Breaking the STEM Stereotype:

Investigating the Use of Robotics to Change Young Children's Gender Stereotypes About Technology and Engineering

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Abstract

Women have made important progress in historically male-dominated fields, such as law and business over the past two decades. However, when it comes to technology and engineering, progress is being made at a much slower rate. Science, Technology, Engineering, Mathematics (STEM) educational interventions aimed at addressing the gender disparity between men and women have generally focused on increasing the interest of girls and women during high school and college. There is limited research on technology interventions during the formative early childhood years. This dissertation addresses this gap by working with young children (ages 5-7) and exploring their newly forming attitudes and stereotypes toward technology and engineering toys, educational robotics kits, and engineering focused careers. The study asked the following research questions: (1) What are children's initial attitudes and ideas about technology and engineering in Kindergarten through second grade? (2) Does participation in a seven-week robotics curriculum (taught once a week using the KIWI robotics kit) have an impact on children's attitudes and ideas about technology and engineering? (3) After receiving the same robotics curricular instruction, do boys and girls perform differently on robotics and programming tasks? A sample of children in Kindergarten through second grade (*N*=105) from a public school in Somerville, MA participated in this research. Robotics instruction was provided by two teams- one all female and one all male. Children's attitudes were assessed before and after they participated in the robotics curriculum using a modified version of the Engineering is Elementary (EiE) Science & Engineering Attitudes assessment and the newly developed Gender and Technology Attitudes protocol. Responses were compared to a Control Group who did not receive the robotics curriculum. Children’s mastery of programming concepts was measured using the Solve-Its programming assessment. Results provide preliminary evidence that young children are beginning to form gender stereotypes about technology and engineering, and that robotics may improve children’s attitudes toward engineering. Girls in the Curriculum Group (but not in the Control Group) displayed a statistically significant increase in agreement that they would “enjoy being an engineer” at the posttest ($Z=-2.435$, $p=.015$). Additionally, while boys began with a significantly higher level of agreement that they would enjoy being an engineer than girls at the pretest, there was no significant difference between boys and girls after completing the robotics curriculum ($U=477.5$, $p>.05$). When taught by an all-female teaching team, there were no significant differences between boys' and girls' performance on the Solve-Its programming assessment ($p>.05$); however, when taught by an all-male teaching team boys performed significantly better than girls on one advanced programming task ($p<.05$). Using a combination of qualitative and quantitative analyses, this dissertation highlights the importance of early childhood interventions to combat newly forming masculine biases about technology and engineering. Design, research, and theoretical implications are presented.

Keywords: robotics, STEM, technology, gender, stereotypes, attitudes, early childhood education

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Chapter One: Introduction

This is an exciting time to be a woman. Over the past fifty years, women have made important progress in traditionally male-dominated professions such as law, business, and the military (Jacobs & Schain, 2009). Women have continually shown their intelligence, capability, and desire to contribute to society in ways that were once thought to be only appropriate for men. However, when it comes to technology and engineering, progress is being made at a much slower rate. Today, only about one out of every seven engineers is female (AAUW, 2010). In computer science, there has been a visible *decline* in the number of women choosing this major during their undergraduate years (National Center for Women and Informational Technology, 2015).

These statistics are as disturbing as they are puzzling. If women have demonstrated their capability to perform in these fields, why don't they *choose* to be a part of these professions at a similar rate to men? Interdisciplinary scholars from a range of fields have struggled to shed light on this question. Psychologists have studied the impact of implicit attitudes and stereotypes, feminist theorists have examined the role of masculine influences embedded in our culture, and educators have looked at the role of social structure and dynamics in schools and curriculum content. No easy answer has emerged.

Educational interventions over the years have tended to focus on increasing the interest of girls and women during the peak career decision years of high school and college. In many cases, these interventions happen *after* girls have already decided they do not have a strong interest in STEM (Science, Technology, Engineering, Mathematics) fields. Only recently have researchers started to look at the impact of engaging young children (ages five to seven) with technology and engineering. Until the past five years, there were very few technological tools that engaged young children as engineers. The majority of commercially available robotics and computer programming tools were designed for upper elementary, middle, and high school students (e.g., Scratch, LEGO® WeDO™, LEGO® NxT). It was rare to see engineering being taught in younger grades until recently (Rogers, 2012). The KIWI robotics kit used in this dissertation study (now commercially available from KinderLab Robotics under the name "KIBO") was one of only a handful of robotics kits specifically designed for young children at the time it was being developed.

Today, there is a newfound abundance of technological tools aimed at young children (and tools specifically marketed to girls) on the commercial landscape. Still, there is very little empirical research on the impact of these new tools on young children's attitudes and stereotypes about engineering. This dissertation addresses this gap by looking at very young children (ages 5-7) and examining their initial attitudes toward the wealth of new technology and engineering toys and tools on the commercial market. This study also looks at young children's newly forming ideas about science and technology careers and their interest level in possibly having one of these technical jobs "when they grow up." Finally, it systematically examines the potential of using a developmentally appropriate robotics curriculum to *change* negative stereotypes and ideas children may initially have about technology and engineering. Ultimately, the goal of this work is to determine how to address the issue of gendered STEM stereotypes beginning in early childhood before they are deeply ingrained in later years.

Chapter Two: Review of the Literature

Feminist Theory

This study is rooted in Interactional Feminist Theories (e.g., Lloyd, 2007; West & Fenstermaker, 1995), which look at *how* and *why* masculine biases exist in every day experiences and interactions, in order to explore gendered stereotypes that young children may (or may not yet) have around technology and engineering. Feminist theory can potentially serve as a critical link between the fields of gender studies and the fields of technology and engineering (Beddoes & Borrego, 2008). Jawitz and Case (2004) argue that feminist perspectives may provide an explanation for women's unique experiences in fields like engineering. Others similarly argue that key components of feminist theory may be underutilized within engineering education scholarship (Beddoes & Borrego, 2008; Nelson & Pawley, 2010). In particular, Interactional Feminist Theory provides a lens to look at the everyday processes that "create" gender by looking at everyday interactions that are biased or problematic (Beddoes & Borrego, 2008; West & Fenstermaker, 2005). These theories attempt to understand the underlying reasons for the persistence of masculine biases (Beddoes & Borrego, 2008). The following sections review relevant literature from the fields of technology, psychology, child development, and education to explore the current state of masculine biases as it relates to technology and engineering.

Defining Gender

Before reviewing the literature on gender and technology, it is important to discuss the way gender is being defined and used in this dissertation. The American Psychological Association (2012) defines gender as "the attitudes, feelings, and behaviors that a given culture associates with a person's biological sex." This is distinguished from a person's "sex" which refers to the biological categorization of a person as male, female, or intersex (American Psychological Association, 2012).

In most cases, this dissertation is concerned with one's "gender identity" or one's sense of their own gender as male, female, transgender, or another gender (American Psychological Association, 2006, 2012). Therefore, when gender is referred to in the Sample or Results section of this paper, it is referring to the child's own definition of their gender, not a sex classification provided by their parents or teachers. When reviewing literature on men and women in technology and engineering fields, this study defaults to using the term "gender" or "sex" as it was used in the research being presented.

Women in Technology and Engineering

In most career fields, female participation has been on the rise over the past decade. This has not been the case, however, for technology and engineering fields (National Center for Science and Engineering Statistics, 2013; National Center for Women and Informational Technology, 2011). In 2009, only 11% of undergraduate Computer Science degrees from major research universities were granted to women. Between the years of 2000-2014, there has been a 7% decline in the number of undergraduate women interested in majoring in Computer Science (National Center for Women and Information Technology, 2015). In the professional arena, women's participation in engineering and computer science on the whole remains below 30% (National Center for Science and Engineering Statistics, 2013). More specifically, women still make up less than 15% of engineers and only 25% of computer and math scientists

(National Science Board, 2014). These statistics bring to light a need to understand *why* female participation in technical fields is drastically low compared to men.

The Role of Stereotype Threat

In order to investigate the persistent disparity between men and women, many researchers have theorized that stereotype threat explains why women and girls underperform in STEM fields. *Stereotype threat* refers to the anxiety that one's performance on a task or activity will be seen through the lens of a negative stereotype (Steele, 1997; Spencer, Steele, & Quinn 1999). For example, Spencer, Steele, & Quinn (1999) found that women performed significantly worse on a math test if they were first shown information indicating that women do not perform as highly as men on math tasks (to induce the negative stereotype). If the negative stereotype was not triggered (i.e. participants were told that there were no gender differences associated with the math test) women and men performed similarly on the test. Negative stereotype threat can be triggered by explicit statements or through more subtle and implicit messages. For example, a study by Stricker and Ward (2004) for the Educational Testing Service (ETS) found that moving the standard demographic inquiry about test-taker gender (an explicit trigger of stereotype threat) to the end of the test resulted in significantly higher performance among women who took the AP calculus test. In addition to these explicit cues, subtle environmental and situational factors can also trigger a negative stereotype (Shapiro & Williams, 2011).

When considering how to engage children with STEM education, it is important to consider that stereotypes may play a role in children's engagement and performance in curricular activities. While a great deal of focus is placed on stereotype threat in adolescence and adulthood, research shows that children already begin to form stereotypes beginning in early childhood (Kuhn, Nash, & Brucken, 1978).

Stereotypes in Young Children.

Basic stereotypes begin to develop in children around two to three years of age (Kuhn, Nash, & Brucken, 1978; Signorella, Bigler, & Liben, 1993). As children grow older, stereotypes about sports, occupations, and adult roles expand, and their gender associations become more sophisticated (Sinno & Killen 2009). For example, children may go from making associations such as “boys like trucks” during preschool and kindergarten to associations like “trucks and airplanes are masculine” around age eight (Martin & Ruble, 2010).

Despite this early formation of stereotypes, the majority of empirical research investigating stereotype threat on girls’ performance in STEM has focused predominantly on women at the high school and college level (Good, Aronson, & Harder, 2007; Steele, Spencer, & Aronson, 2002). Because of this focus on young adult women, it is difficult to pinpoint when exactly stereotype threat begins to affect girls’ performance on tasks (Good, Aronson, & Harder, 2007). Only recently has there been a newly forming body of research looking at stereotype threat that emerges in middle school and elementary school. For example, McKown & Weinstein (2003) found that awareness of other’s stereotypes dramatically increase from ages six to ten and a similar effect was found for cultural stereotypes. Children who were aware of stereotypes and associated themselves with these negative stereotypes performed lower on a diagnostic test than those who were not associated with the stereotype (McKown & Weinstein, 2003).

As children are growing up and developing a sense of what they are good at and what they enjoy, these stereotypes and associations may cause children to diverge based on how much they think STEM classes and hobbies fit into their growing sense of self. These early experiences may play an ongoing role in children's sense of belonging and confidence in different STEM activities and their own developing identity as they grow up. Forming a positive "STEM Identity" (Aschbacher, Li, & Roth, 2010) during this time can be pivotal to maintaining girls' interest in these fields .

STEM and Identity Development

STEM identity.

According to Capobianco, French, & Diefes-Dux (2012), most definitions of identity are rooted in Erikson's (1968) work, which emphasized that identity is a highly personal construction as well as a social construction. It develops through the integration of various identifications with other individuals and specific groups, and through internalization of roles and feedback from others (Capobianco, French, & Diefes-Dux, 2012). Stevens, O'Connor, and Garrison (2005) argue that identity is a key component of student development and in keeping students in engineering majors during college.

Even before college, gendered identity regarding science and engineering influences the participation of boys and girls in their scientific pursuits (Bell, Lewenstein, Shouse, & Feder, 2009). "STEM identification" refers to the extent to which students view themselves as members of STEM-related communities of practice (Aschbacher et al., 2010). STEM identification is informed by students' own perceptions of who they are and who they want to become with respect to STEM (Brickhouse & Potter, 2001). This may be particularly salient during the adolescent years when young adults experience what Erikson (1963; 1968) called a “psychosocial moratorium.” This moratorium refers to a time when teenagers can “try on” different identities and roles without a feeling of permanence (Erikson, 1963; 1968). During this time, teenagers may consciously try out different projects, clubs, and hobbies as they decide how much STEM fits into their identity.

Before entering adolescence and a time of intense identity exploration, children are already beginning to form their sense of identity and self-image, particularly when it comes to gender. Young children are beginning to understand and make basic conclusions about sex differences and their own sex (Bauer & Coyne, 1997; Zosuls et al.,, 2009). Children generally develop the ability to label gender groups and to use gender labels in their speech between 18 and 24 months (Zosuls et al., 2009). Experimental studies have shown that young children are often quick to jump to conclusions about sex differences, even on the basis of only a single instance. For example, in a study by Bauer & Coyne (1997), when 3-year-olds were told that a particular boy likes a sofa and a particular girl likes a table, they generalized this information to draw the conclusion that another girl would also like the table.

By age 5, children have developed a range of stereotypes about gender that they apply to themselves and others (Martin & Ruble, 2004). Cognitive theories of gender make the assumption that children are actively trying to make sense of their environment by using gender cues to interpret the information they are taking in (Martin & Ruble, 2004). These theories tend to emphasize developmental changes in the child’s understanding of gender that may be aligned with their growing cognitive abilities. For example, Trautner et al. (2005) categorize three phases of gender stereotyping development:

- Toddler/Pre-School Years: Children learn gender-related characteristics
- Ages Five to Seven: Newly acquired gender knowledge is consolidated in a rigid “either-or” capacity. This reaches peak rigidity between five and seven years.
- Ages Seven to Eight: A period of relative flexibility follows

According to these theories, the early childhood years are an important period of gender identity and stereotype development. During the kindergarten through second grade years (ages 5-7) children are developing strict “all or nothing” views about gender making this an important time for children to see that both boys and girls can be successful and competent in STEM areas. These theories prompted this study’s focus on the early childhood period of development. Although views formed during this time may become more flexible in later years, this period remains an important time when children are acquiring gender knowledge.

Thus far, we have been discussing STEM, gender, and identity development trajectories that both boys and girls follow. However, many researchers have looked at the experiences that are unique to women and girls when it comes to STEM fields (Diekman, Brown, Johnston, & Clark, 2010; Goodman, 2002; Packard, Gagnon, Labelle, Jeffers, & Lynn, 2011). When attempting to shed light on why men continue to outnumber women in technical careers, it may be important to examine the unique issues and conflicts that women and girls face.

Gender - STEM identity incompatibility.

One issue unique to women and girls is a conflict between positive STEM identity development and the development of other “female typical” identities and goals. Women who perceive STEM careers as incompatible with female-typical goals express lower interest in STEM careers than do women who view them as compatible, even when controlling for STEM self-efficacy (Diekman, Brown, Johnston, & Clark, 2010). For women pursuing careers in engineering or computer science, their identity as an “engineer” or a “computer scientist” must somehow form and develop in spite of dominant masculine stereotypes that prevail. These types of identity conflicts can potentially cause internal struggles during development as their feminine identities and these masculine stereotypes clash. When women perceive gender-STEM incompatibility and experience “identity interference”, they may experience lower levels of self-esteem and life satisfaction and higher levels of depression (Settles, 2004). These struggles may be compounded by social and cultural factors such as gender roles in the school and community.

Social and cultural influences

Social, cultural, and other environmental influences can change how perceptions of self and identity develop. Such outside factors include, but are not limited to, school, home, and religion. Bronfenbrenner’s (1989, 1994) ecological systems theory looks at child development through the lens of a complex system of “layers” of environments such as family, school, neighborhood, and even larger societal contexts. According to this theory, a child’s development should be looked at in the context of each of these complex layers and also with respect to their interactions (Bronfenbrenner, 1994).

Bronfenbrenner's (1989, 1994) theories suggest that while much of the focus on children and STEM addresses what is being taught in school, the home and community environment may also play a pivotal role. Subtle cues from parents, teachers, counselors, and peers about gender roles can impact girls' desire to pursue STEM subjects (Adya & Kaiser, 2005). Many scholars have found that a child's home environment can strongly influence the interests and personal goals of children (e.g., Bell, Lewenstein, Shouse, & Feder, 2009; Crowley & Jacobs, 2002). When it comes to a girl's developing interest and ideas about computers and technology, the role modeling of parents and parental expectation about ability and interest can change how girls see themselves with regards to computers and computing (Margolis & Fisher, 2002).

Until this point, this literature review has focused on issues of stereotype threat, identity formation, and social and cultural factors that influence children's participation in STEM throughout their schooling. In addition to these factors, the availability of toys, tools, and materials that engage children in STEM concepts has been evolving over the past decade. The range of new technologies designed specifically for young children has skyrocketed in recent years making it easier to find tools that engage young children in technology and engineering initiatives.

Technology and Engineering for Young Children

Growing Digital Landscape.

Digital activities, such as playing video games on a console or iPad, are growing in prevalence among young children under the age of eight. For example, a recent study by Common Sense Media found that two-thirds of children under the age of eight have access to a console video game player at home, and 35% have access to a handheld game player such as a Game Boy, PlayStation Portable (PSP), or Nintendo DS (Common Sense Media, 2013). Additionally, there has been a five-fold increase in ownership of tablet devices such as iPads, from 8% of all families in 2011 to 40% in 2013 (Common Sense Media, 2013).

