her to see what can be done with this stuff and be successful. (Ben Interview 2)

For all students, Ben recognized the important of breaking down any mental barriers. Ben observed that female students often view the coding and robotics lessons as being "nerdy" or a "male thing" (Ben Interview 3). He worked to make sure they could overcome this "perception," because he believed that females could be just as successful as male students. When there are students in the class with mental barriers, Ben suggested addressing this right from the beginning to level the field so everyone could be successful. Ben described it as "being present early on" to ensure he was addressing questions and helping to create a good atmosphere for each student (Ben Interview 3).

Preparing Teachers to Engage Female Learners with LEGO® Education

Ben currently has the opportunity to work with other teachers to bring LEGO® Education materials into their classrooms and described several ideas that he shared with those teachers to prepare their lessons.

> I have purposefully not tried to have a girls coding club or gender specific things because I'm concerned that that will perpetuate the sense of separation with it. What I've tried to do over these past two years here in our district, but also previously, is just continue to provide it for everyone and praise everyone who is doing it and working with it by providing consistent access. I think that that will just start to change mindsets of people and change culture. (Ben Interview 1)

He felt that there was no need to create gender-based STEM activities. By allowing girls and boys to work together, it showed they are all capable of doing the same work. He pointed out the importance of "building the culture of the program that everyone has the opportunity to be able to speak and can share" (Ben Interview 1).

Along the same lines, Ben emphasized the need to create group roles to ensure all students were working together. Often, when lessons were not going well, he noted that it was because the teacher was not adequately facilitating the work within the group. He described it by saying "inevitably, someone is going to feel left out" (Ben Interview 2). He found it important to assign roles such as builders (you put pieces together), coders (you code the robot), or piece retrievers (you find the pieces to use). He explained:

> I have to share with them how important it is . . . [that] you're always working together between the programming. It's ok to have one person, and then another one to [do a task], but you need to keep moving back and forth such that nobody is ever holding others from a role. (Ben Interview 2)

He believed that everyone needed to experience each role to build their skills, but he had to help them see how to work together. He also said it was important to "get them engaged right from the beginning . . . talking with each other" (Ben Interview 3). He thought it was important that students become comfortable with the materials quickly and would consider who he paired together to help those who needed additional encouragement. He said, "If a [female student] is going to be nervous or resistant I want to put them with somebody who will be encouraging or compliment them in a good way or encourage them to keep moving

forward" (Ben Interview 3). He felt this approach erased the obstacles students experienced before being able to settle in and learn.

Because Ben set high expectations for all students and pushed them to be innovative, he stressed the need to scaffold learning for any student who does not understand what it means to innovate their work. He shared the example of talking to a mother, whose female student was struggling to understand what innovation looks like.

> Not every kid is going to be a coder or a scientist or whatever, but they're going to be thinking or a problem solver or innovator. So it's developing that kind of culture where you look and wrestle with the concept to try to gain some understanding of it. You get into it and understand the fundamentals. Then you've got to back up and apply it. (Ben Interview 2)

He was more focused on building skills than teaching robotics and emphasized the need to help students find success and understand what innovation and problem solving really means (Ben Interview 3).

In addition, Ben conveyed that students could easily get caught up in the excitement and the building of the project. He said it was important to take time to reflect on the learning to ensure students grasped the bigger concepts. Ben said that "facilitating that development of thinking and understanding" was one of his goals (Ben Interview 2). He recommended using the tools that were already in the software, or any tools that the school might already use, to document learning and share ideas that students developed (Ben Interview 2 & Ben Interview 3). Given the success female students had using video and photo, Ben also considered the engagement social media could bring to the classroom as a documentation option for female students (Ben Interview 3).

Ben warned not to let processes be a hindrance. He shared a story of assisting a teacher in learning how to use the gyro sensor, which needed to be carefully calibrated. The teacher was concerned that students would "freak out" if the sensor was not working properly. Ben

explained that this was a learning opportunity for the students, and teachers should be ready to teach procedural aspects of the materials to students so students can focus on the learning (Ben Interview 3).

Finally, Ben stressed the importance of how the project is set up and designed by the teacher. He said that lessons must include a "relevant phenomena" (Ben Interview 3) because, in his experience, female learners engage best with lessons that have more social or human interest. He believed that every lesson must include some aspect that connected with the female learners' emotional or social interest.

> I want to show everyone that it's fun to do. I don't try to pontificate as if I am some high end scientist . . . . I want [the students] to see that this, [STEM learning and robotics] is really fun and engaging and neat. [I want them to see], I'm going to find out something cool today and I am going to be able to use these type of skills in the future with what I do. (Ben Interview 3)

Jane

Profile

Jane is a female teacher currently working in a rural public middle school in a western state in the United States. The school's mission included developing students' minds, bodies, and spirits. The school is a community school, with the elementary, middle, and high schools located in the same complex (Jane Field Notes 1). According to Jane, the students in the school had been together since they started school (Jane Interview 2). The students all know each other and the teachers well.

Jane has been teaching for 27 years. With a degree in communications, she taught journalism and writing in a high school for 17 years. She began bringing science fiction and fantasy into her teaching because she loved math and science (Jane Interview 1). She also tried to create fun projects for students. Jane first became aware of *FIRST*® LEGO® League as a speech and forensics teacher and coach. For the last eight years, she has been in the middle school

teaching an enrichment class that incorporated math and science enrichment with literacy and communication. The goal of the class, according to Jane, was to

> develop some math and science enrichment that was not just science-fair or worksheet based. Not just math games, but some problem solving activities for middle school aged kids. That launched me into looking at STEM. (Jane Interview 1)

Jane then began research in STEM to better understand how it could be brought into the regular classroom.

She began using LEGO® MINDSTORMS® Education products while she was investigating good products to use with STEM. She started small, inviting students to come in during lunch and experiment with the robotic sets. Students became very engaged with the materials, so she expanded the program. She sought out funding to bring more materials into the classroom and to grow the program to include several courses for students. She also received training at Carnegie Mellon through the National Robotics Engineering Center (NREC) Teacher Program in LEGO® MINDSTORMS® Education Robotics. Jane explained:

> Robotics was a good fit for me because I did not have to be an expert to get it going in the classroom. I just needed to know enough to get the kids to explore a bit more. I do not teach robotics to create mechanical engineers or robotics engineers; I think robotics is a way to teach critical thinking and allow students to explore the limits of failure that leads to discovery. It is not as threatening as an academic task with specific answers. (Jane Interview 3)

Jane now teaches robotic courses for grades 6 through 8 as well as coaching 11 *FIRST*® LEGO® League teams. The robotics course is an elective course that students choose to take from the options for enrichment classes. Therefore, she does not see all the students in the school each year. The grade 6 course focused on building and design principles and, in the year I observed, students were learning the basics of robotics. Jane said it is about "getting them comfortable with the software and building," which included learning to use sensors (Jane Interview 1). In grade 7, students work through the Space Challenge activities, where they utilized the skills of building,

coding, and using sensors to complete a series of space-themed missions on a challenge mat. In grade 8, students used the Design Engineering curriculum, including a study on gear ratios. The current year is about letting students design, build, and code more complex robots. In addition to these classes, Jane offered *FIRST*® LEGO® League after school options for students (Jane Interview 1).

As I observed, the classroom was a large room with several workstations. The classroom was set up with several competition-sized tables, which were 96" x 48" tables with side walls that were approximately 24" high. One wall in the classroom had 10 desktop computers. The chairs were typically stacked up in the corner during the class. If there was a mini-lesson, students would get a chair as they arrived. If they were in the middle of a project, they would get their materials and start working at the station of their choice. Each group had a bin to keep their materials organized and in one place. Throughout the classroom, there were several cabinets full of materials that students could access. Everything was very student driven and open-ended so that students were moving about working and testing their materials. I noticed that Jane moved from group to group to see students' progress and pose questions as they worked through the project (Jane Field Notes 1).

The classroom was located on the bottom level of the school in the same hallway as the band room and other enrichment classes. This location within the school allowed the teacher freedom to be noisy and allowed students to utilize the hallway when needed (Jane Field Notes 1).

Engaging Female Learners

Jane said she could see engagement the minute students walked into the classroom. When students were ready to work and were so busy that they were not looking for direction from the teacher, she felt that students were engaged (Jane Interview 1). The classroom arrangement allowed for maximizing engagement because all materials were available and

students can easily access what they need (Jane Field Notes 1). She knew that students' excitement to come to class was important, but the real engagement was evident when students worked from bell to bell, without the teacher having to push them, and begging to complete one more trial before leaving the classroom. She described these experiences:

> There are days where the kids will walk into the room and just get started. I think, 'well I am just not going to stop them.' If they are learning and they are making forward progress . . . I watch them working and they are trying to figure something out with very little direction or prodding from me. I have to stop them. I have to say, 'we are looking at 5 minutes I need you to stop what you are doing save your programs save to your files and get your stuff together.' (Jane Interview 1)

Furthermore, Jane recognized that students were engaged when they were discussing their work. She said that the nature of middle school students was to talk. When they were talking about their robot, and she "can hear them actively trying to solve whatever problem they have," she knew they were engaged and wanted to do the work (Jane Interview 2). She shared a recent example:

> I had a group of three girls that day that something didn't work quite right. They're [working on] a drag racer. [While] I was helping another group build something. . . . those three girls, I could hear them talking: "well what if we use this. . . what do you think. . . should we try? Let me go get one of these things. . . oh wait, there's this other piece." (Jane Interview 2)

She recognized that students were engaged when they were discussing solutions and really talking about their ideas. On the other hand, Jane believed students who gave up, or asked her to provide the solution when they had a failure, were not invested in the work.