While access to these types of technologies is growing, children's understanding of *how* and *why* these tools work the way they do is a newer area of research. In recent years, understanding computer programming and foundational engineering concepts has become considerably more of focus of research, in part due to federal education programs and private initiatives making computer science and technological literacy a priority for young children (U.S. Department of Education, 2013; US Department of Education, Office of Educational Technology, 2010). Research with computer programming interventions in early childhood settings has shown that children as young as 5 years old can master fundamental programming concepts of sequencing, logical ordering, and cause-and-effect relationships (Bers, 2008; Fessakis, Gouli, & Mavroudi, 2013; Kazakoff & Bers, 2007; Kazakoff, Sullivan, & Bers, 2013).

During just the past few years, a number of commercially available tools for young children to learn computer programming have emerged, including the ScratchJr and Daisy the Dinosaur programming applications. These applications use colorful and graphical interfaces to engage young children in foundational computer programming concepts as they create onscreen animations. Robotic kits for young children such as Wonder Workshop, Beebot, and KIBO have also been released to teach children as young as four fundamental engineering and programming concepts. For example, the Wonder Workshop robots (called "Dot" and "Dash") allow children to use iPad applications to program their robot to navigate a route, use lights and sensors, and more (for more information visit: www.makewonder.com). Aside from these newer kits, traditional materials such LEGO, blocks, and natural materials are still used by parents and teachers to foster engineering based play.

While engineering focused toys such as LEGO have mainly focused on boys in their advertisements for the past decade, there has been a very recent push on STEM toys being marketed directly toward girls (Docterman, 2014). In addition to LEGO®'s new "LEGO® Friends" division that premiered in 2011 (a series of pink and purple LEGO® sets marketed to girls), there are also new companies concentrating on girls as a target audience. For example, the toy company GoldieBlox that first emerged in 2012, creates toys that foster engineering and problem-solving around a female role model (Goldie) amidst pink and purple packaging. Similarly, the newly available Roominate kit offers girls the experience of building a circuited dollhouse in pastel colors. Empirical research evaluating the efficacy of highly feminine STEM toys on girls' attitudes is very new; however, at least one study demonstrates they may have counterintuitive effects. Betz & Sekaquaptewa (2012) has found that feminine STEM role models actually *reduced* middle school girls' interest in math and self-related ability as compared to gender-neutral role models. Some experts believe that by highlighting differences between boys and girls, unintended effects of reinforcing stereotypes emerge (Docterman, 2014).

As new technology and engineering tools become increasingly available to young children, it is important to examine the impact these tools may play in young children's identity development, engagement with STEM content, and desire to pursue technology and engineering careers down the road. The research reviewed above demonstrates that during the foundational early childhood years (ages five to seven years) children are beginning to develop a sense of self-image that may be influenced by newly forming stereotypes and gender knowledge (Kuhn, Nash, & Brucken, 1978; Signorella, Bigler, & Liben, 1993; Martin & Ruble, 2004). The present research takes a preliminary look at the potential impact of a new robotics kit on children's attitudes toward technology and engineering. This study uses an early prototype of the KIBO robotics kit, called KIWI. Additionally, it presents children with a variety of other technological tools (and non-technological engineering tools like LEGO®) in order to take a first look at children's opinions and attitudes about these innovative new tools.

Robotics and young children.

While there is a range of technologies that can be used with young children, robotics can be a playful and hands-on way to engage young children (both boys and girls) in foundational engineering content. Although educational robotics kits are more often seen in middle and high school environments, robotics can teach young children about the types of electronics and sensors they encounter in daily life. Prior research suggests that children as young as four years old can successfully build and program simple robots while learning a range of engineering concepts in the process (Bers, Ponte, Juelich, Viera, & Schenker, 2002; Cejka, Rogers, & Portsmore, 2006; Perlman, 1976; Wyeth, 2008; Sullivan, Kazakoff, & Bers, 2013). Teaching foundational programming concepts, along with robotics, makes it possible to introduce young children to important ideas that inform the design of many of the everyday objects they interact with (Bers, 2008). Moreover, introducing robotics and computer programming in early childhood may give young girls a chance to positively engage with engineering before gender stereotypes have set in during later childhood (Metz, 2007; Steele, 1997; Sullivan & Bers, 2012). For example, research suggests that children who are exposed to STEM curriculum and programming at an early age demonstrate fewer gender-based stereotypes regarding STEM careers (Metz 2007; Steele 1997) and fewer obstacles entering these fields (Madill et al. 2007; Markert, 1996).

Robotics and computer programming in early childhood education can also foster the development of a range of cognitive and social skills. For example, early studies with the text-based programming language Logo, have demonstrated that computer programming can help young children with number sense, language skills, and visual memory (Clements, 1999). Newer research with the graphical ScratchJr programming language for children age five to seven has found that young children are able to create personally meaningful projects and demonstrate computational thinking and problem solving strategies through using the application (Portelance & Bers, 2015). Computer programming can also help young children practice their developing executive function abilities. Executive functioning consists of mental flexibility, inhibitory control, and working memory (Shonkoff, Duncan, Fisher, Magnuson, & Raver, 2011; Blair & Diamond, 2008). For example, when using the ScratchJr programming language, children must draw on their working memory to remember their given programming challenge, remember the programming blocks that correspond to the actions they want their characters to take, and remember the syntax rules inherent to ScratchJr (Kazakoff, 2014).

Prior research has also shown that robotics can help children develop a stronger understanding of mathematical concepts such as number, size, and shape in much the same way that traditional materials like pattern blocks, beads, and balls do (Resnick et al., 1998; Brosterman, 1997). Unlike many other types of technology such as iPad apps and educational games, robotics activities do not involve sitting alone, in front of a screen. Rather, robotic manipulatives allow children to develop fine motor skills and hand-eye coordination while also engaging in collaboration and teamwork (Lee, Sullivan, & Bers, 2013).

This dissertation utilizes a robotics kit for young children in order to engage them in hands-on projects that teach foundational technological and engineering skills such as sturdy building, sequencing, and the engineering design process. This study examines how engaging young children as engineers through a robotics curriculum may (or may not) impact their newly forming ideas about engineering tools, toys, and professions.

Chapter Three: Statement of Problem

The Problem

Men continue to outnumber women in numerous technology and engineering fields (AAUW, 2010). Prior work demonstrates the importance of piquing the interest of girls during their formative early childhood years before gender stereotypes regarding these traditionally masculine fields are ingrained in later years (Metz, 2007; Steele, 1997). Despite this, the majority of technology and engineering educational initiatives for girls focuses on the middle and high school years and not the potentially important early childhood years (Bers, Seddighin, & Sullivan, 2013; Bers, 2008). This may be in part because the majority of technological tools designed to teach programming and engineering were designed for older children and teenagers. Until recently, there have been very few engineering games and tools to be used with young children.

The Developmental Technologies (DevTech) Research Group at Tufts University has started to fill the gap by initiating several National Science Foundation funded research programs[1] exploring technology and engineering in early childhood education (Bers, Seddighin, & Sullivan, 2013; Bers, 2014; Strawhacker, Lee, Caine, & Bers, 2015; Sullivan, Elkin, & Bers, 2015). These projects have resulted in the development of several new tools for use with young children ages four to seven years (Bers, 2014; Strawhacker, Lee, Caine, & Bers, 2015; Sullivan, Elkin, & Bers, 2015). Furthermore, the group has designed developmentally appropriate curricula (Bers, 2014), and evaluated learning outcomes of said tools (Kazakoff, Sullivan, & Bers, 2013; Sullivan & Bers, 2015).

[1] Tangible Kindergarten (NSF DRL-0735657), Ready for Robotics (NSF DRL-1118897),

This recent emergence of these new technologies for young children, however, does not address the lack of research exploring early childhood years as a potentially critical time to combat masculine stereotypes about STEM. This study addresses this problem by exploring young children's attitudes and stereotypes about two components of STEM: the "T" of technology and the "E" of engineering. The goal of this work is not only to uncover masculine stereotypes if they exist, but also to explore strategies for *changing* these stereotypes. In order to accomplish this, this research utilizes one of DevTech's newest technologies, the KIWI (Kids Invent with Imagination) robotics construction set for children age four to seven (a prototype of the commercially available KIBO kit). This tool was chosen because it was designed to engage young children in several different aspects of engineering including: building, programming, designing, and iterative testing and redesign. By implementing a 7-week KIWI robotics curriculum in Kindergarten through 2nd grade public school classrooms, this study explores the types of initial attitudes and thoughts young children may have about building, programming, engineering, and technology before being exposed to the curriculum and what influences may change inherently masculine attitudes if they exist.

Research Questions

This study aims to explore young children's emerging ideas and attitudes about technology and engineering by asking, the following research questions:

(1) What are children's initial attitudes and ideas about technology and engineering in Kindergarten through second grade? Do boys and girls differ in their initial attitudes?

(2) Does participation in a seven-week KIWI robotics curriculum have an impact on children's attitudes and ideas about technology and engineering?

(3) After receiving the same KIWI robotics curricular instruction, do boys and girls perform differently on robotics and programming tasks in Kindergarten through second grade?

Chapter Four: Methodology

Methodology Overview

This dissertation draws on data collected as part of the National Science Foundation funded *Ready for Robotics* project (DRL-1118897). *Ready for Robotics*, led by primary investigator Dr. Marina Umaschi Bers at Tufts University, is a project focused on addressing two components of STEM education that are often neglected in early childhood education: the “T” of technology and the “E” of Engineering (Bers, Seddighin, & Sullivan, 2013). The project addresses this gap by creating a new developmentally appropriate robotics construction set for young children ages four to seven years (Bers, Seddighin, & Sullivan, 2013). Along with creating a new robotics kit, the Ready for Robotics project also explores the creation of new curriculum and pedagogical strategies for effectively teaching foundational robotics and programming content to young children.

The study examines a subset of the participants in the *Ready for Robotics* project. This subset consists of children from six classrooms (2 Kindergarten, 2 first grade, and 2 second grade) in a public school in Somerville, Massachusetts. Three classrooms (one of each grade) were assigned to the Curriculum Group and three classrooms (one of each grade) were assigned to the Control Group. The Curriculum vs. Control classrooms were selected based on the scheduling needs of the classroom teachers and when researchers could visit their classes.

Prior to curriculum implementation, all children (Control and Curriculum) participated in qualitative assessments regarding their attitudes, ideas, and experiences towards technology and engineering in general and robotics in particular. Next, the

Curriculum Group participated in a 7-week KIWI robotics curriculum unit. After the curriculum implementation was complete, the students in the Curriculum Group completed a KIWI knowledge post-assessment called the "Solve-Its." Finally, children from all classes (Control and Curriculum) were assessed again on their attitudes, ideas, and experiences towards technology and engineering in general and robotics in particular to determine if any changes were present. All of the robotics classes in the Curriculum Group were taught by an all-female teaching team in order to control for effects of teacher gender.

After all data collection was complete, the Control Group received the same 7-week robotics curriculum unit so that no children or teachers missed out on any of the potential benefits of participating in this research study. This wave of curriculum implementation was taught by an all-male teaching team so that comparisons between the male-taught and female-taught groups could be made.

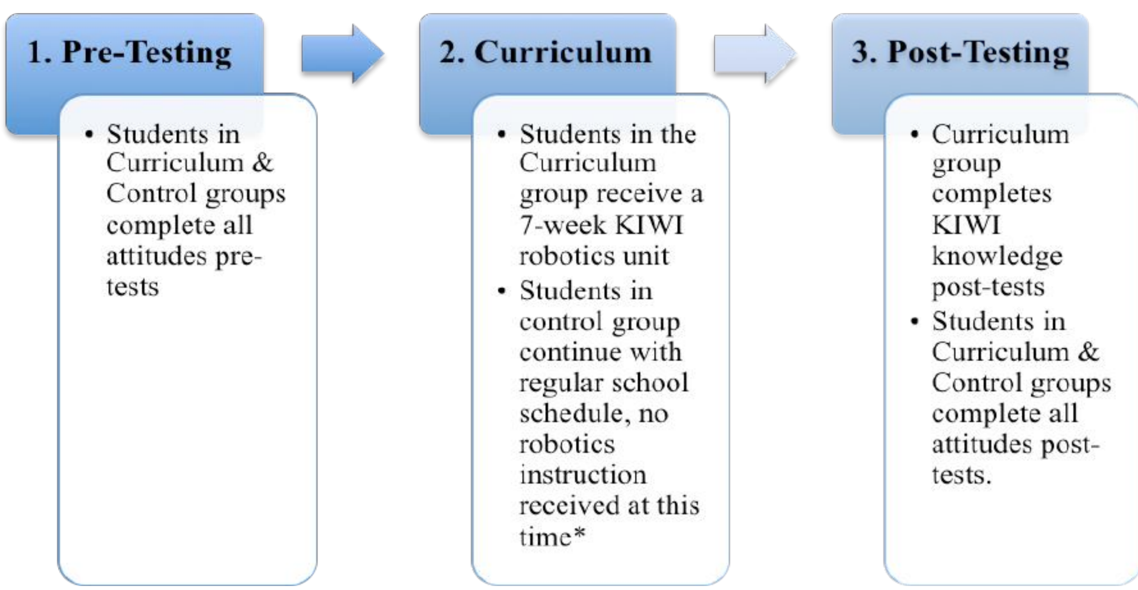

Figure 1. Research Overview
Note. Students in Control Group received the same 7-week KIWI robotics curriculum after data collection was completed so that no participants missed out on any benefits of the program.

Sample.

A sample of a *N*=105 children from six classrooms (2 Kindergarten, 2 first grade, and 2 second grade classes) from the Arthur D. Healey School, a public school in Somerville, Massachusetts, participated in this research. *n*=48 children in Kindergarten through second grade were assigned to the Curriculum Group (*n*=26 boys and *n*=22 girls). Due to a conflict with the original Control Kindergarten classroom, the study began with only *n*=35 children in first and second grade in the Control Group. A new Kindergarten Control class (*n*=22) was added after the study had begun. Therefore, they are not included in attitudes analyses since their pretests were conducted two months after the pretests for the other groups. Their data are only included as part of Solve-Its programming knowledge analysis for the male-taught group.

Nearly half (47.8%) of the Arthur D. Healey School's students were reported as "economically disadvantaged" in the 2014-2015 school profile. 44.4% of the school's students speak a language other than English as their first language and 25.7% report some kind of disability. Children in this study came from homes that speak English, Spanish, and Portuguese as their primary language at home.

Curriculum Implementation

Robotics Technology.

Children from classrooms assigned to the Curriculum Group completed a 7-week robotics and programming curriculum as an introduction to technology and engineering. The robotics classes met once a week for approximately one hour. The unit used the KIWI (Kids Invent With Imagination) robotics kit developed by the DevTech Research Group at Tufts University as part of the *Ready for Robotics* project. KIWI is specifically designed for children ages 4-7 and consists of easy to connect parts including: wheels, motors, light output, and sensors. All of the parts of the KIWI robot are made of a mix of natural plywood and smooth plastic that is easy and comfortable for a child to grip and manipulate. The sensors snap into place only when properly oriented, much like a puzzle.

KIWI's actions are controlled with wooden programming blocks that have barcodes, each representing different actions for the robot to carry out. There are eighteen different programming blocks that can be used with KIWI. With these blocks children can make KIWI move, light up, and make sounds. With more complex blocks, children can program KIWI to respond to stimuli in the environment through the use of sensors. KIWI has an embedded scanner that allows children to scan the barcodes on the blocks and send the program to their robot instantaneously- no screen time from an iPad, computer, or other digital technology is required (See Figure 2 below).

Figure 2. KIWI robot with Tangible Programming Blocks

The KIWI robotics kit contains many parts that are transparent in order to show the inner workings of the robot (see Figure 3. below). While many technologies remain a mystery to young children (for example, they cannot see inside a television or computer) KIWI was designed this way after initial pilot testing in order to dispel children's mistaken concepts that the robot moved "by magic" and to promote conversations about how the batteries, wires, motors, and the like work. The entire back of the KIWI robot is transparent along with one side of the robot's motors.