> I see a lack of engagement when they hit that failure and they really don't care. The resilience [isn't there]. They just want to stop and think 'Well that didn't work. I guess I won't do any more.' And that's the piece that's not okay. (Jane Interview 2)

Jane said the goal was not to produce the best robot, but for students to persevere and find solutions to the problem through teamwork. When students were comfortable working toward this goal, they were engaged.

Additionally, Jane recognized engagement in the excitement and pride her students had for their work. Her students constantly showed their work in the class to get feedback and gather data for modifications. When Jane saw the students reacting to the trials with enthusiasm, such as "clapping or jumping up and down," what she recognized was the pride her students had for what they created (Jane Interview 1). She shared:

> They want the satisfaction. My favorite thing is when I take those videos and the kids have the "yes" or the clapping or jumping up and down or flapping or whatever they do that is the behavior to signal that they are just so proud of themselves. (Jane Interview 1)

Through this pride, students pushed themselves to be better and better, which only engaged them further with the work. Jane described this type of engagement as students not just doing the minimum required, but wanting to go further to be the best (Jane Interview 1).

Engaging female learners in STEM areas was important to Jane because of the gender roles she saw when she was growing up. She believed that it was important for females to have strong role models, as opposed to just seeing females in "support roles" (Jane Interview 1). She tried to expose female students to various roles within STEM and females who are successful in these areas. She brought in a lot of videos to share from NASA and Discovery that showed careers that students, in her opinion, "do not even know exist" (Jane Interview 1). She stated:

> I just want to take from my own experience and make sure girls consider all the possibilities that are out there. And I see them as having the same strengths as the boys, they just don't have the same exposure. (Jane Interview 1)

Jane believed that role models could keep girls from "clos[ing] the door" to the opportunities in STEM areas (Jane Interview 1). She tried to consistently expose all students to various possibilities, allowing them to see what jobs were out there and the importance of having a variety of people working together in those jobs. She taught students that "the world benefits from having different perspectives," making it important for females to be in STEM jobs (Jane

Interview 1). Jane tried to ensure students got this message so they could see the relevance of going into these career paths.

Jane also recognized the need for students to be interested in the work so they would be fully engaged. She not only designed projects to ensure that students were interested in getting started but also considered how to keep students interested throughout. According to Jane, girls were "more interested in the story behind" the robot (Jane Interview 1). Jane found that girls did not just want to create a robot to do a task but enjoyed telling a bigger story around the robot and how it completed the task. One aspect of this storytelling was sharing the work through social media. Jane encouraged all students to create videos and pictures that could be posted on social media. Students posted pictures to Instagram and videos to YouTube to share what they created.

> I tell them the only thing they can keep of the robot is the video from the project. And I will post that. Girls love that. They love the social media. They love making an iMovie of their robot. They love that when they are doing the space challenge that I will send tweets out of [the robots rescuing] the curiosity [model]. . . . It is really great to get them to want to show off their stuff. (Jane Interview 1)

The space challenge lesson Jane references has students program a robot to rescue the curiosity model, which is stuck, simulating rescuing the rover on Mars. She found that, in general, females were more excited to engage in this social way then male students. Her female students would ask for materials to be posted so they could share their narrative about the robot with others.

Engaging Female Learners with LEGO® Education

In Jane's experience, female learners were just as excited as male students to work with LEGO® Education materials and robotics. She realized, however, that they engaged with the materials in different ways. Jane found that

> the girls love character robots, and for the most part many of the boys do too. But I always have a girl that wants to build Gyro boy and turn it into Gyro girl and make a LEGO® skirt for it or a little bow to put on its head, kind of 'girly it up' Girls like to build the Dog and Znap and then girly Znap up. I have a lot of LEGO® [pieces].

> People will bring in and donate a lot of pieces. I have a lot of colored technic pieces and I love that the girls will do a lot with design. (Jane Interview 1)

Knowing that girls wanted to be creative in their designs helped Jane create lessons that would allow girls time and the ability to innovate their robotic builds. She perceived that "girls are sometimes more interested in the design and overall appearance of their robot" (Jane Interview 2). Therefore, she allowed students to choose their pieces, including what colors to use, when building something.

However, she found that girls needed scaffolding when it came to building in general. Jane explained that they were "not as experienced" with building and sometimes are "uncomfortable" with using the technic pieces (Jane Interview 2). Rather than push the female learners too far outside their comfort zone, Jane discovered it was better to give them some instructions and then help them make modifications from the original design to make the robot more their own. She explained:

> I have some girls with the dragster who were really kind of dragging their feet. And in that case, because I can see that they were uncomfortable, [unlike] the boys who, you know, take a pile of technics pieces and just put them together to figure out how they go together. And . . . I do have some girls who do that, too, but for the most part, when the girls as a team are not as experienced with building they feel much better with instruction. And so I'll give them . . . a number of drag racer designs that they can do. I give them the instructions and I said 'well, why don't you start with that. And then, you know, we can talk about how to adapt it.' (Jane Interview 2)

She felt this approach kept the girls engaged with the lessons so they did not give up, and they were still learning through the modifications that they did on the robot.

Jane observed that female learners engaged with the lessons in the classroom using EV3 when programming by embellishing the program to make the robot have more personality. When programming, she noticed that

> the girls almost always add a screen image and a sound no matter what we are doing. The boys sometimes do, the boys like the mechanical sounds. The girls love

> the eyes and then when they finish, the robot stops to do a twirl and then the love eyes come up and the hearts. (Jane Interview 1)

While Jane recognized that girls like to create a character out of the robot, this does not mean that they only like to play with the robot. She observed girls taking programming seriously and are more orderly when managing projects.

> When they program, the girls are much more methodical in their approach. The boys will just jump in, create a program and download it. The girls will talk it through and will talk about what they want the block to do. So when they download and run it their first program is more on its way to be successful then some of the boy groups. When it is a boy and girl team maybe there is that combination. (Jane Interview 1)

Jane found that girls were more reflective in their approach to solving a problem and really discussed the issues more in-depth rather than just using trial and error to make discoveries. She wondered aloud if girls were better at going through the iterative process, which she was teaching as part of the engineering process, because they were willing to carefully go through the steps. She shared the impression that girls will aim for "perfection" from the start (Jane Interview 1). They wanted to see the robot go the right distance the first time, rather than estimating and then running trials to see what might happen.

Therefore, Jane claimed the difference is that the "boys want to get it done first, where the girls want to get it done the best or with more style" (Jane Interview 1). She considered it her responsibility to coach female students on how to make changes and not give up (Jane Interview 2). In observing the classroom, students were working on a project to design and build a dragster car. Through testing and modifying the design, their goal was to create the fastest model. Jane asked students questions to get them thinking. When they seemed to reach a barrier, she suggested pieces to choose from to help modify the car. She also had them look at images of other models for inspiration to consider what factors might affect the speed. The female students

discussed their ideas at length before making any changes and were careful to track the changes made to ensure they knew what variables had the biggest impact (Jane Field Notes 1).

Preparing Teachers to Engage Female Learners with LEGO® Education

When she has the opportunity to work with other teachers in using the LEGO® Education materials, Jane had a few recommendations for engaging female learners. First, she suggested that teachers are careful to ensure girls don't get stuck in certain roles. She observed in her classroom that girls like to decorate the robot, and the team might assign the girl the role of always getting pieces. In *FIRST*® LEGO® League, she observed female learners wanting to work on the project.

> It happens on my FLL teams. The girls will gravitate to the project and the boys will gravitate to the robot. When you're in a robotics class and you don't have that delineation, you get the robot sometimes and the girls will be the ones going to get pieces or to sit next to the person who's coding. [It's] just making sure that they rotate those roles. (Jane Interview 3)

If she does not make sure the roles are rotated, the girls will not leave with the same experiences in coding and building. Jane emphasized the importance of having the teacher create a culture where students can have rich experiences in all aspects of the work.

The key to preparing the classroom for female learners, according to Jane, was to have "empathy" (Jane Interview 3). She suggested considering the following questions to create the right culture in the classroom:

- Where are [the female students] in terms of skill and background?
- What do [the female students] need to feel comfortable?
- What does a facilitated classroom look like as opposed to all teacher-directed?
- Who is in the room, including in front of them (the teacher)? (Jane Interview 3)

She felt that having empathy also tied back to having role models included in the lessons. She believed female students would be more confident in their abilities by seeing STEM role models and feeling a culture of understanding and support in the classroom. She worried that teachers

will assume the students are seeing the role models, but the examples must be explicit (Jane Interview 3). Jane emphasized that teachers had to make an effort to bring relevance to the role models utilized in lesson plans and in the classroom.