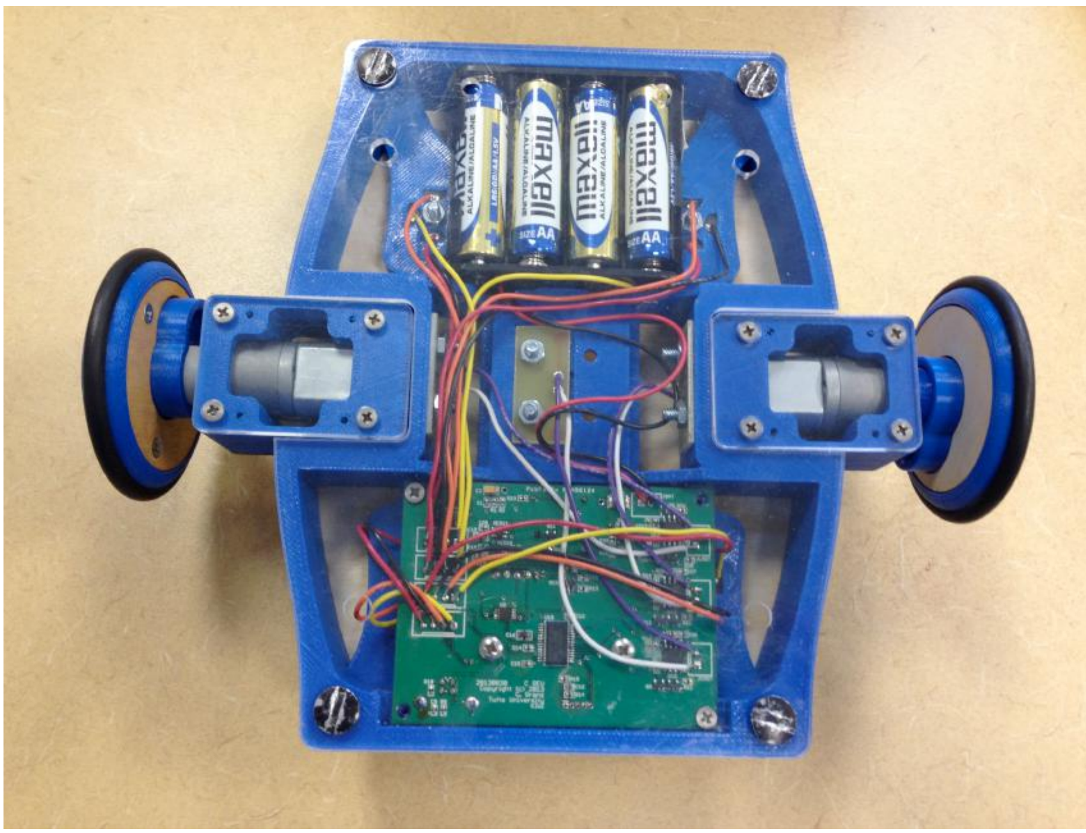

Figure 3. Transparent back of KIWI robot

During the research and development phase of KIWI, the robot was used by hundreds of children in camps, museums, public, and private school settings (Sullivan, Elkin, & Bers, 2015). It has also been used with early childhood educators in the context of professional development workshops (Bers, Seddighin, & Sullivan, 2013). This pilot testing served to iteratively redesign features of the robot (See Figure 4 below). KIWI is now commercially available through KinderLab Robotics (www.kinderlabrobotics.com) under the name “KIBO”. However, data for the study was collected prior to the release of KIBO and as such it was the KIWI prototype that was used in the curriculum described in the following section.

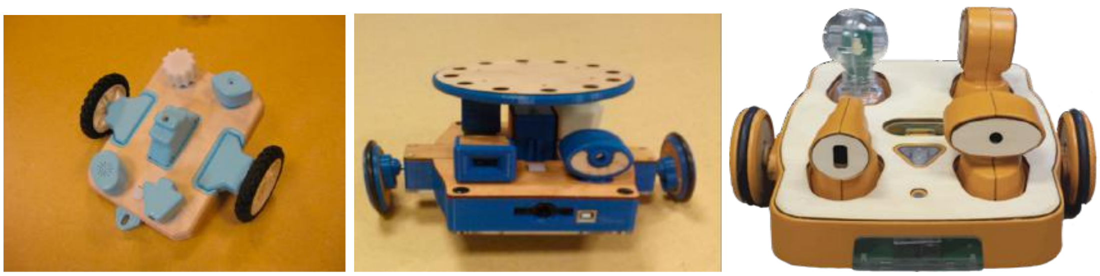

Figure 4. From KIWI to KIBO

Note. Figure above shows the evolution of the KIWI robot from original prototype (far left), to the second KIWI prototype (center) used in this dissertation, and the newly available KIBO robot (far right).

Positive Technological Development as a Guiding Framework.

The KIWI robotics curriculum in this study was designed as an intervention that could potentially change young children’s views of themselves and their capabilities as engineers and programmers. To do this, the Positive Technological Development (PTD) framework (Bers, 2012) was used to guide the development and implementation of a KIWI robotics curriculum that would promote learning as an aspect of Positive Youth Development. The PTD framework, developed by Marina Umaschi Bers (2012), provides a model for how children’s development can be supported by the use of technology. PTD draws heavily on two bodies of literature: Papert’s (1980) work on Constructionism and the Positive Youth Development framework rooted in applied developmental science (Lerner et. al, 2005). Constructionism describes how internal constructions of knowledge are support by constructing external objects in the world, for example, with computers or other technologies (Papert, 1980).

The PTD framework is unique because it adds psychosocial and ethical components to the cognitive ones (Bers, 2012). PTD proposes six positive behaviors (the “six C’s”) that should be supported by educational programs that use new educational technologies, such as KIWI robotics. These are: creation, creativity, communication, collaboration, community building and choices of conduct. Each of these “6 C’s” was used for inspiration, guiding the activities, and materials used in the KIWI curriculum developed for this study (See Table 1 on the following page).

Table 1

Positive Technological Development in the KIWI Curriculum

The 6 C's	Classroom Practices
1. Content Creation	Children designed and assembled a KIWI robot and programmed its behaviors. Children used the engineering design process and the computational thinking involved in programming to foster competence in computer literacy and technological fluency throughout the curriculum unit.
2. Creativity	By making and programming personally meaningful robotics projects, children engaged with problem solving in creative and playful ways. Lessons prompted children to use different media with robotic parts such as: recyclable materials, arts and crafts in order to foster the creative process.
3. Collaboration	Children worked in groups of 2-3 in order to foster a collaborative group-work environment. Students were encouraged to "ask a friend" when they needed help with their robotics and programming tasks before going to a teacher. This helped to promote a helping, collaborative, classroom with varied expertise.
4. Communication	Each KIWI robotics session began and ended with a "Technology Circle" where the class shared and provided feedback to one another on their projects. This time was used as a chance to practice respectful communication, speaking and listening skills, as well as providing (and receiving) constructive peer feedback.
5. Community Building	Throughout the curriculum there were scaffolded opportunities to form a learning community that promoted contribution of ideas. For example, children came together as a community in order to share their final projects in a final exhibition. This provided an authentic opportunity for children to share and celebrate the process and tangible products of their learning with family and friends or peers.
6. Choices of Conduct	Children found themselves faced with many situations that prompted them to choose actions in a just and responsible way throughout the unit. For example, due to limited robotic and programming materials in the classroom, children had to decide between taking and using materials in a way that was fair to the whole group or hoarding and taking too much for themselves so that other groups did not have enough. These choices of conduct were regularly discussed during Technology Circle.

Curriculum Theme and Activities.

The KIWI robotics theme was developed in collaboration between the lead researcher for this project and the participating teachers at the Healey School in Somerville, Massachusetts. Teachers at Healey were interested in a theme that would foster community, helping, and caring. These behaviors were also aligned with the Positive Technological Development Framework, in particular, the fifth “C” of “Community Building”. Additionally, the teachers and the researcher worked together to decide upon a theme that they believed would be equally appealing to both boys and girls. Together we came up with the theme “Helping at Healey.” Throughout the curriculum, children learned about robots that perform helpful jobs in the real world (such as hospital robots, robots that clean like the Roomba, etc.). As a final project, children worked in groups to create their own “Helping at Healey” robots to do helpful classroom jobs, teach important ideas, and demonstrate respectful behaviors and school rules.

Each week, children spent one hour learning and practicing new KIWI robotics and programming concepts such as sturdy building, sequencing, repeat loops, sensors, and conditional statements. This continued for the first five weeks of the curriculum. The final two weeks were spent working on their final “Helping at Healey” robot creations. While the same curricular structure was used across classes and grades, modifications were designed to make the curriculum developmentally appropriate. For example, younger grades spent more time on new concepts while older grades moved through the same concepts more quickly.

Table 2

Curricular Lessons and Concepts Addressed in Each Grade

Lesson	Kindergarten	First	Second
1	***What is a robot?*** ***Who are engineers?*** Children were explicitly taught about the engineering design process and built sturdy robots that can carry a ball of paper to the recycling bin	***What is a robot?*** ***Who are engineers?*** Children explicitly taught about the engineering design process and built sturdy robots that can carry a ball of paper to the recycling bin	***What is a robot?*** ***Who are engineers?*** Children learned explicitly taught about engineering design process and built sturdy robots that can carry a ball of paper to the recycling bin
2	***What is a program pt 1?*** Children programmed their robots to dance the Hokey-Pokey	***What is a program?*** Children programmed their robots to dance the Hokey-Pokey	***What is a program?*** Children programmed their robots to dance the Hokey-Pokey
3	***What is a program pt 2?*** Children continued to practice sequencing a program by navigating masking tape maps on the floor	***What are sensors?*** Children added sound sensors to their robots and programmed them to wait for their clap	***What are sensors?*** Children added sound sensors to their robots and programmed them to wait for their clap
4	***What are sensors?*** Children added sound sensors to their robots and programmed them to wait for their clap	***What are repeat loops with number parameters?*** Children practiced estimation while using repeat loops and number parameters to make their robots navigate floor maps	***What are repeats loops with number parameters and sensor parameters?*** Children practiced estimation while using repeat loops and number parameters to make their robots navigate floor maps. Next, children navigated the same maps using distance and light parameters with their repeat loops instead of number parameters
5	***What are repeats loops with number parameters?*** Children practiced estimation while using	***What are repeat loops with sensor parameters?*** Children learned about the distance and light	***What are conditional statements?*** Children learned about using conditional "if

	repeat loops and number parameters to make their robots navigate floor maps	sensors and programmed them to work with their robots using repeat loops.	blocks" in their programs. They program their robots to respond to light and distance sensor input in order to "decide" what to do
6	***FINAL PROJECT*** Children planned, built, and began to program their "Helping at Healey" final projects	***FINAL PROJECT*** Children planed, built, and began to program their "Helping at Healey" final projects	***FINAL PROJECT*** Children planed, built, and began to program their "Helping at Healey" final projects
7	*F**INAL PROJECT*** Children finished their projects. In a final exhibition, they shared their final projects.	***FINAL PROJECT*** Children finished their projects. In a final exhibition, they shared their final projects.	***FINAL PROJECT*** Children finished their projects. In a final exhibition, they shared their final projects.

Each class moved through the KIWI robotics and programming concepts at their own pace over the course of the seven weeks. While the Kindergarten group spent multiple classes practicing basic sequencing concepts, the second grade students were able to move through all of the programming concepts available with the KIWI programming language. Within each class, students were also given opportunities to move at their own pace. For example, if students completed a task quickly and demonstrated content knowledge, they were given the option to learn a new block or sensor even if these concepts were not taught to the whole class.

Figure 5 Child-made KIWI Projects**.** The figure above shows sample KIWI "Recycler robots" made by the first grade class in Lesson 1. These robots were designed to carry paper and other recycled materials to the recycling bin without anything falling off along the way.

Data Collection

A combination of quantitative and qualitative research methods was used to collect data on children's attitudes and knowledge before and after curriculum implementation. The Gender and Technology Attitudes Protocol (developed for use in this study) was used for children to share their thoughts and opinions on a variety of technology and engineering materials before and after curriculum implementation. The Engineering and Science Attitudes assessment (Cunningham & Lachapelle, 2010;

Engineering is Elementary www.eie.org) was also administered as a pre and post test to see how much children agreed or disagreed with statements about science and engineering. Finally, the Solve-Its programming assessment was administered to determine children's mastery of KIWI programming concepts after participating in the curriculum. Each of these assessments is described in detail in the following sections.

Gender and Technology Attitudes Protocol.

Information about children's attitudes, ideas, and stereotypes about technology were collected using a hands-on Gender and Technology Attitudes Protocol, developed specifically for this study based on a year of pilot testing in public school and camp settings (See Appendix). Children sat down with the researcher one-on-one and played with a variety of different toys and tools (both tech and non-tech) and were asked to decide who from their class would enjoy playing with them most: boys, girls, or both equally. The purpose of this line of questioning was to determine whether, at this young age, children see some tech tools as inherently masculine, feminine, or neither/both.

In addition to sharing their opinions on which toys would be most enjoyable to boys or girls, these toys were also used as a means to open up conversation between the child and researcher in an unstructured way. Children were encouraged to share their own experiences and feelings about each toy or tech tool. For example, children were shown objects they are typically familiar with such as Barbie dolls, play-dough, LEGO®, and footballs as well as digital tools such as iPads, computers, and a variety of robotic and electronic kits and toys. They were prompted to discuss what they like or do not like about these toys, who they have seen using them, and to share more examples of why they believe boys or girls would like each of the toys most. While these prompts were used to get the session started, children were encouraged to freely share other thoughts and opinions on each toy.

Figure 6. Gender and Technology Attitudes Protocol

During pilot-testing of this protocol during a previous stage of the research, it was found that hands-on manipulation of materials often prompted children to talk about their personal experiences with technology and engineering at school, their experiences at home with their parents, and what they have observed from their classmates, siblings, and friends. This was not the case when children were asked questions without the physical tools present. Based on this pilot testing, this study incorporated a hands-on and play-based interview approach. Analysis of the interview transcripts was used to uncover rich images of each child's worldview of technology and engineering beyond what researchers could have observed in the classroom or with a rigid interview technique.

EiE Engineering and Science Attitudes Assessment.

Data were also collected on children's attitudes and knowledge toward science and engineering before and after curricular intervention. Analysis of these data will allow us to determine if any changes in attitudes were made based on participation in the KIWI unit. Children completed an adapted version of the standardized Engineering is Elementary (EiE) “Engineering and Science Attitudes Assessment” (Cunningham & Lachapelle, 2010; Engineering is Elementary www.eie.org) to gain insight into students’ opinions about engineering. Engineering is Elementary is a classroom-tested curriculum that was designed to increase students’ interest in and confidence about engineering. In addition to curricula, EiE also designs and researches student assessments such as the one adapted in this study (Cunningham & Hester, 2007; Cunningham, 2009).

The EiE Engineering and Science Attitudes Assessment consists of twenty statements, in which students in third through fifth grade are asked to indicate their agreement/disagreement on the five-point Likert scale. This assessment was tested for internal reliability by the Engineering is Elementary team and was found to have marginal reliability with a Cronbach’s α of .798 (N=327 in 2nd-5th grade) (Engineering is Elementary www.eie.org).

The EiE assessment described above was adapted so that it could be used with the younger children in this study. Instead of having children use a numerical scale, they used a pictorial Likert scale (see Figure 7 below) to indicate how much they agreed or disagreed with the statements. Children completed a series of practice questions with this scale, to indicate their understanding of the protocol and the scale before beginning the task. The practice session included simple statements such as “Peanut butter is my favorite food” or “I love stinky garbage.” After children selected the face on the scale, they were prompted to explain their answer in order to demonstrate they understood the scale.

Figure 7. Pictorial Likert Scale for EiE Assessment

During implementation, all statements were read aloud by a researcher so that children were not required to read any of the words. For example, researcher read aloud statements such as “I would enjoy being a scientist when I grow up.” Children in first and second grade followed along as the researcher read the statements aloud to the class and they marked their own answers on paper according to the picture scale. While this assessment was read aloud by the lead researcher, two assistants and the regular classroom teacher walked around the room to ensure that everyone understood the statements and were keeping up on their papers. If anyone had issues keeping up, the research assistants or teachers helped them to complete the assessment one on one.

With children in kindergarten, this full-class implementation as not possible. Instead, children in kindergarten completed the task in a one-on-one setting with a researcher. More time was devoted to the practice questions to ensure that children understood the assessment. When the official questions were asked, children simply pointed to their answer on an enlarged picture scale and a researcher marked their answers for them so that no writing was required.

Solve-Its Programming Assessment.

“Solve It” tasks were used to assess children’s individual KIWI programming knowledge at the end of curriculum implementation. The Solve-It tasks were developed to target areas of foundational programming ability (Strawhacker, Sullivan, & Bers, 2013, Strawhacker & Bers, 2015). This assessment is intended to test students’ mastery of programming concepts, from basic sequencing through repeat loops.

The Solve-It tasks require children to listen to stories (that are read aloud by a researcher) about a robot and then spend 3-5 minutes attempting to create the robot’s program using programming icons on paper (See Figure 8 below). For example, one story is about the bus from the children’s song “Wheels on the Bus” (Strawhacker, Sullivan, & Bers, 2013, Strawhacker & Bers, 2015). For each Solve-It task, children were provided with all of the paper programming blocks they needed to solve the task. They were given only the blocks they needed and no extra or alternative blocks. The child’s job was to put these blocks in the correct order to demonstrate their knowledge of KIWI syntax (for example, starting with a Begin block and ending with an End block) as well as their ability to listen and understand the story being read.

Figure 8. Sample Child-Completed “Wheels on the Bus” Solve-It

Eight solve-Its were administered to the children in this study upon completion of the curriculum. The eight Solve Its tested the following programming concepts: Easy

Sequencing, Hard Sequencing, Sequencing with the “Wait-For” Command, Easy Repeat Loops with Number Parameters, Hard Repeat Loops with Number Parameters, Easy Repeat Loops with Sensor Parameters, and Hard Repeat Loops with Sensor Parameters, and Programming with Conditional Statements. Tasks were called “easy” or “hard” based on how many commands children needed to sequence (i.e. easy tasks had fewer blocks for children to sequence than hard tasks, but both addressed the same programming concept). Children were only administered Solve-It tasks if their class covered the targeted concept in their curriculum. For example, the Kindergarten group did not complete the last three Solve-It tasks because those concepts were not introduced to them.