Additionally, Jane warned not to take competition out of the lessons. In her experience, many teachers assume girls are not as competitive as boys. She said, “They are competitive and they’re competitive with each other” (Jane Interview 3). She observed her female students wanting to succeed just as much as the male students. Jane explains: "They want to beat the boys. They want to beat each other. They want to beat themselves" (Jane Interview 3). The girls may not seek out competition, but they will compete. However, Jane also observed females can become “hormone-driven” and they “will put flirting with a boy above beating the pants off of him” (Jane Interview 3). As the teacher, she recognized that it was her job to make sure this does not happen and keep high standards for her female students

Jane has found that girls took more time to think about their designs and were more “methodical” in the way they programmed their robots (Jane Interview 1). As a result, the girls took longer and were not in a hurry to complete their project. Jane said that girls needed time “to talk it through” (Jane Interview 1). Jane observed that female students, in general, were not concerned about being the first to finish a project and were more concerned about finishing it correctly, so she ensured that the girls had time to work (Jane Interview 2). She observed that her girls shine at the end of the project because they are able to explain and talk about what they did as part of the lesson or project (Jane Interview 3). She believed that teachers needed to allow girls the time and support to work through a project.

Finally, Jane emphasized the need for choice in the classroom. Knowing what engages female learners meant that teachers could create lessons that allowed for choice and allowed for

students to bring their own interests into their learning. She suggested teachers use the curriculum to "pick and choose what works best for them" without letting the curriculum assume anything about the students or learning environment (Jane Interview 3). What she looked for was "rich content" that challenged students with a range of difficulties, but not a rigid requirement to complete the project in a certain way (Jane Interview 2). She observed that female students respond best to this type of curriculum. Using LEGO® Education in her classroom, Jane felt her female students learned that "there is no limit to when you can learn something new. . . I like kids saying that 'you can change', 'you're not limited to one thing' " (Jane Interview 1).

Jane believed that students were growing up in a world where they should not be limited to one possible answer. Therefore, she wanted curriculum that allowed for the following:

> I have always been a fan of student-driven classrooms, and my natural style has always been to be more of a learning coach and facilitator. I like having the freedom to experiment with my teaching practice. (Jane Interview 3)

Findings Summary

This chapter provided insight into the findings for each participant separately, creating a profile for each to build an understanding of their experiences in teaching female learners in STEM areas. The participant interviews and classroom observations revealed how teachers create projects using LEGO® Education materials to engage female students in STEM areas. Interestingly, none of the teachers showed that they instruct the female students differently than male students. Chapter 3 will further investigate the findings across all teachers to find commonalities amongst the participants and relevant literature to discover implications for other teachers looking to engage female learners in STEM classrooms using LEGO® Education materials. The themes that emerge across all three participants will further support the implications for my own practice as Educational Specialist with LEGO® Education, which will be discussed in Chapter 4.

CHAPTER 3
COMMON THEMES: LOOKING ACROSS THE TEACHERS

In order to support my own practice as an Educational Specialist, I completed this study to investigate ways that LEGO® Education Ambassador Teachers engage female students in LEGO® Education lessons to heighten their interest in STEM learning. In the previous chapter, I outlined findings from the data collected from three ambassador teachers in the study who are purposefully trying to engage female learners in their STEM classroom. There were several consistencies in the ways Judy, Ben, and Jane engaged female learners that provide insights into how LEGO® Education model teachers are fostering the engagement of female students in STEM areas. This chapter will report these consistencies.

Specifically, in this chapter, I will look at how the big ideas each teacher shared corresponded with that of the other teachers in order to identify the major areas of implication for my own practice, which will be discussed in the final chapter of this dissertation. To orient the reader to the cross-teacher discussion that appears in this chapter, Table 3.1 illustrates the themes and subthemes, providing a comparison of the three teachers. My collective look across all three teachers will be organized by the same sections that formed each individual teacher profile and are the themes represented in Table 3.1: engaging female learners, engaging females with LEGO® Education, and preparing teachers to engage female learners with LEGO® Education. The sub-themes will also be discussed within the discussion of each theme.

Table 3-1. A summary of findings across all three teachers

Theme	Sub-theme	Judy	Ben	Jane
Engaging Female Learners	Creating a Culture of Discussion	Girls are talking when engaged	Girls are discussing work when engaged	Girls are discussing when engaged
	Using Challenging Projects	Girls are interested in solving a problem and project-based lessons	Girls are interested in solving a real-life "novel" problem and working with relevant projects.	Girls are interested in working in solving problems and sharing their solutions.
	Providing Role Models	Girls need role models	Girls need to see they can be successful which can be supported by using role models.	Girls need strong role models
Engaging Female Learners with LEGO® Education	Scaffolding Building and Spatial Skills	Girls don't have experience building	Girls don't have as much experience, but can still meet high expectations	Girls like the materials, but need support with building
	Encouraging Stories	Girls enjoy creating a story around and decorating their robot	Girls like to make connections to other lessons or projects	Girls like to decorate their robot design and embellish program and share their projects
	Planning for Success	Girls try to be perfect, but sometimes are not risk-takers	Girls are more methodical during project to plan steps, which could lead to learning more	Girls strive to be best and plan and manage their projects carefully
Preparing Teachers to Engage Female Learners with LEGO® Education	Devising Group Dynamics	Teachers should consider how to group students	Teachers need to build the culture of the class so everyone has a voice	Teachers need to make sure girls do not get stuck in certain roles
	Promoting Self-Efficacy	Students solve problems in different ways	Students thrive on praise and success without gender specific things like clubs	Students will celebrate their success
	Setting High Expectations	Teachers should encourage girls, but keep high standards	Teachers need to set high standards where girls can reflect on learning	Girls set high standards for themselves and will be competitive
	Allowing for Relevancy and Choice	Teachers should create lessons that provide choices	Teachers should create projects which allow for choice	Teachers should design lessons that give choice and do not take competition out

Engaging Female Learners

All three teachers emphasized the importance of engaging female students and utilized teaching methods that supported female student success in STEM areas. Summarizing all three participant's findings for engaging female students, I found that there were three major sub-themes: a classroom culture of student discussion, using relevant problem-solving projects, and providing role models.

Creating a Culture of Discussion

Judy, Ben, and Jane consistently reported that it is appropriate to have students talking, and all three teachers foster a culture of collaboration as this leads to engagement. Each teacher indicated that one sign that female learners were engaged was when they were talking about the lesson or their work. As Judy explained, "True engagement is when they're doing it. They're talking about it. They're thinking about it. They're interacting, and that's when I know that this is challenging them enough" (Judy Interview 1). Ben similarly said that students were engaged when there was "a lot of talking with each other surrounding the actual subject" (Ben Interview 1). Jane recognized that her students were engaged when she "can hear them actively trying to solve whatever problem they have" (Jane Interview 2). Having an environment that allowed and encouraged students to discuss work was key to engaging students.

We learn from all three teachers that noise in the classroom is a good thing when it shows that students are engaged through discussing their learning. It is important for students to talk about their work to find solutions. This finding is consistent with literature that shows creating a culture of discussion in the classroom potentially allows female students to thrive. Knezek et al. (2015) discusses the idea that female learners perform better in a social environment. Tenenbaum, Ford, and Alkhedairy (2011) further state that female students use more collaborative speech than boys. Hence, teachers who wish to interest female learners in STEM

education may wish to take stock of the culture of discussion that exists in their classrooms and look for ways to enhance the time and space devoted to it, as giving female learners opportunities to discuss their work may engage them more strongly.

Using Challenging Projects

Judy, Ben, and Jane also show that it is important to deliver relevant, problem-based projects in the classroom, which allows female learners to engage with the project in their own way. Judy said that she "tries hard not to do that one size fits all kind of thing" (Judy Interview 1). She wanted students to find the way that worked best for them. Ben emphasized the need to create "a real novel problem [for students] to work with" (Ben Interview 1). Judy shared the need to create a challenging task that did not overwhelm the students to prevent female students from becoming quiet and disengaged (Judy Interview 2). Students still needed a challenge to push their thinking, and Ben really liked to see his students "puzzling with the problem to make sense of it" (Ben Interview 1). If the problem was "personal and relevant" to the female student, then they would be more interested to work on the problem (Ben Interview 1).

We learn from the three teachers the importance of designing project-based or problem-based lessons that challenge and interest students. This finding is consistent with the literature that shows females have high interest in problem solving, the cornerstone of problem-based and project-based lessons (Cooper & Heaverlo, 2013; Buschor et. al, 2014). Female learners approach STEM learning positively through problem-based learning (Lou, Shih, Diez, & Tseng, 2011). Teachers need to create problems that relate to females' broad range of interests and build their problem-solving skills (Cooper & Heaverlo, 2013; Buschor et. al, 2014; Lou, Shih, Diez, & Tseng, 2011). Additionally, problem-based or project-based learning environments can keep female learners engaged in STEM. Hence, teachers who wish to interest female learners in

STEM education may wish to ensure their instruction is designed to be more student-led (rather than teacher-led) through presenting problems or projects that interest students.

Providing Role Models

Judy, Ben, and Jane also recognized the importance role models can play in the classroom. Each participant discussed how the use of role models engaged female students in his or her class and lessons. Judy and Jane each recognized that they were role models for girls because they were female STEM teachers. Judy said that she would act "girly" so the female students could "see that you can be excited about math and science and skill keep your girliness about you" (Judy Interview 1). Judy and Jane also included role models by showing videos of females in STEM positions. Jane said it was important to "make sure girls consider all the possibilities out there" (Jane Interview 1). Ben valued using role models for female learners in several ways. In one example, he utilized peer role models in his own school by bringing in high school female students to work with the middle school female students. Judy also used peer role modeling for her elementary students. Her middle school students taught the younger students, which she felt was "empowering [females] to feel like they can teach these things and understand these things" (Judy Interview 1). Jane said it was important that girls did not "close the door" to any possibility (Jane Interview 1). As Judy said, role models are important for females to see the "need for different thinkers" (Judy Interview 1). Ben further explained that girls need to see that they can be successful.

We learn from the three teachers to encourage the use of role models in various ways to support female learners. This finding connects to literature, which shows the positive effects role models play as part of a program to interest female learners in STEM areas and build self-efficacy (Buschor et al., 2014; Bystydzienski, Eisenhart, & Bruning, 2014; Knezek et al., 2015; Liu, Lou, & Shih, 2014). Female learners need to have consistent role models early-on to

overcome negative stereotypes they are exposed to in society (Milam, 2012; Hill, Corbett, & St. Rose, 2010). Nieto's (2010) research furthers the fact that students will believe the perceptions other people have of them. It is important that female learners see themselves in these roles (Bamberger, 2014). Therefore, teachers who wish to interest female learners in STEM education need to work towards integrating examples of role models from various areas of STEM careers into lessons as well as consider how to physically bring multiple role models into the classroom.

Engaging Female Learners with LEGO® Education

All three teachers used LEGO® Education materials to teach in their STEM classrooms and adjusted the lessons to engage female students. Summarizing all three participant's findings in engaging female students using LEGO® Education materials, I found that there were three major sub-themes for female students: scaffold building and spatial skills, creating a story, and working toward success.

Scaffold Building and Spatial Skills

When using the LEGO® Education materials, all three teachers referenced a specific need from their female students for more support when building with the LEGO® Education materials. Judy, Ben, and Jane all noted that most female students do not have the same prior experience as their male students when it comes to building, particularly with the Technic pieces. LEGO® Technic building elements provide the ability to build more advanced models using connection pieces, like pegs, axles, and beams, which can make models more stable or allow for movement. Technic pieces are often used in conjunction with gears, belts, wheels, and motorized parts. Jane described her female students as being "uncomfortable" using technic pieces and, in general, did not have as much experience building as the male students (Jane Interview 2). Judy reiterated the same issue with female students using Technic pieces (Judy Interview 2; Judy Interview 3). Similarly, Ben said that the "boys tend to do well with the spatial/relation pieces and building"

(Ben Interview 2), but did not say the same for his female students. Both Judy and Jane said they scaffold the learning for girls by providing access to a lot of additional materials, including pictures of robots to build and building instructions.

We learn from all three teachers there is a need to support female learners who may have less prior experiences that would lead to their ability to build with the LEGO® Education materials successfully. Hill, Corbett, and St. Rose (2010) suggest that spatial skills are grown through experiences, which can include playing with construction type toys. In general, females are less likely to play with the construction type toys that inspire the development of spatial skills than boys as they are growing up, given the gendered nature of toy selection and play. As a result, teachers who enact the LEGO® Education curriculum, may find girls in their classes experience difficulty building with LEGO® Technic pieces, as Judy, Ben and Jane did in this study. Therefore, it is important that teachers ensure females have many opportunities to work with the LEGO® Education manipulatives and prepare lessons that scaffold building skills for their female students.

Encouraging Stories

Judy, Ben, and Jane all shared that their female students enjoy working with the LEGO® Education materials to extend their project and tell a story. In fact, Jane found that girls were more concerned than boys about the "overall appearance of their bot" (Jane Interview 2). Judy found that girls dig even deeper, wanting "more thematic kind of things and more backstories" for the robots (Judy Interview 3). Girls wanted to create a narrative for the robot, not just build, which actually pushed them to build more as they decorate their robot. Jane added that "girls love character robots," citing their enthusiasm to build the Dog bot and Znap (Jane Interview 1). She found that girls liked to make the robot more alive, and they liked to "add a screen image and a sound" (Jane Interview 1). Ben said that girls liked the "creativity" the most and looked for

ways to incorporate other projects with their work (Ben Interview 2). Overall, girls wanted to create a storyline for the robot that they could share. Jane found that her female students especially enjoy sharing their work through social media, which is not currently part of the LEGO® Education curriculum (Jane Interview 2 and 3).

We learn from all three teachers that female students are interested in not only problem-solving, but in "storying" the problems they work to solve by creating the identity or character for their robots. This, in turn, helps female learners relate better to the overall activity. This finding echoes a study conducted by Tenenbaum, Ford, and Alkhedairy (2011) who found that female students like to create a whole story, whereas boys focus on just giving facts. In sum, female learners may engage more with a project when they can create a story as well. Hence, to engage female learners in STEM education using LEGO® materials, teachers may wish to create opportunities in their lessons that include developing the robot into a character that a story can be built around.

Planning for Success

Additionally, Judy, Ben, and Jane show that teachers need to allow time for female students to plan how to approach their project. The three participants observed female learners engaging with the LEGO® Education materials differently than the male students. Ben felt that the female learners actually learned more from the lesson because of the way they approached solving the problem. According to Ben, "girls tend to be a little bit more efficient as far as what they are trying to do" (Ben Interview 2). Jane said, "The girls will talk it through and will talk about what they want the [programming] block to do. So when they download and run it, their first program is more on its way to [being] successful" (Jane Interview 1). Ben agreed that female students "are doing a better job of thinking through the planning of the organization" of their project to set themselves up for success (Ben Interview 2). As Jane said, girls do not just

want to get it right, they want to do it the best (Jane Interview 2). Judy did not discuss how her female students approach a project, but did indicate that females work "to be a little bit more perfectionist, worried about messing something up" (Judy Interview 2). Judy perceived this as a potential barrier for female students and wanted to ensure girls learned the "perseverance of pushing through" a problem (Judy Interview 2).

We learn from the three teachers that female students work toward success in their approach to problems by not rushing, being thoughtful in their approach, and working toward a right answer. Not rushing and being thoughtful in their approach may be explained by the literature that female learners are more collaborative in their communication (Tenenbaum, Ford, & Alkhedairy, 2011). Because of this communicative collaboration, female students are more likely to talk through the planning stage rather than jumping into building or programming. Furthermore, females' desire to work towards the right answer may be explained by literature that shows that females are under the scrutiny of stereotypes that make them believe they might not be able to be as successful as male students (Shapiro & Williams, 2012; Hill, Corbett, & St. Rose, 2010). Because female students feel a pressure to be more successful, they push themselves to work toward perfection. Hence, when working with female learners with the LEGO® Education materials, it is important for the teacher to provide time for the students to work through the planning stage and help them not feel pressured to rush into building.

Preparing Teachers to Engage Female Learners with LEGO® Education

All three teachers have had the opportunity to work with other teachers on how to use LEGO® Education materials in the classroom. Summarizing all three participant's findings in preparing other teachers, I found that there were four sub-themes: grouping students, building confidence, setting high expectations, and allowing for choice.

Devising Group Dynamics

Judy, Ben, and Jane demonstrate that grouping students is a key to creating success for female learners. The nature of working with LEGO® Education materials is that students in the classroom work together in small groups or pairs. The three teachers recognized that the way groups are formed and how they function could prohibit success for female students. As Judy said, "I want everybody to participate and do something" (Judy Interview 2). She did not want to see her female students "just kind of sit back and let the boys do their thing" (Judy Interview 2). The result, according to Ben, is that "inevitably someone is going to feel left out" (Ben Interview 2). Therefore, Judy was careful who she grouped with her more passive female students to ensure they did not lose confidence or disengage.

The three teachers agree that gender roles are prevalent in the classroom. Since male students tend to be more vocal and assertive, teachers need to consider how to ensure that females have a voice and stay involved rather than sit back and let others take control. Ben talked about the need for "building the culture of the program that everyone has the opportunity to be able to speak and can share" (Ben Interview 1). When building the culture, Jane advised not to let female students get stuck in "certain roles" such as piece finder or just working on the project (Jane Interview 3). Jane and Ben both indicated the need for teachers to establish roles within groups and make sure the roles rotated among the group members so every student had a good learning experience.

We learn from the three teachers that group dynamics is a key for engaging female learners in the projects. Literature supports this finding that how students are grouped can impact how female students participate in a project (Baker, 2013). Boys and girls see gender differences in certain jobs and roles that students take on in the classroom (Shapiro et al., 2015). Teachers need to be careful that female students do not give into social pressures to act a certain way

based on gender roles, and therefore only take on certain roles within a group. Female students often take passive roles when working in groups, which can result in the students creating negative self-efficacy (Brown et al., 2016). Students that do not have experiences in active roles often do not show as much interest or confidence in STEM as females who are exposed to STEM growing up (Hill, Corbett, & St. Rose, 2010). However, in some cases, female students will not assess themselves as being as capable as the male students, which could lead to students not self-selecting certain roles. Shapiro and Williams (2012) warn that this could further lead to self-as-source stereotype threats, where the female students could internally believe that they cannot fulfill a certain role. One possible solution is to create all-girl groups, forcing girls to perform *every* role. While some literature calls for single-sex experiences for female learners, Baker asserts that having mixed groups can have a positive effect on female learners at the middle school level. Hence, when planning instruction, teachers need to consider the group dynamics including defining roles for all group members and ensuring female students experience different roles. Teachers need to work with female students to feel confident working in different roles and stay active in those roles.