Each of the Solve-It tasks described above is scored on a 0-6 rubric based on how close the child’s program came to being completely correct (a score of 6). The score of 0-6 was derived from sub-scores targeting concepts of control flow and action sequencing. Interscorer reliability tests during the development of the Solve-Its showed precise agreement (two items; K=0.902, p<.001) (Strawhacker & Bers, 2015).

Chapter 5: Results

In this chapter results from the Engineering is Elementary (EiE) pre and post tests, the Gender and Technology Attitudes pre and post tests, and the Solve-It post tests are presented. These results are organized by the three research questions and analyses are presented as they pertain to answering each question. Prior to describing these results, a summary of the final robotic constructions and programs from the “Helping at Healey” KIWI curriculum unit are presented in order to look at children’s mastery of concepts outside of a formal assessment. Additionally, these projects give an example of what children were capable of successfully creating when working with partners or small groups, while the formal assessments demonstrate individual attitudes and knowledge.

Final KIWI Projects

Robotics Final Projects.

During the last two sessions of the curriculum intervention, children worked on their final “Helping at Healey” robots. Working in groups of 2-3, children designed, built, and programmed their robots to help address a need or problem of their choosing facing their classroom or school community (See Table 3 on the following page for examples). Projects ranged in theme, but many centered on the idea of helping to carry items (e.g., garbage, recycling, school supplies) or the idea of helping to clean the classroom. Some groups created robots to help with more interpersonal issues, such as, a robot that reminds children when they need to listen. Still others were created to help overworked teachers by teaching classes for them so that they could take a break. By the end of the final session, all groups (across all three grades) had robots with syntactically correct programs and properly attached robotic parts (e.g. motors, lights, and sensors when used).

Table 3

Sample Final Projects

Helping Behavior Category	Examples	
Carrying and transporting useful objects	 Helping to carry school supplies	 Helps with writing (by carrying the writing supplies)g, and because it is programmed to draw letters
Fostering caring behaviors, classroom policies, and/or "school citizenship"	 A robot that reminds children when they need to listen	 Lets the teacher take a break by teaching Gym and Music class for her
Cleaning Robots	 Collects trash through a chute and transports to garbage can	 Drags paper scraps to the recycling bin

Final Project Programs.

Groups varied when it came to the types of programming commands they used in their final projects (See Figure 9). In general, programs were more complex in older grades. For example, although the kindergarten class was taught Repeat Loops, no kindergarten groups used Repeat Loops in their final projects. The only sensor used by Kindergarteners was the sound sensor, which was the only sensor they were exposed to in the curriculum. In the first grade class, five groups used Repeat Loops with number parameters and none used sensor parameters. Once again, the only sensor used by the first graders was the sound sensor. In the second grade class, which was introduced to all concepts, eight out of nine groups used either a Repeat Loop or a conditional If statement (6 groups used repeats while 2 groups used the If statements). Therefore, the second graders were the only students to use sensors other than the sound sensor in their projects.

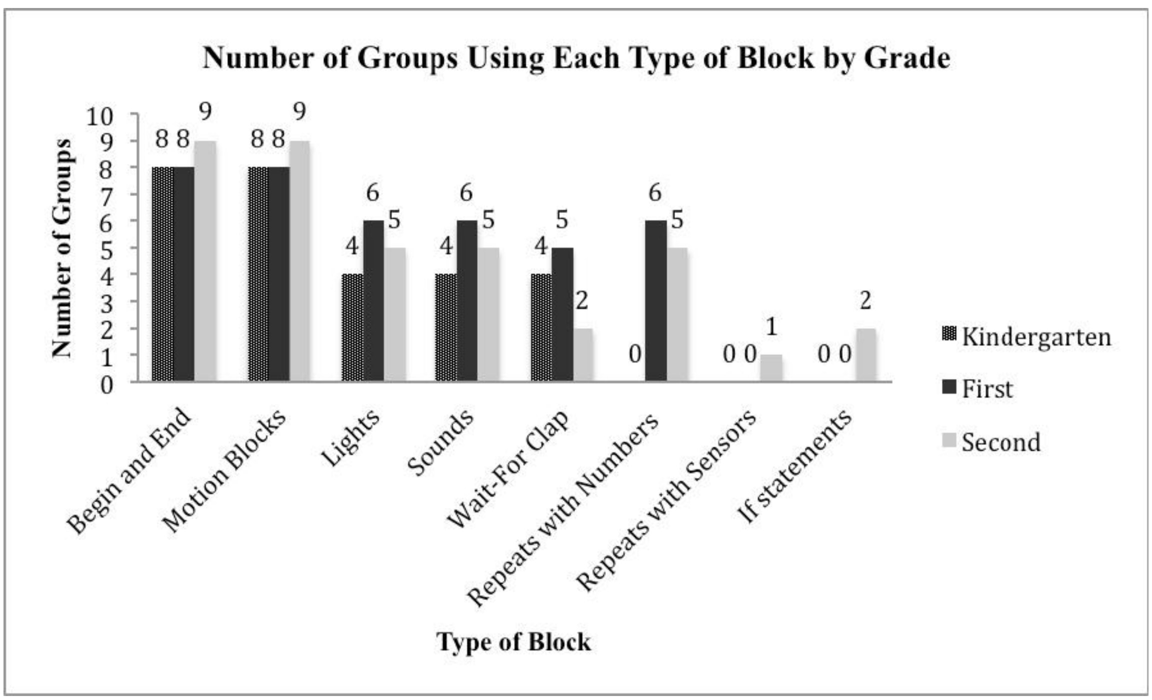

Figure 9. Block Usage by Grade. The graphic above illustrates the number of groups that used each type of block at least once in their programs. The kindergarten and first grade classes had eight groups in each class while the second grade class had nine groups.

Research Question One

Research question one asks: What are children's initial attitudes and ideas about technology and engineering? To answer this question, responses to the EiE pretest and the Gender and Technology Attitudes Protocol pretest were analyzed.

EiE Pretest Results.

Children in the Curriculum Group (*n*=45) completed the Engineering is Elementary pretest. Results from this assessment were used to assess children's initial attitudes about engineering before participating in the KIWI curriculum. The assessment contained a total of twenty questions related to science and engineering. For the purpose of the present study, the individual questions related to engineering are examined while the individual items related to science are not considered because science was not a part of the curriculum implementation. Additionally, analysis was performed on some combined items in the form of new scales related to engineering based on prior research by Lachapelle, Cunningham, Oware, & Battu (2008). Table 4 below describes the individual and combined items examined.

Table 4

EiE Survey Questions Examined

Item Scale	**Range of Scale**	**Text of Component Questions**
Enjoy being engineer	0-4	I would enjoy being an engineer when I grow up
Know about job	0-4	I think I know what engineers do for their jobs
Make lives better	0-4	Engineers help make people's lives better
Invent	0-12	I would like a job where I could invent things. I would like to help plan bridges, skyscrapers, and tunnels. I would like a job that lets me design cars.
Figure things out	0-16	I would like a job that lets me figure out how things work. I like thinking of new and better ways of doing things. I like knowing how things work. I am good at putting things together.
Help society	0-12	I would like to build and test machines that could help people walk. I would enjoy a job helping to make new medicines. I would enjoy a job helping to protect the environment.

Results show that prior to the curriculum implementation, children expressed a relatively low level of interest in being an engineer when they grow up (*M*=1.98, *SD*=1.532). They expressed a slightly higher level of knowledge of what engineers do for their jobs (*M*=2.31, *SD*=1.607) and agreement that engineers make people's lives better (*M*=2.93, *SD*=1.232). When it came to the combined item scales, there was a fairly high mean level of interest in figuring things out (*M*=11.78, *SD*=3.06 on a 0-16 scale). There was a relatively low level of interest in helping society (*M*=7.98, *SD*=2.93 on a 0-12 scale) and a relatively low level of interest in inventing (*M*=7.27, *SD*=3.32 on a 0-12 range).

Table 5

EiE Pretest

Engineering is Elementary Attitudes Pretest (Curriculum Group, All Students Combined)

	Scale	Minimum	Maximum	Mean	Std. Deviation
Enjoy being engineer	0-4	0	4	1.98	1.53
Know what engineers do for jobs	0-4	0	4	2.31	1.61
Engineers make lives better	0-4	0	4	2.93	1.23
Figure things out	0-16	4.00	16.00	11.78	3.06
Help Society	0-12	2.00	12.00	7.98	2.93
Invent	0-12	0	12.00	7.27	3.32

The Mann Whitney U test was used to determine whether there were significant differences between boys and girls in any of these attitudes at the pretest. Results indicate that boys had a significantly higher level of agreement that they would enjoy being an engineer (Mann-Whitney *U*=670.5, *p*=.005). There were no other significant gender differences at the *p*=.05 level.

Table 6

Boys' and Girls' Attitudes on EiE Pretest (Curriculum Group by Gender)

gender		N	Minimum	Maximum	Mean	Std. Deviation
Female	Enjoy being engineer	18	0	4	1.44	1.29
	Know what engineers do for jobs	19	0	4	2.05	1.75
	Engineers make lives better	19	0	4	2.68	1.29
	Figure things out	19	8.00	16.00	12.21	2.86
	Help Society	18	2.00	12.00	8.72	2.59
	Invent	19	.00	12.00	7.11	3.33
Male	Enjoy being engineer	26	0	4	2.35*	1.60
	Know what engineers do for jobs	26	0	4	2.50	1.50
	Engineers make lives better	26	0	4	3.12	1.18
	Figure things out	26	4.00	16.00	11.46	3.2
	Help society	26	2.00	12.00	7.46	3.09
	Invent	26	.00	12.00	7.38	3.37

Gender and Technology Attitudes Protocol Results.

Children in the Curriculum Intervention group (*n*=45) completed the Gender and Technology Attitudes Protocol pre-test. During this task, they were asked to sort different types of toys and technologies into categories: boys would like it more, girls would like it more, or both would like it equally. The task began with sorting "traditional toys" including a football, jump rope, Barbie, and toy car. This was meant to get children familiar with the task before showing them technology and engineering tools. It was also used to determine if children had any gender-based notions about everyday toys they were likely familiar with before showing them things they may not have been familiar with, such as robots.

Results showed that Barbies elicited a highly feminine response with 93.5% of children saying girls would prefer Barbies over boys. Similarly, the toy car and football elicited a highly masculine response with 71.7% and 91.3% of children saying boys would prefer these toys respectively. The jump rope was received as borderline feminine and gender-neutral with 47.8% saying boys and girls would like it equally and 45.7% saying girls would like it more.

When it came to the technology and engineering tools, every tool had at least 50% of the children responding that boys and girls would like the tool equally (see Table 7). The technology received as the most gender-neutral was the computer, with 70.5% of children responding that boys and girls would equally enjoy using it. Other technologies, like the robots, were more spread out in terms of predicted gender preference. For example, while approximately half (53.3%) of children responded that both boys and girls would equally enjoy the LEGO® WeDO™ robot, another 40% said that boys would like it more and only 6.7% (or 3 children) said that girls would like it more. Similarly, 51.1% of children stated that both boys and girls would equally enjoy the LEGO® Rcx robot, but another 35.6% replied that boys would like it more and only 13.3% stated girls would like it more. The KIWI robot had the highest percentage (at 18.2%) of children respond that girls would like it more. KIWI also had about half (56.8%) of the children reply that both boys and girls would like it equally and 25% of children state that boys would like it more.

Table 7

Technology and Engineering Toy Preference Combined

Category	Tech/Engineering Tool	Boys would like it more	Girls would like it more	Both like it equally
Building	Blocks (*n*=45)	10 (22.2%)	11 (24.4%)	24 (53.3%)
Building	LEGO® (*n*=44)	15 (34.1%)	2 (4.5%)	27 (61.4%)
Digital	iPad (*n*=44)	9 (20.5%)	8 (18.2%)	27 (61.4%)
Digital	Computer (*n*=44)	7 (15.9%)	6 (13.6%)	31(70.5%)
Digital	Video Camera (*n*=43)	15 (34.9%)	6 (14.0%)	22 (51.2%)
Robots	KIWI (*n*=44)	11(25.0%)	8 (18.2%)	25 (56.8%)
Robots	Rcx (*n*=45)	16 (35.6%)	6 (13.3%)	23 (51.1%)
Robots	WeDO™ (*n*=45)	18 (40.0%)	3 (6.7%)	24 (53.3%)

Note. n varies from toy to toy on the table above because children were allowed to skip a question during the protocol if they could not decide or could not answer.

Children described a variety of reasons for categorizing tools as something boys, girls, or both would like. The most commonly occurring strategies included: deciding based on color and aesthetic features or deciding based on personal observations, (see Table 8 for examples). Another strategy was simply drawing on their own gender notions of girls and boys to determine if an object was “for boys” or “for girls” whether the reasons for these notions could be fully articulated to a researcher or not.

When children were faced with a novel tool they had never seen before, which was the case with many of the robots, children tended to employ a different type of strategy. Children tended to make sense of the novel tools by likening them to familiar objects. Based on how they resembled familiar objects, children decided if it would be preferred by boys, girls, or everyone equally (see Table 9 for examples). For example, when looking at the screen on the Rcx robot, one child likened it to a phone and then drew on their gender notion that "girls love talking on phones" to decide that girls would like the Rcx robot. In other cases, when children did not employ this strategy, they told researchers they were "just guessing" because they had never seen the object in question before. These techniques are described in more detail in Chapter Six: Qualitative Themes Explored.

Table 8

Children's Methods of Determining Gender Preference of Toys

Strategy	**Example Quotes**
Color/Aesthetic	"because it has sparkles"
	"because of the different colors"
Personal Observations	"I've never seen a girl with a football"
	"My friend likes them"
	"Boys and girls use it at choice time"
	"I've never seen a boy with a Barbie"
Gender Notions (not qualified with an observation)	"Girls don't like building things that are harder"
	"Usually boys build things"
	"Girls have to do more real things in life than just doing it on a screen"

Table 9. Making Sense of Novel Tools by Likening to Familiar Objects

Tool/Technology	**Example Quotes**
KIWI Robot	"It looks like a car"
LEGO® RcX Robot	"girls love talking on phones" (*referring to the screen and buttons on the Rcx)"*
	"it has LEGO"
LEGO® WeDo™ Robot	"It's kinda looks like a spaceship"
	"Looks like it has missiles"

Finally, at the end of the interview, children were also asked to choose their favorite robot. Of the three robots that children were shown (the LEGO® WeDO™, LEGO® Rcx, and KIWI), more than half of both boys (54.2%) and girls (52.4%) reported that the LEGO® Rcx robot was their favorite one (See Table 10). Although the second most popular robot amongst both girls and boys was the KIWI robot, there were a greater number of girls (9 girls, 42.9%) who chose KIWI as their favorite as compared to boys (6 boys, 25%). Many boys also liked the LEGO® WeDO™ robot (5 boys, 20.8%) while only one girl chose the LEGO® WeDO™ as her favorite.

Table 10

Children's Favorite Robot by Gender

Gender		Frequency	Percent
female	WeDo™ Robot	1	4.8
	KIWI Robot	9	42.9
	Rcx Robot	11	52.4
	Total	21	100.0
male	WeDo™ Robot	5	20.8
	KIWI Robot	6	25.0
	Rcx Robot	13	54.2
	Total	24	100.0

Research Question Two

Research question two asks: Does participating in a robotics curriculum have any impact on children's attitudes and ideas about technology and engineering? Analysis of the adapted Engineering is Elementary (EiE) assessments were used to answer this question and to see whether boys and girls differed in their changes.

Differences Between Boys and Girls.

During the pretest, the Mann-Whitney *U* test was used to identify significant differences between boys and girls on the EiE assessment, and it was found that boys had a significantly higher level of agreement that they would enjoy being an engineer and that there were no other significant differences between boys and girls on the EiE. At the posttest, the Mann-Whitney *U* test found that there was no longer a significant difference between boys and girls and there was a level of agreement that they would enjoy being an engineer (U=477.5, p>.05). However, at the posttest, Mann-Whitney *U* tests show that boys now had a significantly higher level of agreement that they know what engineers do for their jobs than girls (*U*=357.50, *p*=.04).

EiE Changes from Pre to Post.

Children's EiE responses were also compared to pre and post curriculum intervention to determine if any changes were present. Pre and post responses from children in the Control Group were also compared to determine if changes occurred due to curricular intervention or other due to other factors present at the school. Preliminary analysis of the six EiE constructs of interest (see Table 4 in the previous section) showed that these data were not normally distributed. Therefore, the Wilcoxon signed rank test was used to determine whether there were differences in attitudes before and after curriculum implementation because this test does not rely on an assumption of normality. Additionally, this test is appropriate for use on ordinal variables, such as the 0-4 scales of agreement that were part of the EiE assessment.

Wilcoxon signed-rank tests showed that the KIWI robotics curriculum elicited a statistically significant positive change in girls' desire to be an engineer (*Z*=-2.435, *p*=.015). The tests also showed a significant *negative* change in girls' Figure Things Out score (*Z*=-1.967, *p*=.049). No other attitudes were significantly changed for girls at the *p*=.05 level. The Figure Things Out construct consisted of a combined score on the following EiE scales related to engineering: I would like a job that lets me figure out how things work, I like thinking of new and better ways of doing things, I like knowing how things work, and I am good at putting things together.

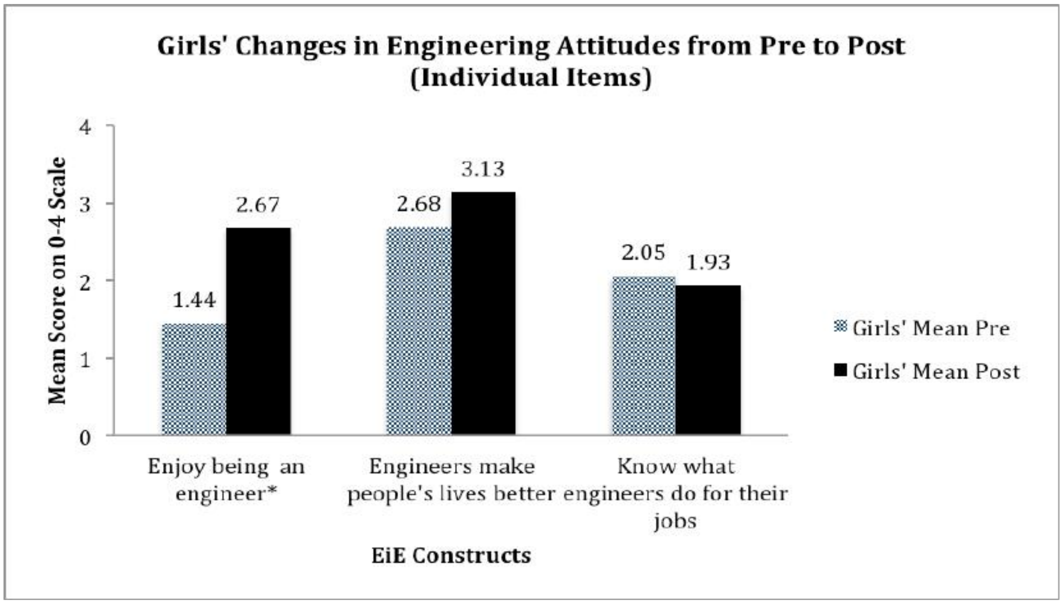

Figure 10. Changes in Girls' Attitudes on EiE from Pre to Post
Note. * Indicates significant increase from pre to post at the .05 level

The Wilcoxon signed-rank tests also showed that the KIWI robotics curriculum elicited a statistically significant increase in boys' understanding of what engineers do for their jobs (Z=-2.288, p=.022). No other attitudes were significantly changed for boys at the p=.05 level.

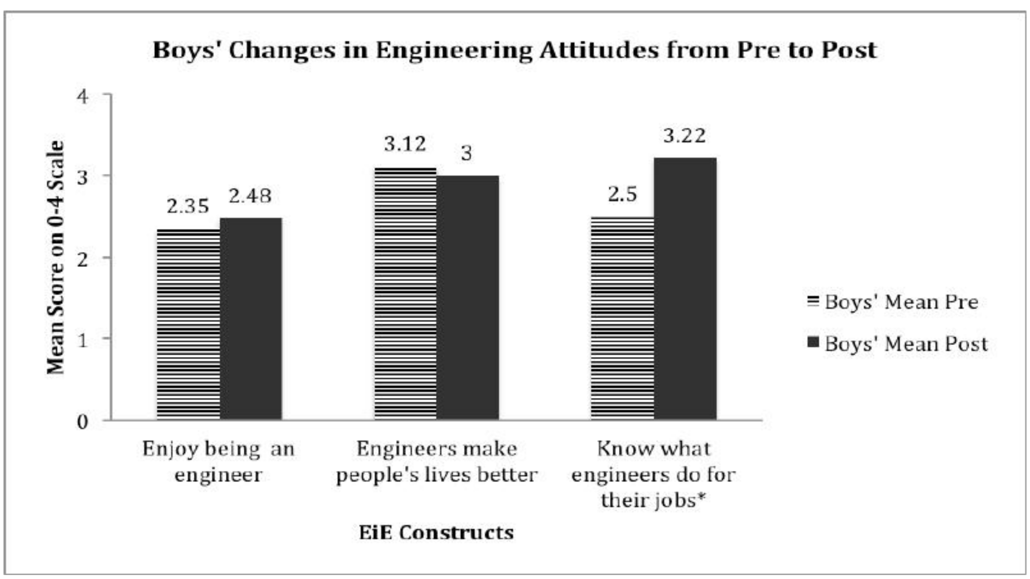

Figure 11. Changes in Boys' Attitudes on EiE from Pre to Post
Note. * Indicates significant increase from pre to post at the .05 level

The same Wilcoxon signed-rank tests were also performed on the Control Group to determine whether changes were a product of the KIWI curriculum or other factors in the school day. Results showed that girls in the Control Group did not have a significantly increased desire to become an engineer (Z=-.612, p=.541); however, they also showed a significantly *lower* score on the Figuring Things Out construct (Z=-2.44, p=.014). This indicates that girls' lessened desire to figure things out was likely influenced by other factors in the school day and may not have been directly related to the KIWI robotics curriculum. No other significant changes were present at the p=.05 level. When looking at boys in the Control Group, they displayed a significantly increased desire to be an engineer (Z=-2.014, p=.044). No other significant changes were present.

Gender and Technology Attitudes Protocol Changes.

A sub-sample of children from the Curriculum Group (n=15) completed the Technology Attitudes Protocol again after completion of the unit. After completing the KIWI robotics curriculum, the majority (86.7%) of children responded that both boys and girls would equally enjoy using the KIWI robot (while only 56.8% thought boys and girls would like it equally at the pretest). This change appeared to be technology-specific to KIWI, as the other two robots, LEGO® WeDO™ and Lego Rcx, still hovered at only approximately half of the students predicting that boys and girls would like it equally (53.3% and 40% respectively).

When it came to choosing their favorite robot, the majority of students (66.7%) chose KIWI as their favorite robot after completing the curriculum, as compared to just

33.3% during the pretest (Table 11). During the pretest, the LEGO® Rcx robot was the most commonly chosen favorite robot.

Table 11
Favorite Robots Pre and Post

	Percent Pre	Percent Post
WeDo™ Robot	13.3	13.3
KIWI Robot	33.3	66.7
Rcx Robot	53.3	20.0

During the Gender and Technology Attitudes posttest, several children cited their robotics class experience as the reason they chose to say that both boys and girls would enjoy playing with the KIWI robot (see Table 10). For example, one second grade girl commented, “because we all love robotics. I learned that from our robotics class.” These types of comments and reflections on class experiences with KIWI provide some initial evidence that, from the child’s perspective, the intervention impacted their viewpoints.

Table 12

Quotes Demonstrating Impact of Class Experience on Children’s Views

Child	**Quote**
514, male	“Everybody would like to play with these **because my class played with one a lot**” “**I saw a lot of people using it in robotics**”
569, female	“Because we all love robotics class, **I learned this from our class**” “…**when you came to our class**, everybody enjoyed all of these things”
517, female	“**You came with it** in my classroom”

563, male	"**At robotics time** I always see both girls and boys playing with them"
527, male	"Because **boys and girls in your class like them** when you used them yourselves"
502, male	"We **used it in class**"

Note. In the table above, bolded words or phrases indicate a direct reference to the robotics curriculum intervention.

Research Question Three

Research question three asks: After receiving the same curriculum, do boys and girls differ in their performance on tasks? In order to answer this question, participants' Solve-It programming assessments were analyzed. Other potential influencing variables such as grade level and teacher gender were also examined where possible.

Solve-Its.

Upon finishing the KIWI robotics curriculum, children completed the Solve-It programming assessment to look at their individual mastery of the concepts taught. 46 children (n=23 boys and n=23 girls) in the Curriculum Group completed the Solve-Its. As described in the Methods section, the eight Solve-It tasks each addressed a different concept and difficulty level. These included: 1) Easy Sequencing, 2) Hard Sequencing, 3) Sequencing with the "Wait-For" Command, 4) Easy Repeat Loops with Number Parameters, 5) Hard Repeat Loops with Number Parameters, 6) Easy Repeat Loops with Sensor Parameters, and 7) Hard Repeat Loops with Sensor Parameters, and 8) Programming with Conditional Statements. Children were only administered Solve-It tasks if their class had covered the targeted concepts. For example, the Kindergarten students only completed Solve-Its one through five because they did not cover the concepts of sensors and conditional statements over the course of their curriculum intervention. Table 13 shows children's mean scores on each of the eight Solve-It tasks by grade. Tasks were scored out of a possible 6 points (with 6 indicating a perfect score). Scores varied by grade, with older students generally performing better on all of the tasks. More advanced programming tasks, such as repeat loops with sensors (tasks six and seven) generally had lower averages than the simpler sequencing tasks (tasks one through three).

Table 13

Solve-It Tasks by Grade

Solve-It Number	Kindergarten *M* (*SD*)	1st *M* (*SD*)	2nd *M* (*SD*)	All grades *M* (*SD*)
1-Easy Sequencing	4.65 (1.80)	5.80 (.76)	5.79 (.80)	5.37 (1.36)
2-Hard Sequencing	4.94 (1.35)	6.00 (0.00)	6.00 (0.00)	5.61 (.95)
3-Wait-For	4.76 (1.79)	6.00 (0.00)	6.00 (0.00)	5.54 (1.22)
4-Easy Repeats with Numbers	3.24 (.97)	4.80 (1.01)	5.71 (.73)	4.50 (1.38)
5- Hard Repeats with Numbers	3.06 (1.09)	4.67 (.72)	5.36 (.75)	4.28 (1.31)
6-Easy Repeats with Sensors	*Did not complete*	4.27 (.96)	5.46 (1.05)	4.82 (1.16)
7- Hard Repeats with Sensors	*Did not complete*	4.53 (1.06)	4.86 (.86)	4.69 (.97)
8-Conditionals	*Did not complete*	*Did not complete*	5.23 (1.01)	5.23 (1.01)

In addition to looking at each of these eight Solve-Its individually, related concepts (such as easy and hard sequencing) were combined into a new cumulative score ranging from 0-12 possible points, presented as Solve-It 9 (Sequencing Cumulative), Solve-It 10 (Repeats with Numbers Cumulative), and Solve-It 11 (Repeats with Sensors Cumulative).

Table 14

Cumulative Solve-It Tasks by Grade

Solve-It Number	Kindergarten *M* (*SD*)	1st *M* (*SD*)	2nd *M* (*SD*)	All grades *M* (*SD*)
9 (Sequencing Cumulative)	9.5882 (2.063)	11.800 (.775)	11.786 (.802)	10.978 (1.745)
10 (Repeats with Numbers Cumulative)	6.294 (1.896)	9.467(1.552)	11.071 (1.385)	8.783 (2.590)
11 (Repeats with Sensors Cumulative)	*Did not complete*	8.800 (1.897)	9.929 (2.336)	9.345 (2.159)

Note. These Solve-Its were scored out of a possible 12 points.

A 2-Way ANOVA was performed to examine whether gender (male or female) or grade level (kindergarten, first, second) had a significant effect on students' performance on each of the following tasks: Wait-For Clap, Sequencing Cumulative, Repeats with Numbers Cumulative, and Repeats with Sensors Cumulative. These four tasks were selected for ANOVA analysis because each one targets discrete programming concepts taught in two or more grades. In addition to determining whether grade or gender independently impact Solve-It scores, this analysis was also used to examine whether there was a significant interaction between the two independent variables (grade and gender) on Solve-Its scores. Because of this potential interaction, it would be misleading to analyze simply for gender effects alone.

Results from the 2-way ANOVAs showed that there were no significant main effects for gender ($p>.05$) and no significant interaction effects for grade and gender

($p>.05$) for any of the four tasks. However, there was a significant simple main effect for grade level on the Wait-For Clap Solve-It $F(2,40) = 7.746$, $p<.005$; on the Sequencing Cumulative Solve-It $F(2,40) = 12.062$, $p<.0001$; and on the Repeats with Numbers Cumulative Solve-It $F(2,40) = 26.031$, $p<.001$. This indicates that on each of these tasks, grade significantly impacted students' performance on the respective Solve-Its but gender did not.

Post-hoc testing was completed on the three tasks that showed a main effect for grade level in order to determine more specifically where differences fell between kindergarten, first, and second grade. Post-hoc Tukey testing indicated that there was a significant difference between the way first grade and kindergarten performed on the Cumulative Sequencing task ($p<.0001$) and the way second grade and kindergarten performed on the Cumulative Sequencing task ($p<.0001$). However, first and second grade did not perform significantly differently from one another on this task ($p>.05$). On the Cumulative Repeats with Numbers task, post-hoc Tukey testing showed that once again, first grade performed significantly better than kindergarten ($p<.001$) and so did second grade ($p<.001$). Once again, first and second grade did not perform significantly different from one another ($p>.05$). Finally, on the Wait for Clap task, post-hoc Tukey testing showed the same trend. First grade ($p<.01$) and second grade ($p<.01$) performed significantly better than kindergarten but there were no significant differences between first and second grade ($p>.05$).

Teacher Gender and Solve-It Performance.

The findings in the previous section described Solve-Its performance by girls and boys in Kindergarten, first, and second grade in the Curriculum Group. This Curriculum

Group was taught by all-female instructors to control for the impact of teacher gender on children's performance on the various assessments. Results from the prior section show that when taught by an all-female teaching team, grade level played a significant role on children's performance on tasks but gender did not. After Fall 2014 data collection was complete, the Control Group received the same KIWI robotics curriculum. However, an all-male teaching team taught this group. The same Solve-Its were collected at the end of their curricular intervention. These were analyzed the same way as the Curriculum Group in order to determine if having a male robotics instructor resulted in any different grade or gender based effects on children's Solve-It performance.

2-Way ANOVAs were performed on the following discrete tasks: Cumulative Sequencing, Cumulative Repeats with Numbers, Cumulative Repeats with Sensors, and Wait-For Clap. Results from the 2-Way ANOVAs show that there were no main effects for grade or gender alone on the Cumulative Sequencing task ($p>.05$), but that there was a significant interaction effect of grade and gender $F(2,46)=7.434$, $p<.005$. On the Cumulative Repeats with Numbers task there was a significant main effect for grade level $F(2,45)=5.845$, $p<.05$ and a significant main effect for gender $F(1,45)=4.709$, $p<.05$. Looking at the gender differences, we see that boys significantly outperformed girls with a mean score of 10.17 while girls had a mean score of 8.89 on this task. Post-hoc Tukey testing to explore the grade level differences on the Cumulative Repeats with Numbers task showed that first grade performed significantly better than kindergarten ($p<.05$) and second grade performed significantly better than kindergarten ($p<.05$) but that first grade and second grade did not perform differently from one another ($p>.05$). 2-Way ANOVAs on the Cumulative Repeats with Sensors task and the Wait for Clap task revealed no significant main or interaction effects ($p > .05$).

In summary, these findings show that when taught by male robotics instructors, grade level still significantly impacted student performance on certain Solve-Its (as it did for the female group). However, there was *also* a significant gender effect on the Repeats with Numbers task when taught by male instructors that was not present when taught by female instructors. On this task, boys performed significantly better than girls. These results should be interpreted cautiously as not all Solve-It tasks were normally distributed, likely due to the small sample size of each group.

Chapter Six: Qualitative Themes Explored

Overview

In the Results section, descriptive findings from the Gender and Technology Attitudes protocol were presented. Those findings were drawn from quantifying children's sorting choices for which gender would most enjoy each toy. Beyond just completing the sorting task, children were encouraged to talk more about their decision-making process and share experiences with the interviewer. Although many children simply completed the sorting without talking extensively, some children shared personal experiences, vignettes, and theories about the different toys and technologies.

In this chapter, qualitative findings about technology, engineering, and gender are presented. A qualitative coding approach was used to identify common themes that emerged from the Gender and Technology interviews. In the following sections, the themes will be identified and sample interview transcripts and illustrative quotes are presented. The goal of this work is to illustrate the nuanced ideas children have about gender and STEM during early childhood that are not captured by the quantitative analysis.

Purposeful Sampling

A total of n=48 children were in the Curriculum group and n=57 were in the Control Group for a total sample of N=105. Purposeful sampling was used to gather a small subset of children whose interviews would be appropriate to be coded and examined for themes. Because the purpose of this coding was not to determine the effect of the Curriculum intervention, but rather to look at all gender and technology related themes that emerged, children from the Curriculum and Control group were combined in the qualitative analysis.