Promoting Self-Efficacy

The three participants described an atmosphere that allowed students to find their successes and test their abilities. Judy shared the story of her own learning and the need to know more than one way to approach a problem, and students need to be able to find the way that best suits them. She said, “Just encouraging them and helping them feel like this is something they can do” goes a long way (Judy Interview 3). Ben shared how the female student in his class thrived after he praised her for her ability. He described the student’s reaction by saying she “lit up” and worked harder after that (Ben Interview 2). Helping the student see she was doing a good job made a difference in her confidence in the class and the STEM content. Similarly, Jane

commented on how the female students reacted with joy when females saw their robot complete the tasks appropriately. She observed them “jumping up and down” with joy (Jane Interview 1). Although different in their own way, all three examples show the benefits that come from helping students see what they are capable of doing and how celebrating achievements helped build the confidence of female students. Ben, however, emphasized that part of encouraging female learners is to not make a difference between the girls and the boys. He said he has “purposefully not tried to have a girls coding club or gender specific things because I'm concerned that that will perpetuate the sense of separation” (Ben Interview 1).

What we learn from the three teachers is that creating an atmosphere in the class where students can learn in their own way and celebrate their successes allows female students to thrive without the need for gender specific tasks or lessons. Connecting to the literature, we see it is better to create a classroom environment where girls can thrive without removing boys or creating gender specific tasks (Baker, 2013). It is important the individual student sees that she can be successful to fight against the belief many girls hold that females in general can do it, but as an individual I cannot (Bamberger, 2014). Building self-efficacy is an important factor to create female success (Milam, 2012). Female students need to believe they can do it. Therefore, teachers should consider ways to promote self-efficacy in the classroom without creating gender specific lessons.

Setting High Expectations

Judy, Ben, and Jane confirm that female students can be just as successful as male students. All three teachers said it was very important to keep standards high for their female students. Ben said that “not every kid is going to be a coder or a scientist or whatever, but they’re going to be thinking or a problem solver or innovator” (Ben Interview 2). So he continued to hold all students to a high standard of learning to ensure they gained the skills to be

successful, no matter what they did in life. Judy told her students "to take it to the next level" and pushed them to "make [it] more complex" to show what they can do and used rubrics to guide the students (Judy Interview 3). Without her influence, Jane observed her female students push themselves to a higher standard by wanting to be the best or do better than they had previously (Jane Interview 2). She observed that "[girls] are competitive and they're competitive with each other" (Jane Interview 3) and they want to be the best (Jane Interview 1). Jane described females as being just as competitive as the boys and felt this had a place in the classroom.

We learn from the study that the three teachers had high expectations for their female students. The participants found girls were capable of meeting those high standards. Literature supports this finding showing that students will respond to the performance expectations set for them (Nieto, 2010) and will focus on their goals (Buschor et al., 2014). Hill, Corbett, and St. Rose (2010) report that female students will set higher expectations for themselves in fields that male students are considered better at because they believe they have to work twice as hard to succeed. While this potentially puts female students at risk for stereotype threats (Shapiro and Williams, 2012), where females can internalize and create a situation where they believe the stereotypes are true and perform to that level, teachers can mitigate these threats by maintaining high standards. Hence, it is important for teachers to stay conscious of the expectations set and communicated to students to ensure female students see the same high expectations set for them as male students and that they work to meet these expectations.

Allowing for Relevancy and Choice

All three teachers emphasized the need to design lessons that were project-based and allowed for choice. Ben described the need to create engagement at the start of a lesson through presenting a relevant project to solve (Ben Interview 3). He explained that "the real engager is a real novel problem to work with" (Ben Interview 1). When the lesson is given as a project, there

were more opportunities for the students to have choices within their learning. Judy gave students choice by allowing the female students to tell the "whole story" behind the robot (Judy Interview 3). She designed her own lessons rather than using the LEGO® Education lessons to allow "my kids to be able to take pieces and make it their own" (Judy Interview 1). Students had choices in what they created or how they presented their solution, which allowed the female students to bring their interests into the project. Ben showed that females were interested in areas that benefit society. As Ben describes, bringing in interests and connecting to society makes the project "personal and relevant" (Ben Interview 1). Jane agreed and observed her female students were interested to use social media to share what they created (Jane Interview 1).

What we learn from the three participants is the importance of creating problem-solving projects and lessons that allowed female students to solve real world problems and have choice in their learning and the way they shared their solutions. This findings is supported by literature that shows that female students "learn best in environments that promote collaborative learning, hands-on experiences, creativity, and practical applications" (Cooper & Haverlo, 2013, p. 28). Girls seek choice and control in their learning through real world, problem-based or project-based learning, which has a positive effect on interesting female students in STEM and can be intrinsically motivating (Buschor et al., 2014; Lou, Shih, Diez, & Tseng, 2011; Patall, Cooper, & Wynn 2010). Girls especially are motivated by projects that are relevant to them because they have an impact on society (Buschor et al., 2014; Knezek et al., 2015). As a result, teachers need to find ways to create learning that allows choice through considering a problem-based or project-based approach to teaching. If female students can bring their interests into the lesson because there are areas of choice, then they are more likely to be motivated to complete the lesson.

Findings Summary

In this chapter, I looked across the three teachers I studied to distill common sub-themes that existed in relationship to three overarching themes: (1) Engaging female learners, (2) Engaging female learners with LEGO® Education, and (3) Preparing teachers to engage female learners with LEGO® Education. A total of ten sub-themes emerged across the three topic areas that provide insights into how teachers might work to engage female learners in STEM education using LEGO® Education materials. These 10 themes include: (1) Creating a culture of discussion, (2) Using challenging projects, (3) Providing role models, (4) Scaffolding building and spatial skills, (5) Encouraging stories, (6) Planning for success, (7) Devising group dynamics, (8) Promoting self-efficacy, (9) Setting high expectations, and (10) Allowing for relevancy and choice. In this chapter, I described each one of these sub-themes in detail, connected it to relevant literature, and shared considerations teachers who wish to interest female students in STEM education using LEGO® Education materials may wish to consider as they plan for and deliver instruction. In the next chapter, I present these considerations all together as "lessons learned" from the study of Judy, Ben, and Jane, and discuss implications of these lessons for my own practice and actions as an Education Specialist for LEGO® Education.

CHAPTER 4
DISCUSSION AND IMPLICATIONS FOR PRACTICE

The purpose of this study was to investigate ways that LEGO® Education Ambassador Teachers engaged female students in LEGO® Education lessons to heighten their interest in STEM Learning. In Chapters 2 and 3, I provided the findings of my research by sharing the narratives of the three teachers I studied as well as common themes and sub-themes across these teachers' practice. In this chapter, I repeat the 10 individual sub-themes shared in Chapter 3, representing them as lessons I learned from the study of Judy, Ben, and Jane, and discuss implications of these lessons for my own practice and actions as an Education Specialist for LEGO® Education. It is fitting to end this dissertation with discussion of implications for my own practice and actions I will take in my work as this is consonant with the goal of practitioner research, the lens I used to frame this study. In her foreword to the text *Digging Deeper into Action Research*, Marilyn Cochran-Smith stated that the value of practitioner research rests in "practitioners engaged in the work of reflecting on, studying, and interrogating their practice in order ultimately to improve … the learning opportunities and life chances of children" (Dana, 2013, p. xiii). I used this capstone project for my attainment of a professional practice doctorate to reflect on, study, and interrogate my practice as an Educational Specialist for LEGO® Education for the purpose of improving the learning opportunities for female students who use our LEGO® Education curriculum materials, and hence, expand the perceptions female students have of entering careers in STEM fields.

Lessons Learned

Lesson #1: Creating a Culture of Discussion

> *Teachers who wish to interest female learners in STEM education may wish to take stock of the culture of discussion that exists in their classrooms and look for ways to enhance the time and space devoted to it, as giving female learners opportunities to discuss their work may engage them more strongly.*

In Chapter 3, it was reported that Judy, Ben, and Jane all believed that providing female students with multiple opportunities to discuss their work was critical to their learning. In my work as a LEGO® Education Specialist, I discuss the importance of communication as part of the learning process. I follow the LEGO® Education teaching philosophy, which focuses on collaborative learning where students work together in pairs to complete projects. When preparing teachers to implement this teaching philosophy, I need to discuss the importance of developing a culture of collaborating in classrooms rather than assuming it will happen naturally for all students by providing examples and modeling in workshops. Additionally, I try to highlight for educators the final step of all projects, which is sharing. In this step, students are able to communicate what their group learned and did during their investigation. As a result of this study, I will continue to discuss the importance of the sharing step, now stressing the value it can bring to female learners. One way that I will emphasize the importance of sharing is through modeling this step during workshops with teachers and through having participants discuss how they can build a culture of discussion and collaboration in their classroom.

Lesson #2: Using Challenging Projects

> *Teachers who wish to interest female learners in STEM education may wish to ensure their instruction is designed to be more student-led (rather than teacher-led) through presenting challenges as problems or projects that interest students.*

In Chapter 3, it was reported that Judy, Ben, and Jane all believed that female learners were most engaged when they are problem-solving. In my work as a LEGO® Education Specialist, I support teachers to consider how to bring these practices into their classroom and can provide support through training. However, currently the support is more focused around the use of the materials specifically. I see a need to provide teachers with more pedagogical practices along with training them to utilize the materials in the classroom. The LEGO® Education curriculums are designed to present students with a problem to solve or project to design a solution for.