Of these *N*=105 children, a subset of children (*n*=23) was chosen as possible candidates for qualitative coding. Children were excluded from consideration if they completed the Gender and Technology Attitudes protocol by just sorting the toys and not providing verbal explanations beyond quick sentences or remarks. They were also excluded if they spoke too softly or inaudibly for the voice recorder to pick up. Due to working with very young children, many of whom were kindergarteners in school for the first time, this eliminated the majority of the children. Finally, children were eliminated if they were absent for one of the interview time-points (pre, post, and end of year). A final sample of *n*=13 children (each with three interview transcripts each from the three time points) were chosen that met all of this criteria. These thirteen children's transcripts were coded for themes as described in the following section.

Coding Process

Children's interviews were recorded with a free voice-recording app called "Voice Record" and later exported and transcribed using the NVivo software. Once the transcripts were exported, a modified phenomenological coding technique was used in order to analyze the Gender and Technology interview transcripts by combining Corbin and Strauss' (2008) grounded theory coding methods along with Moustakas' (1994) phenomenological methods. After chunking kids' responses, two researchers (the author and a research assistant) went through the transcripts to identify significant statements and conceptual ideas. As concepts and ideas emerged, they were identified and discussed. For a complete list of data analysis steps illustrating how Moustakas' (1994) phenomenological techniques were combined with Corbin & Strauss' (2008) grounded theory methods see Table 15.

Table 15.

Interview Coding Steps

Steps of Data Analysis
1. Chunking data from the transcript by paragraphs. (Corbin & Strauss, 2008)
2. Explore each chunk and highlight significant statements or quotes (Corbin & Strauss, 2008)
3. From these significant statements, identify and name conceptual ideas that are emerging (Moustakas, 1994)
4. Memo as about each concept that emerges (Corbin & Strauss, 2008)
5. Refine memos as repeated concepts emerge (Corbin & Strauss, 2008)
6. Make a list of concepts or themes that are identified (Corbin & Strauss, 2008)
7. Write an explanation of how these concepts go together (Corbin & Strauss, 2008)
8. Diagram the explanation (Corbin & Strauss, 2008)
9. Write a "textural description" based on the significant statements and themes of what each of the interviewees experienced (Moustakas, 1994)
10. Write a "composite description" of the meanings and essences of the experience representing the group as a whole (Moustakas, 1994)

Although many interesting concepts emerged, there were two conceptual ideas that were determined to be significant by both the author and the author's research assistant. These ideas, or themes, include: are boys better at building? And, girl games versus boy games. A section on the other gender stereotyped ideas that emerged and were marked as significant by the researcher and the research assistant are also briefly described, although they were not present in enough transcripts to be fully described as a theme. Finally, all of these observations are taken together to shed light on decision making process children engage in when deciding whether toys and technologies are appropriate for just one or more than one gender.

Theme One: Are Boys Better at Building?

The first theme that was identified in the interviews was the idea that one gender might be better than the other at building. While on the surface it appeared that most children thought that both girls and boys equally enjoy building materials such as blocks and LEGO®, a deeper look at children's anecdotes and explanations revealed that there was still the presence of a persistent stereotype that boys are better than building amongst many of the children. Statements where children explained that boys liked building more than girls or that girls don't like building or using building materials were highlighted during the coding process to help identify this stereotype in the transcripts (See Table 16 for examples).

It is interesting to point out that many times these comments emerged in the interview even *after* children had already chosen that boys and girls would equally like using a toy during the sorting task. The presence of this theme indicates that although children may generally feel that both boys and girls might enjoy using building materials for fun, it is possible that they still have stereotyped notions about who would be *better* at using these items.

Table 16

Boys Are Better at Building Stereotype

Child	Illustrative Quotes
Kindergarten female	“Usually boys build things”
Kindergarten male	“Boys like playing with legos because they can build stuff and also they can make race cars”
First grade male	“Girls don’t like building things that are harder like legos”
Kindergarten Female	“Boys like building stuff and girls like seeing stuff”

This stereotype was interesting to explore in the transcripts because many of the significant statements exploring the theme of gender and building directly *contradicted* the stereotype that boys are better at building than girls. For example, many children drew on their own personal experiences and observations to determine that, in fact, girls and boys *both* like to build, particularly when it came to using LEGO® during choice time or other activities in school. For example, one child stated that, “at choice time there’s Legos [and] almost everybody likes to use the Legos.” Therefore, this theme is articulated as a question (Are boys better at building?) rather than a stated stereotype (Boys are better at building) because the stereotype was both presented and negated in the children’s transcripts.

Theme Two: Girl Games versus Boy Games

Although the iPad and computer were deemed the technologies most equally appealing to both boys and girls according to the sorting task, coding through the kids’ interview transcripts shows that there is still a consistent belief that boys and girls would enjoy different activities on these technologies. When the theme of “boy games versus girl games” first emerged, the researcher and research assistant went back through the interview transcripts to identify all of the games that were called “girl games” or “boy games.” All quotes identfying the different types of games were collected in order to come up with a composite of the types of games children named. In some cases, children gave an example of a specific game (i.e. “Minecraft”) while at other times children just gave a description of a type of game (i.e. “math games”).

Table 17 provides a list of the different games identified. Once the games were identified, the researcher attempted to group them into different categories based on charactersistics of the game. These categorizations were later discussed amongst a a group of researchers from the DevTech Research Group. Although some games could certainly fall into more than one category, the researchers were able to identify a “main category” based on the group discussion.. These categorizations are also presented in Table 17.

Table 17

Boy and Girl Game Classifications

Category and Definition	Game Examples by Gender
Virtual World and Sandbox Games: Open world games explore and/or complete missions as they choose	**Boys-** Minecraft, Terraria **Girls-** *None*
Action/Adventure/Racing: Games that inolve engaging in an adventure or quest, racing, or fighting	**Boys**- Transformers, Star Wars, Ninja Turtles **Girls**- Temple Run
Physics/Puzzles/Problem Solving: Games that involve strategic problem solving, solving non-language based puzzles, and spatial reasoning.	**Boys**- Chess, Angry Birds, Math Games, Fire Boy and Water Girl **Girls**- Math Games
Programming Games: Games that explore foundaitonal coding concepts	**Boys**- ScratchJr **Girls**- *None*
Literacy Games: Games that involve reading, letter recognition, and the alphabet	**Boys**- *None* **Girls**- ABC games
Story & Character Based Games: Games that center around a character or characters and a story about them.	**Boys**- None **Girls-** My Little Pony, Dora, Frozen
Caregiving/Nurturing Games: Games that engage the player in traditionally nurturing activties such as cooking, taking care of people, and taking care of animals.	**Boys- None** **Girls-** Cooking games, cat/animal care games
Identity Exploration Games: Games that involve playing with appearance, behaviors, and self-presentation	**Boys-** *None* **Girls-** Dress up games

General Characteristics of Boy Games.

Games that children brought up as examples of “boy games” were more likely to engage players as creators (i.e. sandbox open world games). For example, Terraria is a 2D sandbox game that revolves around exploration, action, and building. The player uses resources to craft new items and equipment and create their own unique experience. Other “boy games” engaged children in math, problem-solving, strategy, and puzzle style games. These games that were seen as for boys were more likely to engage in STEM play than the games that children thought were for girls.

General Characteristics of Girl Games.

Games that children brought up as examples of “girl games” were more likely to engage storytelling, literacy, fantasy, and identity play. For example, “ABC games” and “dress up” games were given as examples of games girls would like to play on the computer or iPad. The “girls games” were less likely to involve open-world creation, programming, or math skills. It is also interesting to note that there were far more games given as examples of “boy games” than of “girl games,” indicating that it might have been easier for children to think of digital activities that boys enjoy than girls enjoy.

Other Gender Stereotypes

There were several significant statements that were highlighted by the researcher during the coding process that did not come up consistently enough across multiple children to form a fully identified theme. However, they are interesting to present because they provide examples of the different types of stereotyped ideas that young children form regarding gender traits. Table18 gives a list of gender related stereotypes that were expressed by children in their interviews.

Table 18

Other Gender Stereotypes

Stereotype	**Illustrative Quote**
Girls are creative	"Girls are creative" "Girls kind of like to write stuff"
Girls have to do things in "real life" rather than onscreen	"[girls] have to do more things in real life than just doing it on a screen"
Boys like electronics	"boys kind of like wires and moving stuff"

The Decision Making Process

As briefly mentioned in the Results section, the interview transcripts revealed different types of criteria that contribute to the decision making process when it came to deciding if a toy was for girls or for boys or for anyone to enjoy. The themes that were explored in the qualitative coding came together to form a six-part system of influencing factors that children consider when deciding if a toy or technology would be suited to their gender: Aesthetics, Observations, Role-Modeling, Likening to Familiar Objects, Personal Experience, and Gut Instinct (Figure 12).

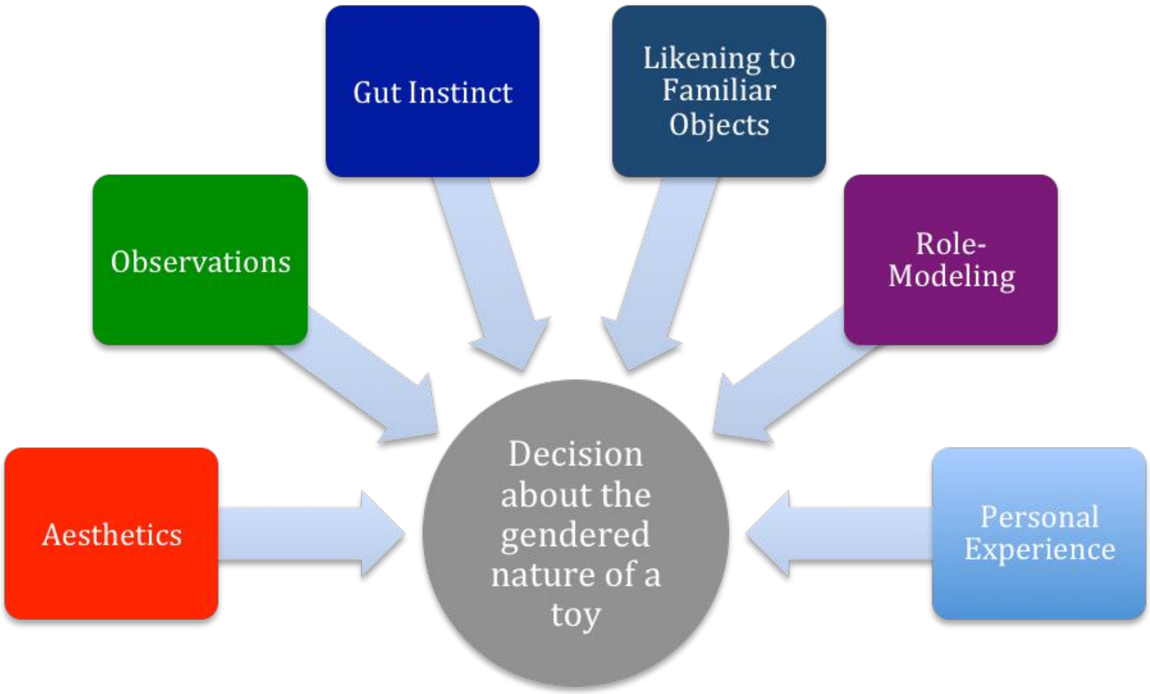

Figure 12. Diagram of Child's Decision Making Process

Aesthetics.

Color, material, and appearance were consistently one of the first things that children noticed when looking at a new toy or object. Therefore, it may not be surprising that children made gender decisions about the different objects they encountered by drawing on their own interpretation of the aesthetic design. One of the most common design features that children responded to was color, saying things like "because it's blue" or "because it has sparkles." At times, children referred to specific design elements. For example, one child commented that, "boys would like the wheels" on the KIWI robot while another child commented that, "girls would like touching the button." These examples demonstrate how subtle and overt design choices can make a large impact on the appeal of technologies to boys and girls.

Observations.

When deciding if a toy was most appropriate for girls or boys, children also drew on observations from their class or home whenever they had these memories to draw upon. For example, when making decisions about the computer and iPad, many children thought about what they had observed in their Library Class, where they told the interviewer they learn how to use computers and iPads. Some of the kids' classrooms had LEGO® choice areas or used LEGO® throughout the day for various activities. Children from these classes often drew on their own third-party observations of what was taking place in these areas. For example, one child reported that, "the legos a lot of boys and a lot of girls like to do it at free choice time." These observations tended to be third party observations of other children (not themselves) and did not identify specific peers or family members by name.

Role-Modeling.

In the decision making process, children often reflected on a very specific type of observation: the modeling of their friends, siblings, family members, and teachers. This was different from general observations, which might just refer to "boys and girls in their class" rather than specific classmates. Observations categorized as role-modeling included a specific reference to a family member, a friend by name, or a clearly specified person. For example, when making decisions about the iPad and computer, many children referenced their parents' usage of these tools. One boy who was deciding who would like to use computers reflected that, "well, my dad um, goes on his computer for work." Another child, when trying to decide what the iPad was for and who would use it reflected that, "My mom has it [an iPad] like it but bigger. She has an Apple one." In one vivid example, a child decides that boys are better at building because his dad is very good at building with LEGO while his mom is not:

> Interviewer: Can girls build as well as boys?
>
> Child: No because boys are excellent at building because my dad can build like any LEGO set. Whenever he gives me a LEGO set he builds them, any of them. Like, I don't know how he did this, but he told me he didn't build LEGOS when he was a kid so he just knows.
>
> Interviewer: Really? And he does it now? He builds LEGOS now? [*Paus*e] What about your mom?
>
> Child: I don't…no she's not good
>
> Interviewer: She's not good at LEGOs?
>
> Child: She always looks at the directions and she doesn't know which piece goes on [each] piece

In addition to older role-models, like parents and teachers, siblings and friends served as a memorable source of peer-modeling in children's decisions. In many cases, these powerful examples were enough to contradict gender-normative notions about an object. For example, although most children thought boys would like the toy car more, one child commented that, "my baby sister likes to play with cars" in their process of deciding that girls and boys might both like the toy car. Other children reflected fondly on technology or engineering play-activities they participated in with a friend or sibling. For example, one child told the interviewer, "my brother and me like to play with legos" when deciding that everyone probably enjoys playing with LEGO®.

Likening to Familiar Objects.

When children were faced with novel technologies they had never encountered before (like many of the robots during the pretest) they often drew similarities between the object in question and other objects they have seen before. For example, one child who had never seen the LEGO® Rcx before draws the conclusion that it must be a calculator because of the buttons and screen:

Interviewer: This is a robot, just like you said.

Child: A robot?

Interviewer: All of these are robots actually.

Child: I….the robot calculator?

Interviewer: I see what you think, it kind of looks like a calculator, right?

Child: Yes

Once children were able to make a connection to something they were familiar with, they were able to draw on their own storage of gender associations the way the normally would with a familiar object. For example, one child who had never seen a LEGO® WeDo™ robot made the jump that, "WeDo looks like a car so boys want to play with it."

Personal Experience.

When children had a personal experience and could remember a specific time they did or did not enjoy using a toy, this was typically the deciding factor in the decision making process. This was different than general observations (which were of a third party) but instead focus on the self. The clearest example of this that appeared in the interview transcripts were children's reactions to KIWI after they had the KIWI robotics curriculum. Children drew not only on their third party observations of what they saw other people in the class doing with KIWI (e.g. “at robotics time, I always see both girls and boys playing with them”) but they also drew on their own personal memories of how the robot works and what they enjoyed about using it (e.g. “[KIWI is my favorite] because it spins, turns, and shakes” and “I like when they make light”). These personal memories were powerful when it came to deciding whether or not they would decide a toy was appropriate and enjoyable for their gender or not.

Gut Instinct.

For many toys that children were shown, whether they were familiar or novel to the child, there were an overwhelming number of times when children relied on their immediate reaction and “gut instinct” about the object. This is in part illustrated by the number of children who were able to complete the Gender & Technology Attitudes protocol without being able to articulate why they had grouped the toys the way they did (and were later removed from qualitative analysis during the purposeful sampling phase).

Many times this “gut instinct” was influenced by whether children were personally drawn to a toy or not. For example, many children gave the reason “it’s awesome” or “it’s cool” to explain why they chose to say their gender or both genders would like to use it. In many cases they were never able to articulate what was cool or awesome. This intangible ability for children to decide whether they personally like a new toy and whether they think others from their own gender or the opposite gender would enjoy the toy is something that should be explored in future research.

Summary of Qualitative Findings

Taken together the qualitative results from the Gender and Technology indicate that there are in fact persistent gender stereotypes when it comes to technology and engineering. While many children find that boys and girls both like computers and iPads, the types of games designated as “girl games” and “boy games” show a clear leaning towards boys being more engaged with STEM oriented play. Finally, these findings reflect the many factors that go into children’s decision-making process when determining the gender appropriateness of new technologies and toys. In addition to personal enjoyment and general observations, children were heavily influenced by the behaviors of their parents, caregivers, siblings, and friends. There was also an unexplained “gut instinct” that was alluded to in this research but not fully uncovered based on the sample of transcripts examined.

Chapter Seven: Case Studies

This chapter provides two short vignettes of one boy and one girl who participated in the KIWI robotics curriculum during the Fall of 2014. Each of these children illustrates a different way that the concept of gender did (or did not) influence their ideas about technology and engineering and their personal interest in these fields. Additionally, they show varying examples of how participation in the KIWI robotics curriculum impacted their personal views. These case studies are based on Gender and Technology Attitudes Protocol interviews at three time-points in the year, the Engineering is Elementary assessments (pre and post curriculum), Solve-Its, Final Project documentation, and video footage from the curriculum implementation. Please note that all names and some identifying information have been changed to preserve the anonymity of participants.

Vignette 1: Masculine View of Robotics Kits, Some Change Post-Curriculum

Kyle, Male, Second Grade. At the time of this research Kyle was in second grade. From the outset, he was confident in his knowledge of what engineers do and inquisitive about the three different types of robots he was shown during the pre-interview, taking note of batteries, weight, and even hypothesizing about what the different parts of the KIWI robot were for (e.g. "Wow. Are those solar panels?"). In fact, Kyle was so curious about the functions of the different parts, it was at times difficult for the interviewer to get him to articulate *why* he was so drawn to these tools.

Despite this challenge, over the course of the interview Kyle presented some of his masculine attitudes about robotics and toys in general. During the Gender and Technology Attitudes Protocol, Kyle explained that boys would like all three of the robots more than girls. When prompted to explain his thinking, Kyle simply stated that, "usually boys play with this." When prompted further to explain why girls would not want to play with them, he stated "because they usually like Barbies." Kyle was further encouraged to think about whether girls would like the robots if they were another color, such as pink, and he replied that if they were pink "nobody would wanna do it" indicating that girls would still not like them.

During the robotics curriculum, Kyle readily explored advanced concepts and was always quick to volunteer his work during the Share Time at the end of robotics class. For his final project, he worked with a female student to create a robot that helps with students' writing by carrying writing supplies such as pens and crayons and also because it was programmed to move in the shape of the letter "L" (See Figure 13). Kyle and his partner's final project was unique from a programming standpoint, as they were one of only two groups in this study that used the most complex Conditional Statement blocks ("If Statements") in their program. When it came time to present, it was Kyle, rather than his partner, who took the lead and explained the robot and demonstrated the program running.

Figure.13 Writing Robot

Kyle demonstrated a high level of mastery of the programming concepts he was taught and he often took on a leadership role when navigating decisions with his female partner. He obtained a perfect score on all eight of the Solve-It tasks he was administered. Upon completion of the curriculum, he sat down with an interviewer to complete the Gender and Technology Attitudes Protocol again. After completing the curriculum, Kyle's masculine attitudes about robotics changed only with regard to KIWI. He still felt that boys would like the LEGO® WeDO™ and LEGO® Rcx robot more than girls. When asked to explain why he now thought that girls and boys would both like using KIWI, he drew on his own observations during robotics class explaining that, "at robotics time I always see both girls and boys playing with them."

At the end of the school year, approximately four months after the robotics curriculum had been completed, Kyle was interviewed one last time and shown some of the same robots along with other types of technologies, such as the newer KIBO robot. Kyle still believed that boys would like both Lego robots more but felt that both boys and girls would both like KIWI and KIBO equally. When shown other electronic materials, such as the Snap Circuits Jr. kit and an Arduino kit, Kyle explained that boys would like these materials more because "a lot of boys like electric things."

Even after learning about robotics and engineering (taught by female robotics instructors) Kyle's initially masculine views about the robots he was shown were only shifted when it came to KIWI. His mind was changed about KIWI based on his own observations during robotics class, indicating the power that curriculum interventions can have on children's opinions about technology. However, Kyle's example also highlights a critical limitation of this work. His change in view was technology specific to KIWI (and later KIBO) and did not transfer to robotics, or electronics kits, in general.

Vignette 2: Consistently Gender-Neutral View of Robotics Kits, Masculine View of Professional Robotics

Carla, Female, Second Grade. At the time of this research, Carla was in second grade. Prior to beginning the KIWI robotics curriculum, Carla demonstrated gender-neutral views of the different children's robotics kits she was shown. During the Gender and Technology Attitudes Protocol pretest, she explained that she felt boys and girls would equally like all three robots (KIWI, LEGO® WeDO™, and Rcx), despite not knowing exactly what they were. She also felt this way about other technologies, such as the computer and iPad, explaining that, "well, everyone likes computers."

Before participating in the KIWI curriculum, Carla was a bit unsure about what exactly engineers do. According to her Engineering is Elementary pretest, Carla strongly disagreed with the statement "I know what engineers do for their jobs" and was also unsure about whether engineers make people's lives better or not. However, she strongly agreed that she liked knowing how things work and that she was good at putting things together. However, she did not want a job that allows her to figure out how things work when she grew up.

For her final project in the KIWI curriculum, Carla was partnered with a male student from her class. Together they created a robot that helps with carrying things for students, such as pencils, crayons, and other school supplies (See Figure 14). Their program was somewhat advanced, including a Repeat Loop with Number Parameters as well as a Wait for Clap block. When it came time to present the final robot, Carla opted to let her partner speak and present the program and the robot on behalf of both of them.

Figure 14. Helpful Carrying Robot

Despite not taking ownership over her and her partner's robot and program during the presentation, Carla demonstrated a fairly high level of programming mastery of on the Solve-Its assessment. She received a perfect score on half of the Solve-It tasks (all of the sequencing tasks, the easy repeats with sensors task, and the wait-for clap task). She received a score of 4 (out of 6) on all of the other Solve-It tasks. On her Engineering is Elementary posttest, she indicated an increased knowledge of what engineers do for their job (strongly agreeing at the post-test, while she strongly *disagreed* that she knew what engineers do for their jobs during the pre-test). Carla also indicated an increased desire to have a job that allows her to figure out how things work and an increased desire to figure out new and better ways of doing things after participation in the KIWI robotics curriculum. After the curriculum, she also held to her gender-neutral view of the different robotics kits, saying that boys and girls would equally like all three robots during the Gender and Technology Attitudes post-test interview.

When following up with Carla at the end of the school year, approximately four months after she completed the KIWI robotics curriculum, she shared with the interviewer that she still felt boys and girls would equally like all of the robots, including the new KIBO robot that she had not seen before. When asked to explain this, she drew on her own memory of robotics class saying that, “because when you came to our class, everybody enjoyed all of these things.” Like Kyle, Carla’s interview demonstrates how she observed interactions during class to come to her conclusions about who would enjoy robotics. Unlike Kyle, her views began as gender-neutral and were re-assured during class, rather than changed based on the curriculum intervention.

During the end of the year interview, Carla also shared her thoughts on who would enjoy a job building things like robots when they grow up. Despite consistently feeling that boys and girls her own age would equally enjoy using robots, Carla readily tells the interviewer that she thinks that boys would like a job making robots more than girls:

> Interviewer: “Who do you think would like having a job making robots more?”
>
> Carla: “Um, boys”
>
> Interviewer: “Boys. Why do you think they would like a job making robots more?”
>
> Carla: “Because, um, in my class they like making stuff.”

Carla also went on to guess that the KIWI robots used by her class were created by a man, not a woman. This guess was made based on the color of the robot and she explained this by saying, “because a boys favorite color [is] blue.” She also guessed that the LEGO® Rcx robot w as built by a man based on how it looked saying that, “because this kinda looks like a monster truck and boys like monster trucks.” She was unable to decide who was most likely to have made the LEGO® WeDO™ robot. Interestingly, she did think that the new KIBO robot was made by a woman because, "it's creative and girls are creative."

Carla's comments on who might be more likely to enjoy a job building robots demonstrate an interesting limitation of this work. Although she consistently felt that both boys and girls would equally enjoy playing with all of the robots, her immediate response was that a boy would enjoy a job making robots more. Her gender-neutral view of robotics was limited to the context of children's use of robotics for play and learning and did not necessarily transfer to the professional world. When encouraged to think further about who she thought built each of the robots, she presumed that at least two of them were made by a man based on aesthetic design cues in the robots (colors, shapes, parts). The only robot she guessed was made by a woman was the new KIBO robot. This may suggest that the aesthetic design of KIBO is more "feminine" than the other commercially available robots and may be due to the fact that the KIBO robot was no longer blue like the early prototype. Further research should look at the design of children's engineering tools and whether they connote a feminine, masculine, or neutral feel to children during pilot testing.

Chapter Eight: Discussion

Summary of Findings

The results from this study provide preliminary evidence that beginning in early childhood children have attitudes about technologies that are colored by their ideas of sex and gender. When performing the gender-sorting task as part of the Gender and Technology Attitudes Protocol pretest, only approximately half of children reported that both boys and girls would equally like each of the three robots they were shown. KIWI had the highest percentage (56.8%) of students viewing it as equally enjoyable to both boys and girls. Both LEGO robots had more than a third of students reply that boys would like using it more than girls (35.6% with the RcX and 40% with the WeDO™ robot). The iPad and computer were viewed as the most gender-neutral technologies, with 61.4% and 70.5% respectively of children saying boys and girls would enjoy them equally. Results from the Engineering is Elementary pretest also showed that boys had a significantly higher agreement that they would enjoy being an engineer as compared to girls. This is aligned with Engineering is Elementary research by Cunningham & Lachapelle (2010) with slightly older children in third through fifth grade. Cunningham & Lachapelle (2010) also found that boys were significantly more likely to agree that they would enjoy being an engineer than girls.

Results also show that KIWI robotics curricula, even taught just once a week for seven weeks, can have a powerful impact on young children’s interests, attitudes, and feelings about engineering. Girls displayed a statistically significant increase in thinking they would enjoy being an engineer after completing the KIWI curriculum. After the curriculum, boys and girls no longer significantly differed in their level of agreement that they would enjoy being engineers. Girls in the Control Group (who did not have access to the KIWI curricula) did not display this significant increase, indicating this newly formed interest in an engineering career was in direct response to the robotics intervention. This was a relatively mild intervention, considering that it was only taught once a week for less than two months. Additional factors such as field trips and school holidays at times disrupted to consistent flow of the seven-week intervention. Still, these results indicate the promising impact of female robotics instructors and developmentally appropriate curricular on girls' interest in engineering.

Interestingly, boys in the Control Group also had a significant increase in their desire to be an engineer from pretest to posttest, despite the fact that they had not been exposed to the KIWI curriculum. These students still had their regular technology and computer classes, some access to LEGO™ centers, and potentially other types of engineering-themed material. Any of these activities may have been enough to spark boys' interest in being an engineer. However, it is important to reiterate that these regular school day classes did *not* increase girls in the Control Group's desire to be an engineer, only the KIWI curriculum did. This may indicate that the "normal" engineering and technology curriculum implemented at the school was more tailored to male students than to female students.

On the flipside, the KIWI curriculum may have been overly tailored to the interest of girls. Boys in the Curriculum Group did significantly increase in their understanding of what engineers do for their jobs but they did not significantly increase in their desire to be an engineer like the girls in this group did. This may be because they already started with a fairly high interest in being an engineer but it may also be because the KIWI curriculum did not tailor itself enough to the interest of boys. This may have also been attributed to the all-female teaching team leading the robotics classes serving as a positive role model for the girls in the class. Finally, it may have been attributed to the collaborative theme of the "Helping at Healey" robotics unit, which may have appealed more the female students than male students.

One unexpected finding was the significant *decrease* for girls in both the Curriculum and Control group on the Figuring Things Out construct. Figuring Things Out was a combined construct made up of the following individual scales: I would like a job that lets me figure out how things work, I like thinking of new and better ways of doing things, I like knowing how things work, and I am good at putting things together. Because this decrease was present in both groups, but did not occur in boys, there was likely some aspect of the regular school day during the time of this study that impacted girls' interest in figuring things out. It is unclear which activities may have contributed to this decrease, as children anecdotally mentioned a variety of building, problem solving, and technology activities that occur throughout the week. Several children shared that they have LEGO® centers in their classrooms and participate in LEGO® activities that prompt them to practice putting things together. It is possible that these activities may have impacted girls' confidence in their skills at figuring things out as they build and construct. In the open-ended portions of the Gender and Technology Protocol interviews, several children in both the Curriculum and Control groups made gender related comments regarding LEGO®. For example, one boy commented that, "Girls don't like building things that are harder like LEGOs." Future replications of this study may need to include observations throughout the school day, not just during robotics classes, to see learn about other possible activities that may impact engineering mindsets.

Gender and Technology Preference

The traditional toys (Barbie, football, and toy car) shown to children in this study elicited a predominantly gender-normative mode of categorization both before and after curriculum implementation. This is not surprising given that developmental research has found that children consistently prefer toys stereotyped for their own sex more than toys *not* stereotyped for their sex (Campenni, 1999; Miller, 1987). This preference is not a new finding as it emerged in early research on children's play (Eisenber, Murray, & Hite, 1982; Fein, Johnson, Kosson, Stork, & Wasserman, 1975; Goldman, Smith, & Keller, 1982). In the context of this study, children drew on their own personal observations at home and school to decide who would like the toys best. For example, if a child had never seen a boy playing with a Barbie, they would draw on this to conclude that girls like Barbies more than boys or that Barbies are "for girls."

When it comes to emergent new technologies, like robotics kits, that young children may not be familiar enough with, it was unclear how children would view these objects. Results from the Gender & Technology Attitudes protocol show that when presented with tools children are unfamiliar with, they still draw on a pool of past experiences, observations, and ideas to make sense of the object and decide which gender it is most appropriate for. For example, children looked for cues based on color or by likening the novel technology to something they were familiar with in order to make their decisions.

After being exposed to the KIWI curriculum, the overwhelming majority of students (86.7%) felt KIWI would be equally enjoyed by both girls and boys when just 56.8% felt it was equally appealing to both genders before having the curriculum. However, this change was technology specific to KIWI and did not translate to the other robots. At the posttest, the LEGO ® Rcx and LEGO® WeDo™ robots both still had more than a third of students think boys would like them more than girls. This demonstrates both a limit and strength of the intervention. On the one hand, it demonstrates the power curriculum intervention can have on changing children's mind about girls' interest and enjoyment of robotics. However, it is limiting in the sense that this change was only visible with regard to KIWI and not to other types of robots. This brings to light something important to consider when designing engineering curricula for young children. It may be more effective to teach children foundational concepts through a variety of tools and to explicitly demonstrate a variety of different types of robots, rather than focusing on just one interface.

Learning Outcomes

Both boys and girls displayed mastery of foundational robotics and programming concepts after completing the curriculum. In all three grades, every group was able to finish building, decorating, and programming their final "Helping at Healey" robots with syntactically functional programs. The major trend in the final projects was that the older grades generally created more complex projects than the younger grades. For example, the second grade class had more groups create robots with sensors and programs that used repeats. This trend in the group projects was further emphasized in children's Solve-Its performance where there was a significant effect of grade level on Solve-Its performance on three different Solve-It tasks, with first and second grade performing significantly better than the kindergarten group. This trend of older children displaying a higher level of mastery of complex programming concepts is aligned with prior research on KIWI and the Solve-Its programming tasks (Sullivan & Bers, 2015).

It is interesting to note that there were no gender effects present in the Solve-Its tasks. This contradicts prior research by Sullivan & Bers (2013) on the Lego Rcx robot and a similar block programming language that found that in Kindergarten boys significantly outperformed girls on two tasks. This may be because one of the tasks involved in the 2013 study involved a building task, which was not a part of these Solve-Its. The lack of gender differences also contradicts prior research by Sullivan & Bers (under review) which found boys outperformed girls on advanced programming Solve-Its with the KIWI robotics kit. This could be attributed to a variety of factors related to the robotics tools, the Helping at Healey curriculum, and teaching implementation. For example, the Curriculum Group was taught by an all-female teaching team and this may have impacted girls' achievement on the Solve-Its. The AAUW (2010) has recommended exposing girls to female mentors in STEM in order to cultivate girls' achievement and interest in engineering. Additionally, the KIWI curriculum implemented focused on helping behaviors, which may have been especially interesting to girls. Research by Cuningham & Lachapelle (2010) show that girls are significantly more interested than boys in jobs that help society. Because of these factors, girls may have been more interested in learning the different KIWI concepts and therefore more capable of performing well on the Solve-Its.

When looking at differences between the male-taught and female-taught KIWI robotics classes, results show that the male-taught intervention resulted in fewer grade based significant differences. This may be because the male-taught curriculum was implemented in the spring semester, after the kindergarteners were more accustomed to being in school and more familiar with completing individual tasks like the Solve-Its. This comfort may have resulted in the kindergarteners performing better on the assessment. Results also showed that the male-taught intervention had a significant main effect for gender on the Repeats with Numbers task, with boys scoring significantly higher than girls. Meanwhile, the female-taught intervention did not result in any significant gender- based differences. This provides some evidence that when taught by female robotics teachers girls perform better on certain tasks than when they have a male instructor. There are mixed results from researchers who have studied the impact of same-gendered role models and students' interest and performance in STEM fields (Drury, Siy, and Cheryan, 2011). While many initiatives focus on providing girls with role models (e.g. MIT's Women's Initiative) some researchers have found that role-model gender is less important than combating current stereotypes of people in STEM fields (Cheryan, Meltzoff, & Kim, 2011). However, most of this research is done with adults or older teenagers. Future research should look more deeply into the ways that same and different gendered teachers impacts young children's performance on robotics and programming assessments and projects.