When preparing teachers to use the materials in this way, they would benefit from additional training in student-centered learning and problem-based and project-based learning. Helping the teachers become more confident teaching this way would ensure they are able to keep the students more engaged with the materials. Model teaching is also way to deliver this support. I plan to investigate with LEGO® Education the potential of hosting webinars or creating videos that will allow a broader audience to experience this type of instruction, which can better prepare them to teach using the LEGO® Education materials and prepare their own open-ended lessons.

Lesson #3: Providing Role Models

> *Teachers who wish to interest female learners in STEM education need to work towards integrating examples of role models from various areas of STEM careers into lessons as well as consider how to physically bring multiple role models into the classroom.*

In Chapter 3, it was reported that Judy, Ben, and Jane all believed that girls need strong role models. In my work as a LEGO® Education Specialist, I see several opportunities to encourage teachers to bring role models into their classroom when utilizing LEGO® Education materials. There are many career connections within the current LEGO® Education curriculums. As a start, I will better align these connections to specific career roles with role models to ensure educators have the resources necessary to engage students with role models in the classroom. The Design Engineering curriculum, for example, provides several career exploration options, including how robotics are used in logistics, medical fields, personal use, production, transportation, space, and safety and security. Showing role models in these areas would add value to the classroom.

I will use a critical eye to review the LEGO® Education curriculum to outline opportunities to use role models for all students. This study has indicated a general need to deepen the career connections within our lessons. I will be careful to ensure there is a balance of male and female role models shown. MacPhee, Farro, and Canetto (2013) remind us that female

students do not have as many opportunities to be mentored as males. I will carefully align the curriculum with role model examples to ensure female role models will be well represented as well as other minority groups. Using the Design Engineering example from above, I know there are resources available to the public through NASA that could tie nicely to areas of transportation and space. I will also leverage The Society of Women in Engineering, who has a similar mission to expose female students to role models. Members of the society, such as NASA engineer Mamta Patel Nagaraja, have created programs to connect students to role models in various areas of engineering (McCabe, 2017). I will utilize work such as hers to help teachers see how to purposefully use role models in the classroom and how to identify role models. My next steps will be to investigate these programs further and map them to our curriculum. I will then share these examples with educators through implementation support and professional development sessions to help them create a learning environment rich with role models.

Lesson #4: Scaffolding Building and Spatial Skills

> *Because teachers who enact the LEGO® Education curriculum may find girls in their classes experience more difficulty than boys in building with LEGO® Technic pieces due to lack of prior experiences working with these types of material, it is important that teachers ensure female students have many opportunities to work with the LEGO® Education manipulatives and prepare lessons that scaffold building skills for their female students.*

In Chapter 3, it was reported that Judy, Ben, and Jane all found that in general, girls in their classrooms had less building experience than boys. In my work as a LEGO® Education specialist, I help educators bridge the gap of experience to ensure all students are ready to build with Technic materials. However, I want to proceed carefully here to ensure that a stereotype is not created around female students' inexperience in building with LEGO® elements. Rather, I want to create a way for any student without previous experience to build their skills and be successful. Therefore, at the conclusion of this study, I will create an implementation alignment

that suggests the use of LEGO® Education Simple and Powered Machines with students prior to beginning any of the LEGO® MINDSTORMS® Education curriculums. This alignment will provide teachers with potential scaffolding to put in place for students who need support learning to build structures. The Simple and Powered Machines curriculum calls for creating mechanisms using Technic element pieces and building instructions, which allows students to build a bank of designs they can pull from later. These experiences provide important scaffolding prior to entering into a curriculum such as LEGO® MINDSTORMS® Education Design Engineering Projects, where students are building their own designs with little support and no building instructions. Providing this resource to teachers will allow them to prepare their lessons to meet the students at their skill levels.

An additional result of this finding is a need within my own practice to ensure that female learners are not victim to implicit bias around their abilities to utilize the tools given to them in STEM classes. Female learners potentially will enter into classrooms using LEGO® Education materials with a belief that they will not be able to build things. Teachers need to deeply consider the implicit bias that may exist for their female students and address these biases in order to create an equitable learning space. My job will be to ensure teachers are aware of this area of potential self-doubt in female students and help them navigate ways to counteract it. I will investigate the best ways to communicate this finding to teachers at the conclusion of this study.

Lesson #5: Encouraging Stories

> *To engage female learners in STEM education using LEGO® Education materials, teachers may wish to create opportunities in their lessons that include developing the robot into a character that a story can be built around.*

In Chapter 3, it was reported that Judy, Ben, and Jane all found that girls enjoy creating a story around and decorating their robots and/or making connections to other lessons and projects. In my work as a LEGO® Education specialist, I see that female students find a way to reflect who

they are in the materials, regardless of whether the materials reflect female learners or not. The participants indicated that female students like to do additional building and designing in order to decorate their robot, to tell a narrative about their robot, and complete larger projects that are relevant to them. These findings signify the need for open-ended projects that allow for students to develop what they want with the materials, rather than requiring students to build a particular robot. As a result, I will work with educators during professional development sessions to consider how to frame their lessons to remain open-ended so that female learners have opportunities to story their building efforts. Furthermore, open-ended design projects will allow female students to design robots with which they connect. When I consider Jane's example of a group of female students who turned Gyro boy into Gyro girl, I see a need to remove gender labels from robot designs. The female students did not relate to the original design, so they changed it to better reflect themselves. Judy also expressed the need to make things more girly for her students, creating a space where girls could see themselves engaging in STEM activities. These examples bring into question how female students connect with the materials and lessons. Teachers and the LEGO® Education development team need to be considerate of the fact that students may not be able to connect with a robot with a specific gender label and rethink the names given to LEGO® model designs. Teachers should be cautious with naming robot designs and consider how the students will connect to the name.

Therefore, I see a need in my own practice to find how I can work with educators as they implement LEGO® Education teaching materials in their classrooms to overcome gender bias in their lessons. I will take time to audit our lessons to find areas of concern. I will then develop a brief to support teachers in developing their own lessons and using our lessons to ensure they allow lessons to be open-ended so that students can choose if a robot represents a certain gender.

Furthermore, I see an opportunity to work with the LEGO® Education development team to provide insight into how we can avoid gender bias in all aspects of model designs including the pieces and colors chosen to be included in future sets.

Lesson #6: Planning for Success

> *When working with female learners with the LEGO® Education materials, it is important for the teacher to provide time for the students to work through the planning stage and help them not feel pressured to rush into building.*

In Chapter 3, it was reported that Judy, Ben, and Jane all found that girls take time to plan through their work rather than getting right to building. In my work as a LEGO® Education specialist, I often see teachers urging student groups to stay on a similar pace. Additionally, I have experienced teachers trying to redirect students that appear off-task when, in reality, students were just taking some time to reflect or think about the problem. The LEGO® Education curriculum is already designed to allow students to be more self-paced. This learning shows me that teachers may need additional training or support in best practices for implementing the curriculum and support how female learners will approach the lessons. Teachers who are not comfortable letting groups of students progress through the project in their own way could stifle the learning process for students by either not allowing enough planning up front or holding students up from forward progress by trying to force too much planning at the beginning. As a result, I see a need in my own practice to identify places for teacher development when implementing these more student-led lessons. I will identify places within our professional development where best practices could be shared and where model teaching that occurs within the sessions could be enhanced.

Lesson #7: Devising Group Dynamics

> *Teachers need to consider group dynamics to ensure female students actively experience all group roles to be confident taking the lead in various duties without exclusively working in all female groups.*

In Chapter 3, it was reported that Judy, Ben, and Jane all found that girls are at risk to not naturally select certain group roles or they become passive in a group setting. In my work as a LEGO® Education specialist, I need to consider the roles that females take on in the classroom as a way to build self-efficacy. I currently work with educators when implementing LEGO® Education to consider classroom management issues, including grouping students. However, I had not previously considered the findings from participants on the importance of gender roles in the classroom. Therefore, I need to evaluate how I can address with educators the gender roles that may be used in student grouping and ensure females are not in the position of accepting passive learning roles (Brown et al., 2016). The findings show that I need to be more purposeful when training and working with teachers to bring LEGO® Education materials into the classroom to prepare teachers to create roles for all students and ensure all students rotate through those roles. As a result of this study, I will create more specific guidance for teachers so they understand how to prepare for grouping female students and determining group roles to ensure females can be successful in all collaborative roles.

Lesson #8: Promoting Self-Efficacy

> *Teachers may wish to consider additional ways to promote the self-efficacy for female learners in the classroom.*

In Chapter 3, it was reported that Judy, Ben, and Jane all found that they needed to build female students' confidence to be successful in the STEM classroom. In my work as a LEGO® Education specialist, I see all levels of students finding ways to be successful with the LEGO® Education materials without changing the environment of the class. However, self-efficacy is a key factor for success for female learners (Milam, 2012). Therefore, it is important to consider the findings that show ways the participants were successful in building confidence among female learners. Ben's example of praising a female student for how she was successful in

coding, which led to her engaging better in the classroom, provides evidence that teachers can build confidence through strategic feedback to female students. By building the student's belief in her own abilities, Ben found that this student engaged more in the class.

As a result, I need to investigate ways in my own practice I can support teachers to build the self-efficacy of female learners. With so many potential ways to do this, I looked at the research conducted by MacPhee, Farro, and Canetto (2013), which shows that female students' self-efficacy increases as they successfully complete their learning. As a result, I see feedback as a good method for female students to see success and how their learning is progressing. In my own practice, I believe I can support teachers by using assessment rubrics to provide feedback to students throughout the learning process. I believe this idea demonstrates the academic success female students need to build their confidence, helping them continue to learn and grow their skills in STEM areas. The Appendix provides two examples of rubrics that LEGO® Education curriculums currently provide for teachers to utilize in the classroom. I will use these rubrics more purposefully in the future with teachers to support their female students. The Creativity Rubric allows teachers to provide meaningful feedback to female students so they can see where they are excelling and where they can continue to grow. The teacher can then help the female students set goals to continue to build their confidence. The Self-Assessment Rubric is another method that uses feedback to support female learners by allowing them to think about how they are expressing themselves and exploring their own ideas within their work. While LEGO® Education provides these tools generically, I will create more explicit communication in how to utilize the tools to build efficacy with students.

Lesson #9: Setting High Expectations

> *It is important for teachers to stay conscious of the expectations set and communicated to students to ensure female students see the same high expectations set for them as male students and that they work to meet these expectations.*

In Chapter 3, it was reported that Judy, Ben, and Jane all found that girls will meet and seek out high expectations. In my work as a LEGO® Education specialist, I believe the LEGO® Education learning materials are designed to allow all students to be successful. As such, I have not considered setting different expectations for students in the past. I have learned from this study that female students approach STEM learning by working toward success, which can mean approaching the problem methodically, carefully planning, and sometimes trying to be too perfect. LEGO® Education STEM lesson plans are designed for students to follow the scientific method or engineering design process, depending on the type of lesson. However, the findings propose that female students may get caught when attempting to follow these processes more linearly rather than seeing the iterative nature of testing and modifying that the LEGO® Education curriculum are designed to include. The teachers found that their female students were working toward high expectations not because different expectations were set, but because the teachers created an environment that allowed them to be successful and work toward high expectations.

As a result of this study, I see a need in my own practice to directly address expectations with teachers. Teachers need to consciously think about the expectations they set for different groups of student, even when they are holding students to the same standard. Ben commented that he did not set different expectations for females because why would he. However, it is important that he thought about the female learners and how they might be different to ensure he was not unintentionally acting on biases (Nieto, 2013). I see an opportunity when working with schools and districts to plan an implementation of LEGO® Education to discuss how to set expectations and outcomes for their various groups of students. Through purposefully planning

outcomes together, I will support teachers in identifying the high expectations for all and seeing the path to ensure all students get there.

Lesson #10: Allowing for Relevancy and Choice

> *Teachers need to find ways to create learning that interests and is relevant to female learners through providing choice in their learning, which can be accomplished with a problem-based or project-based approach that impacts society. If female students are interested in this way, then they are more likely to be motivated to complete the lesson.*

In Chapter 3, it was reported that Judy, Ben, and Jane all found that girls engage better with lessons that allow for choice. In my work as a LEGO® Education specialist, I find that our curriculum is open-ended allowing for students to have choice in their learning. The findings and supporting research showed girls engage with lessons that were relevant to them, project-based, and involved social components, which suggests that the LEGO® Education materials and curriculum are a suitable match for female learners. The three participants agree that female students are engaged when they are challenged with projects that allow for choice and creativity, but also challenges them to solve problems. However, the findings further indicate that female students connect with learning that includes project work that benefits society. The female students in this study indicate a desire to do more than just create the robot itself. They wanted to see a purpose behind the robot. According to the research, females see themselves in STEM careers where they can be of service to society. Understanding how to develop problems relevant to female learners, such as investigating issues in their community, is important to engaging female students in their work.

The LEGO® Education curriculum is already designed to be project-based and open-ended, allowing for choice. Therefore, I see a need in my own practice to focus on making a stronger connection between the projects and benefits to society. For example, I can highlight lessons such as the research projects from the Space Challenge curriculum as a good resource to

utilize with female students because the curriculum is project-based with research into areas that can impact society. There is also particular relevance in two other projects, which look at how robots can help humans and how we generate energy for humans. As a result of this study, I will be able to communicate the positive effects this curriculum could have on female learners. Once I map the lessons that investigate these impacts on society, I will be able to interweave these lessons in implementation plans created with schools.

Implications for Future Research

While this study provided valuable insight into my own practice, it also brings into focus possible continued research. This study examines only a small group of educators using LEGO® Education materials in their classrooms. Therefore, the study is not representative of how all teachers using these materials engage female learners. My hope is that these rich descriptions of the participants and their experiences will allow the reader to translate the information to their own contexts. The research will need to continue with a broader audience to learn about more ways to interest female learners in STEM education.

The research was also limited to studying teachers currently teaching in a middle school setting. This age group was chosen specifically based on the research that found middle school learners connected certain careers to different gender roles (Shapiro et al., 2015). It would be interesting to consider the effects of engaging female learners at a younger age, when they are in elementary school, to see how the results differ. Particularly, it would be interesting to consider if females relate better to the materials at a younger age when societal norms and biases have less of an influence.

Additionally, this research study did not consider male students or a comparison of female and male students. The participants did discuss some areas where they saw differences in male and female students, but the study did not investigate this in-depth. Comparing the

communication styles and use of social media between female and male students in a STEM classroom may provide additional insight regarding what enhances engagement in STEM for female versus male students. Further research that centers on the students rather than the teachers, including both male and female students, could provide additional insight into this area.

By completing this study, I have begun to question the long-term effects of female students engaging with LEGO® Education materials. It is a bit of a leap to say that by seeing female students succeed in the three classrooms studied that female students are more likely to enter STEM fields as a result of using LEGO® Education STEM materials. However, it is an interesting idea to question whether female students who use engaging materials such as these at an early age and have positive experiences would be more likely to consider a STEM field later in college or in their career. Further research is needed to see if any such correlation exists.

Conclusion

Despite the need for additional research, this study has provided valuable insight for me when working with other educators to ensure female learners are engaging in STEM learning. By studying three ambassador teachers for LEGO® Education, I was able to create a rich description of how these teachers were seeing their female students engage in their STEM lessons. The findings in Chapter 2 showed how each teacher was successful when engaging female learners as well as where the students struggled with STEM lessons. The findings were summarized across the teachers in Chapter 3 to show the key areas of how female learners are engaging, how female learners are engaging with LEGO® Education, and how other teachers should prepare to engage female learners with LEGO® Education.

I created this study to impact my own practice through a better understanding of how female students engage and are interested in STEM learning. From the study, I believe there are many ideas that I have uncovered to support teachers in creating environments in their

classrooms conducive to engaging female learners. Based on the finding in this study, I will continue my practitioner research into understanding the importance of role models, creating efficacy, and being wary of stereotyping in how I work with teachers to implement our programs and in how I influence the development of materials, always with the ultimate goal of empowering female learners to enter STEM fields.

APPENDIX
LEGO® EDUCATION RUBRICS

Sample rubric provided by LEGO® Education to teachers in the curriculum as a method to provide feedback to students throughout the learning process.

Creativity Rubric

Directions:
For each student, add dates or check marks to document indicated behaviors.

Student Name:	Date:

Behavioral Indicators	Opportunity	Regularly	Rarely	New Goal
Self-expression While working individually				
While working in groups				
Problem solving Completes the construction				
Problem identification Sees a gap				
Defines task for him- or herself				
Post-conventional decision making Discretion				
Questions assumptions				
Flexible thinking Uses new perspective				
Changes approach to problem				
Fluency with ideas Considers a number of options				
Originality Builds something different from others				
Exploration Tries new combinations				
Thinking with combinations and systems Combines and recombines bricks				
Constructs new meaning Offers a new understanding after finishing construction				
Adaptation Uses bricks in novel ways				
Decision making and generalized creative skills Uses what is learned in new situations				
Mindfulness Concentration				
Attention				
Trying new categories				
Persistence				
Effectiveness				

LEGO and the LEGO logo are trademarks of the/sont des marques de commerce du/son marcas registradas de LEGO Group. ©2016 The LEGO Group.

LEGO education

Sample rubric provided by LEGO® Education to teachers in the curriculum as a method for students reflect on their learning.

Creativity Self-Report

For Students in Grades 6-8

Student Name:	Date:

What do you think...?

Directions: Circle the face that is closest to how you feel, even if it is not exactly right.

	totally DISAGREE	mostly disagree	neutral	mostly agree	totally AGREE
This LEGO Education activity .... was fun!					
This LEGO Education activity .... helped me to understand what ideas we were learning.					
This LEGO Education activity ... had room for me to do things my way and to express myself.					
This LEGO Education activity ... allowed me to think from another point of view or perspective.					
This LEGO Education activity ... allowed me to explore many combinations of ideas or come up with lots of ideas.					
This LEGO Education activity ... allowed me to create an original and effective model.					

LEGO and the LEGO logo are trademarks of the/sont des marques de commerce du/son marcas registradas de LEGO Group. ©2016 The LEGO Group.

LEGO education

LIST OF REFERENCES

Archbald, D. (2008). Research versus problem solving for the education leadership doctoral thesis: Implications for form and function. *Educational Administration Quarterly, 44*(5), 704–739.

Auerbach, S. (2011). "It's not just going to collect dust on a shelf:" Faculty perceptions of the applied dissertation in the new California State University (CSU) Ed.D. Programs Leadership Education from within a feminist ethos. *Journal of Research on Leadership Education, 6*(3), 59-82.

Baker, D. (2013). What works: Using curriculum and pedagogy to increase girls' interest and participation in science. *Theory into Practice, 52*, 14-20. doi: 10.1080/07351690.2013.743760

Bamberger, Y. M. (2014). Encouraging girls into science and technology with feminine role model: Does this work? *Journal of Science Education and Technology, 23*, 549-561. doi 10.1007/s10956-014-9487-7

Bandura, A., & Adams, N. E. (1977). Analysis of self-efficacy theory of behavioral change. *Cognitive Therapy and Research, 1*(4), 287-310.

Basham, J. D., & Marino, M. T. (2013). Understanding STEM education and supporting students through universal design for learning. *Teaching Exceptional Children, 45*(4), 8-15.

Beede, D. N., Julian, T. A., Langdon, D., McKittrick, G., Khan, B., & Doms, M. E. (2011). Women in STEM: A gender gap to innovation. *Economics and Statistics Administration Issue Brief, 4*(11), 1-11.

Brown, P. L., Concannon, J. P., Marx, D., Donaldson, C. W., & Black, A. (2016). An examination of middle school students' STEM self-efficacy with relation to interest and perceptions of STEM. *Journal of STEM Education, 17*(3), 27-38.

Buschor, C. B., Berweger, S., Frei, A. K., & Kappler, C. (2014). Majoring in STEM – What accounts for women's career decision making? A mixed methods study. *The Journal of Educational Research, 107*(3), 167-176.

Bystydzienski, J. M., Eisenhart, M., & Bruning, M. (2015). High school is not too late: Developing girls' interest and engagement in engineering careers, *Career Development Quarterly, 63*(1), 88-95. doi: 10.1002/j.2161-0045.2015.00097.x

Cooper, R., & Heaverlo, C. (2013). Problem solving and creativity and design: What influence do they have on girls' interest in STEM subject areas? *American Journal of Engineering Education, 4*(1), 27-38.

Creswell, J. W. (2013). *Qualitative inquiry and research design*. Los Angeles, CA: Sage.

Dana, N. (Forward by Cochran-Smith, M.). (2013). *Digging Deeper into Action Research*. Thousand Oaks, CA: Corwin.

Dana, N. F., & Yendol-Hoppey, D. (2014). *The reflective educator's guide to classroom research: Learning to teach and teaching to learn through practitioner inquiry* (3rd ed.). Thousand Oaks, CA: Corwin Press.

Executive Office of the President. (2015). *Every Student Succeeds Act: A progress report on elementary and secondary education*. Retrieved from https://obamawhitehouse.archives.gov/sites/whitehouse.gov/files/documents/ESSA_Progress_Report.pdf

Hill, C., Corbett, C., & St. Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics*. Washington, DC: American Association of University Women.

Jacob, S. A., & Furgerson, S. P. (2012). Writing interview protocols and conducting interviews: Tips for students new to the field of qualitative research. *The Qualitative Report, 17*(42), 1-10.

Kim, H. (2016). Inquiry-based science and technology enrichment program for middle school-aged female students. *Journal of Science Education and Technology, 25*, 174-186. doi: 10.1007/s10956-015-9584-2

Knezek, G., Christensen, R., Tyler-Wood, T., & Gibson, D. (2015). Gender differences in conceptualizations of STEM career interest: Complementary perspectives from data mining, multivariate data analysis and multidimensional scaling. *Journal of STEM Education, 16*(4), 13-19.

Liu, Y., Lou, S., & Shih, R. (2014). The investigation of STEM self-efficacy and professional commitment to engineering among female high school students. *South African Journal of Education, 34*(2), 1-15.

Lou, S., Shih, R., Diez, C. R., & Tseng, K. (2011). The impact of problem-based learning strategies on STEM knowledge integration and attitudes: An exploratory study among female Taiwanese senior high school students. *International Journal of Technology & Design Education, 21*, 195–215. doi: 10.1007/s10798-010-9114-8

MacPhee, D., Farro, S., & Canetto, S. S. (2013). Academic self-efficacy and performance of underrepresented STEM majors: Gender, ethnic, and social class patterns. *Analyses of Social Issues and Public Policy, 13*(1), 347-369.

McCabe, S. (2017, January). STEM Outreach: How are we changing the conversation? *Society of Women Engineers Magazine*. Retrieved from http://alltogether.swe.org/2017/01/stem-outreach-changing-conversation/

McCullough, L. (2011). Women's leadership in science, technology, engineering, and mathematics: Barriers to participation. *Forum on Public Policy, 2011*(2), 1-11.

Milam, J. (2012). *Girls and STEM education: A literature review*. Atlanta, GA: Georgia Institute of Technology.

National Girls Collaborative Project. (2016). *Statistics: State of girls and women in STEM*. Retrieved from https://ngcproject.org/statistics

Nieto, S. (2013). *Finding joy in teaching students of diverse backgrounds: Culturally responsive and social just practices in U.S. classrooms*. Portsmouth, NH: Heinemann.

Patall, E. A., Cooper, H., & Wynn, S. R. (2010). The effectiveness and relative importance of choice in the classroom. *Journal of Educational Psychology, 102*(4), 896-915.

Patton, M. Q. (2015). *Qualitative research & evaluation methods* (4th ed.). Thousand Oaks, CA: Sage.

Saldana, J. (2009). *The coding manual for qualitative researchers*. Thousand Oaks, CA: Sage.

Sanders, M. (2009). STEM, STEM Education, STEMmania. *The Technology Teacher, 68*(4), 20-26.

Seidman, I. (2012). *Interviewing as qualitative research: A guide for researchers in education and the social sciences* (4th ed.). New York, NY: Teachers College Press.

Sensoy, Ö., & DiAngelo, R. J. (2012). *Is everyone really equal? An introduction to key concepts in social justice education*. New York, NY: Teachers College Press.

Shapiro, M., Grossman, D., Carter, S., Martin, K., Deyton, P., & Hammer, D. (2015). Middle school girls and the "leaky pipeline" to leadership. *Middle School Journal, 46*(5), 3-13.

Shapiro, J. R., & Williams, A. M. (2012). The role of stereotype threats in undermining girls' and women's performance and interest in STEM fields. *Sex Roles, 66*(3-4), 175-183.

Tan, E., Barton, A. C., Kang, H., & O'Neill, T. (2013). Desiring a career in STEM-related fields: How middle school girls articulate and negotiate identities-in-practice in science. *Journal of Research in Science Teaching, 50*(10), 1143-1179.

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

Tenenbaum, H. R., Ford, S., & Alkhedairy, B. (2011). Telling stories: Gender differences in peers' emotion talk and communication style. *British Journal of Developmental Psychology, 29*, 707-721.

U.S. Department of Education. (2015). *Science, technology, engineering, and math: Education for Global Leadership*. Retrieved from http://www.ed.gov/stem.

Weld, J. (2017). *Creating a STEM culture for teaching and learning*. Arlington, VA: National Science Teachers Association Press.

BIOGRAPHICAL SKETCH

As an educational specialist for LEGO® Education, Jennifer Nash provides insight for educators implementing STEM teaching in the classroom and provides professional learning opportunities for teachers. LEGO® Education's mission is to enable all students to succeed. Through Jennifer's work in the CTTE program, she has been able to investigate what enabling students really looks like and develop an understanding for what success is for different types of students.

While completing her education degree, she worked at Marshall University with the Professional Development Schools program. Jennifer enjoyed working with this program more than any other work she had done as a professional and would return to it later. This early experience taught her the importance literature and collaboration play in every day practice, as she studied teacher practice while reading research to discuss best practices and reflect on classroom experiences. Jennifer took this idea of using literature to guide her practice into the classroom while and quickly moved into the teacher leader role in her school. She taught general science in both middle and high schools in Huntington, West Virginia, the same community in which she grew up. Jennifer became part of the professional development team within the district and brought new teaching practices into her classroom to pilot for her school. As a teacher, she maintained a strong belief that every student could be successful and worked to establish relationships with her students. She tried to meet her students where they were in order to provide meaningful classroom experiences.

Jennifer moved from the classroom to a position with Marshall University, providing STEM outreach to schools. This position continued to challenge her to model teach, provide professional development to teachers, and work with different groups of students. This was a difficult time because, in her new role, she was unable to develop strong relationships with the

students first. Jennifer learned how to enter classrooms and meet the needs of students with which she was not acquainted. She also learned to work closely with the teacher and develop those relationships in order to better know the students.

During this time, Jennifer began working with the Professional Development Schools program again and eventually became the director of the program, which allowed her to provide more support to schools through change in mentoring and research-based inquiry. She began working closely with administration at the school and district level to initiate programs within the school and to support teacher inquiry. Through her work with the PDS, she helped establish critical friends groups and collaborated across multiple districts. This work led her to seek out options for doctoral programs. Jennifer was seeking the ability to better support teachers in being practitioner scholars and conduct teacher inquiry projects. Through the CTTE program at the University of Florida, she found that her education strategies were on target, but there was still much she needed to learn that could benefit the teachers with which she worked.

Although Jennifer deeply enjoyed her work in the schools, when the opportunity arose to work with an innovative company like LEGO® Education, she could not pass it up. In her current position at LEGO® Education, Jennifer shifted from working with teachers daily to working with professional development providers, curriculum designers, marketing, and educators to design meaningful learning experiences for students. Jennifer enjoys working with a variety of educators to investigate how to help every student succeed in STEM education.