Children's Reflection on Success of Curriculum

It is important to highlight that without direct prompting from the interviewers, many children who experienced the KIWI curriculum commented on it during their post and end of year interviews. This is further illustrated by the qualitative coding results that show children draw on their personal experiences and observations when making decisions about the gender appropriateness of tools and toys. While many research studies with young children rely solely on adult assessment of children, this study shares the voices of the child participants. Quotes from children's transcripts explaining that the curriculum intervention taught them something about all genders being able to enjoy and use KIWI robotics speaks to the success of the intervention from the perspective of the child who experienced it, regardless of what the other assessments demonstrated.

Theoretical Implications

Results from this study support cognitive theories of gender that assume children are actively trying to make sense of their environment by using gender cues to interpret the information they are taking in (Martin & Ruble, 2004). Through the Gender & Technology Attitudes protocol, we saw young children making sense of the novel tools they were shown and interpreting them based on perceived gender cues (e.g. colors, behaviors they have seen in class or at home). Beginning in kindergarten, children in this study were already developing ideas about which gender likes making things, building, and the types of products men and women might design and create. These pivotal early childhood years should be considered when developing STEM interventions and initiatives hoping to influence girls' interest in these fields.

This study was situated under the Interactional Feminist theoretical assumption that masculine biases exist in everyday situations and interactions (West & Fenstermaker, 1995; Lloyd, 2007). Findings from this research provide initial support that masculine biases with regard to technology and engineering continue to persist in the way technologies are designed, the way children are taught with new technologies, and the way technologies are marketed. In both the Curriculum and the Control group, girls experienced *something* to significantly lower their interest in figuring things out while boys did not experience this decrease. This finding is alarming and may be a product of masculine biases in the way math, problem solving, and technology classes were implemented in the school. Furthermore, when taught by an all-male teaching team, we saw that boys performed significantly better than girls on one of the advanced programming tasks. Future work should explore the influence that a masculine engineering teacher has not only on girls' interest in engineering but also their performance on tasks.

Design and Marketing Implications

This study explored the use of a newly developed robotics kit for young children called KIWI. The findings from this study had several design implications when it came to producing the commercially available KIBO robot that was based on the KIWI prototype. While the KIWI prototype was originally produced using a combination of blue plastic and tan wood, many young children in this study used the blue as a cue that boys would enjoy using the robot more than girls. Based on this feedback, the DevTech Research Group went on to test several different colors for KIWI to gain user feedback from children and teachers. When it was produced for the commercial market, the gender-neutral color of orange was chosen over the blue used in this study.

In addition to color, children used other design cues to decide whether boys or girls would like each robot. For example, because many mobile robots (such as the KIWI robot and the LEGO Rcx robot shown to children) often use wheels to move, many children thought this made it look like a car, which was seen as masculine. For example, one girl commented that “boys like cars” at the pretest as the reason boys would like KIWI more than girls. This presents important design and marketing implications when it comes to producing and selling technologies, like KIWI and KIBO, for young children.

Some companies, like KinderLab Robotics (the producer of KIBO), are taking this feedback and opting for a gender-neutral approach to designing and marketing their products. On their website, visitors can see that in addition to “car style” robots there are robots that are created to resemble kinetic sculptures that spin and dance as a complement to the masculine car robot (www.kinderlabrobotics.com). This website also features images and videos of both boys and girls playing with KIBO.

Other companies are taking the opposite approach. Debbie Sterling, the founder of GoldieBlox, has stated her goal is “disrupting the pink aisle” by creating pink and purple toys marketed specifically towards girls, that engage girls’ in STEM thinking (Blosser, 2015). Other companies, like LEGO® create and market building toys “for boys” like LEGO® City along with building toys “for girls” like LEGO® Friends. Future work will need to examine the benefits and drawbacks of these two different approaches to design and marketing.

Chapter Nine: Limitations and Future Work

Limitations

Sample and Implementation.

This study was limited by the typical constraints facing research done in an in "imperfect" real world setting. By collecting data in a busy public school, it was impossible to control for absences, unexpected schedule changes, children transferring in and out of classes, and other issues that may have impacted the number of children who were able to complete each assessment. This resulted in a smaller than ideal sample size for the majority of the assessments implemented and an uneven proportion of children in each class. In some cases, this impacted the data analysis. For example, normal distributions were not found for all of the Solve-It tasks, most likely due to the small samples in each group. This may have played a role in the discovery main effects with ANOVA and thus, these results should be interpreted cautiously. In order to address this, future work should replicate this portion of the study with a larger sample of children. These same challenges also impacted the curriculum implementation phase of this project. For example, children were occasionally pulled for special classes or for disciplinary reasons during robotics time. Missing out on certain activities and concepts being taught could have potentially impacted their performance on the Solve-Its assessments or the level of complexity in their final projects.

One of the biggest limitations with regard to sample constraints came when recruiting the Control Group. While the study began with three classroom teachers (one kindergarten, one first grade, and one second grade) agreeing to participate, the kindergarten teacher took a new position during the fall of 2015. By the time a new kindergarten teacher was recruited to fill this spot, the study has already begun. Pretesting could not occur until much after all of the other classes had been pretested. Therefore, no kindergarten students are included as part of the control group analysis in this study. This lack of kindergarten students may have impacted the findings. However, despite all of these school-related challenges, this study was able to gain insight into children’s natural school experience. This is arguably more generalizable than research collected in a lab setting where all of these issues may have been controlled for.

Technical Limitations.

During the time that this study was conducted, the commercial version of the KIBO robot was not available to be used in schools. Instead, the research prototype of KIBO, called KIWI, was used in its place. These robots were hand-built by students at Tufts University and therefore were succeptible to more bugs and technical issues than a commercially produced robot. The KIWI robots used presented some technical difficulties for children that may have influenced their attitudes toward robotics and their learning of different concepts. For example, several children and teachers informally told the researchers that the barcode-scanning feature of KIWI was difficult to use. This may have impacted children’s experience with robotics and their desire to be an engineer when they grow up. Despite these technical limitations, children who used KIWI in the Curriculum Group still generally reported enjoying using the robot and found it to be very appealing to both boys and girls after using it in their classrooms.

Future Work

Next Steps.

A large pool of data was collected as part of this dissertation research, much of which was beyond the scope of this project to present in great detail. For example, coding of Gender and Technology Attitudes led to many interesting themes that emerged with regard to gender stereotypes and technology that were presented. Any one of these themes could be examined in the transcripts in more detail to paint a clearer picture and definition. For example, further exploration of the “Girl versus Boy Games” could be explored more deeply both within the current transcripts and as a follow-up study. Finally, only two case studies were presented in this dissertation as illustrative vignettes of the impact of the KIWI robotics curriculum. However, many of the children would make facinating case studies but they were not chosen to be included because they did not clearly demonstrate the themes being presented.

Replications and Extensions.

Future work should focus on replicating this study with a larger sample and using the newesed version of the KIBO robot to avoid technical and sample-based limitations this study faced. Additionally, subsequent studies should look at the longitudinal impact of one-time robotics interventions as well as ongoing robotics interventions. It is possible that the changes that occurred in attitudes from pre to post curriculum intervention will dissipate over time if children are not exposed to more robotics and programming projects in subsequent years. Additionally, the classes in this study were taught by a trained researcher from the DevTech Research Group. It is unclear what the impact would be when taught by regular classroom teachers that are less of a novelty for students. The DevTech Research Group is currently in the planning phases of future research work using the KIBO robot. One study that is currently underway involves observing and collecting data from KIBO interventions taught by regular classroom teachers.

The results of this study showed that changes in attitudes were fairly technology-specific to KIWI and not generalizable to other robotics kits. The curriculum unit implemented in this study focused solely on exploring the enigneering design process through robotics and programming. It did not deeply explore real-world engineers and what their everyday jobs are like. Additionally, due to time constraints in the school day, there was limited time to show pictures, books, and other media about robotics in the “real-world” in settings such as hospitals, factories, and homes. Future work should develop and implement robotics curricula that also teach about engineering and robotics beyond the classroom and see how this impacts children’s attitudes and their interest in pursuing these types of jobs.

Exploring a Wider Range of Gender.

Children in this study were given the opportunity to tell researchers whether they self-identified as boys, girls, both, other, or to tell us that they weren’t sure how to answer or did not want to answer. In all cases, children only identified themselves as either “male” or “female.” Therefore, due to a limiation in sample, this study only looks at gender as a binary characteristic (male and female), rather than examining gender as a range between masculinity and feminity and it does not include any transgender participants. Future research should work to explore the experiences and attitudes of children who do not define themselves simply as “male” or “female.”

Exploring the "Pink Tech" Movement.

Toys marketed to girls have come a long way since Mattel's "Talking Teen Barbie" uttered the phrase "math class is tough!" back in 1992 (*New York Times*, 1992). In the past few years a range of new engineering education technologies specifically marketed towards girls, complete with pink and purple packaging, have emerged to combat STEM stereotypes (Docterman, 2014). Toys like Roominate that encourage building with motors and wires and Goldie Blox that encourage engineering and problem-solving have begun to "disrupt the pink aisle" in toy stores nationwide (Blosser, 2015). These tools are new and very few research studies have examined their efficacy in terms of increasing girls' knowledge and interest in technology and engineering. Future work should examine how curricula using these types of tools impact girls' interest and attitudes toward technology and engineering and whether they are more or less effective engaging young girls' interest in technology and engineering than gender-neutral tools, such as KIBO, marketed equally towards both boys and girls.

Chapter Ten: Conclusion

Women currently earn better grades than men at all levels of education and outpace men in terms of undergraduate and graduate degrees they earn at colleges and universities (Blosser, 2015). Still, most STEM fields display a gender disparity with men making up the majority (DiPrete & Bauchman, 2013). The underrepresentation of women in STEM fields has been a growing concern to researchers and policymakers over the past 50 years (Hughes, Nzekwe, & Molyneaux, 2013). Research has shown that building and tinkering during one's childhood serves as beneficial in an engineering career later in life and that women often have little experience with childhood tinkering as compared to their male counterparts (McIlwee & Robinson, 1992). This demonstrates the importance of the foundational early childhood years and the exposure educators and caregivers provide both boys and girls with to toys that let them build, create, problem-solve, and tinker.

The present research study barely breaks the surface of uncovering attitudes and ideas that children are developing about technology and engineering during their early elementary years and how these ideas are co-constructed with their expanding ideas about gender. Ultimately, this line of work is not undergone to increase the number of computer scientists and engineers in the world, although this may be a byproduct. It is undergone to address a serious inequity in girls' access and ability to pursue technology and engineering fields at the same rate and level of ease that boys are afforded. It is critical that researchers, sociologists, psychologists, and engineers continue to ask these difficult questions and ensure we move toward breaking the masculine STEM stereotype.

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List of Appendices

This Appendix includes all of the original IRB stamped measures described in the Methods section of this dissertation.

Appendix I. Adapted Engineering is Elementary Assessment

Engineering and Science Attitudes Assessment: Instructions for Implementation

Please read these instructions BEFORE administering the "Engineering is Elementary: Engineering and Science Attitudes Assessment"

Instructions for implementation in kindergarten, first grade or among any students who have difficulty reading or understanding the assessment:

Overview:

The Engineering and Science Attitudes Assessment is used to gain insight into students' opinions about science and engineering. For kindergarteners, first graders or any student who has difficulty reading or understanding the assessment as it is presented in written form; the implementer should proceed in an oral interview format. For these younger students, the individual giving the assessment should read the following instructions aloud to the student, ensuring that they understand the directions:

Directions:

"I am interested in finding out some of your opinions on science and engineering. To get a better idea of your opinions, I am going to ask you to show me how much you agree or disagree with some statements about those topics. So, I am going to read a sentence out aloud, and then I'd like you to show me how much you agree or disagree with the statement by pointing to one of the five faces I have here"

"If you point to the first face (the one that looks very sad) that means you *strongly disagree* with what I just said. You don't agree AT ALL. If you point to the next one (the one that looks pretty sad) that means you're telling me that you *kind of disagree* with what I've just said. If you choose the middle face, that means you're *not sure*. The fourth face, which looks pretty happy, means that you *kind of agree* with what

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I've said, and if you point to the last one, which looks the most happy, you're telling me that you *really, really, agree* with what I've said."

"Let's practice! So if I said, 'I love dogs' how much would you agree? Which face would you point to?"

"Let's try a couple of more practice ones. What if I said, I LOVE eating green beans. Is that true for you or not? Which face will you point to?"

Continue practicing until the child feels comfortable.

"Okay let's begin. Remember, you can always skip or say you're not sure for any of the questions"

Instructions for implementation among second graders or students who are capable of reading and understanding the assessment in print:

- If the student is able to read and understand the assessment as it is printed, he or she should simply be instructed to respond to each statement honestly and to refer to the facial expression scale at the top of the sheet (along with the accompanying words, such as, "strongly disagree") to make it easier to decide how they feel about each statement.

- Be sure to have the child answer some practice questions on the scale and that they are comfortable with the process before beginning the assessment.

- Remind the child that they can always skip a question or choose "not sure" on the scale.

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

	Strongly Disagree	Disagree Somewhat	Not Sure	Agree Somewhat	Strongly Agree
1. I would enjoy being a scientist when I grow up.					
2. I would enjoy being an engineer when I grow up.					
3. I would like a job where I could invent things.					
4. I would like to help plan bridges, skyscrapers, and tunnels.					
5. I would like a job that lets me design cars.					
6. I would like to build and test machines that could help people walk.					
7. I would enjoy a job helping to make new medicines.					
8. I would enjoy a job helping to protect the environment.					
9. Science has nothing to do with real life.					
10. Math has nothing to do with real life.					
11. I would like a job that lets me figure out how things work.					
12. I like thinking of new and better ways of doing things.					
13. I like knowing how things work.					
14. I am good at putting things together.					
15. Scientists cause problems in the world.					
16. Engineers cause problems in the world.					
17. Scientists help make people's lives better.					
18. Engineers help make people's lives better.					
19. I think I know what scientists do for their jobs.					
20. I think I know what engineers do for their jobs.					
	Strongly Disagree	Disagree Somewhat	Not Sure	Agree Somewhat	Strongly Agree

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Appendix II. Solve-Its Assessment Scripts

Assessment

School: ______________________ Researcher: ______________________

Child's Name: ______________________ Date: ________ Class: __________

Comprehension Assessment

Solve-Its – Can the child write a program with a specific goal in mind?

Children are asked to play a game with the researcher, in which the researcher tells a story about a robot performing an action, and then give the children paper icons of programming blocks. Using the given blocks, on a separate sheet of paper children will arrange icons into a program that will cause a robot to act the way described in the story. The Solve-It tasks will range from easier to more difficult, and challenge children to use a variety of programming concepts developed through the class curriculum. Use some of the following scripts as a starting point, but can be adapted to target a range of programming skills.

Assessment Scripts

Solve-It #1: Car Horn

In an animated voice: "This game is about a robot that is a car. Have you ever heard a car honk its horn? Can you make the 'BEEP BEEP' sound? [*Wait a moment*] I want my car robot to turn on – start the engine, vroom! Next, I want to honk the horn – Beep Beep! – to warn people that I'm about to move. Then I want my car to drive straight ahead, and then stop! And turn off." *Repeat explanation once more.* "Can you imagine the program my car needs? Are you ready to try to make the program for my robot?"

Solve-It #2: Birthday Party

In an animated voice: "In this game, my robot is attending a birthday party! First I want my robot to turn on. Next, I want it to move straight ahead into the birthday party room – but the robot has to be very quiet! It's a surprise birthday party! After the robot moves straight ahead into the room, I want it to sing the Happy Birthday song! Last, I want the robot to turn off." *Repeat explanation once more*. "Can you imagine the program my robot needs? Are you ready to try to make the program for my robot?"

Solve-It #3: Baking a Cake

In an animated voice: "This is a game about ! First I want my robot to turn on. Next, I want it to move straight ahead into the birthday party room – but the robot has to be very quiet! It's a surprise birthday party! After the robot moves straight ahead into the room, I want it to sing the Happy Birthday song! Last, I want the robot to turn off." *Repeat explanation once more*. "Can you imagine the program my robot needs? Are you ready to try to make the program for my robot?"

Solve-It #4: Puddle

In an animated voice: "This story is called Puddle. Do you know what a puddle is? Sometimes a puddle is made of water, or mud. Do robots like water? [*Wait a moment*] No, usually water can break a robot, which is not good at all! I want to make a program that lets my robot dry itself off after it accidentally moves into a puddle. First, my robot will turn on, and then it will move straight ahead – but OOPS! My robot is in a puddle! It's going to make a noise – Beep! – as if it is saying 'Oh no!' Then I want it to move backwards, out of the water. Then, I want the robot to shake itself dry – shake shake shake! – and finally, turn off!" *Repeat explanation once more*. "Can you imagine the program my robot needs? Are you ready to try to make the program for my robot?"

Solve-It #5: Wheels on the Bus

In an animated voice: "Do you know the song, the Wheels on the Bus? [*Wait a moment*] I know when we sing that song, the wheels spin around on the bus so many times! Let's sing the song, and count how

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Assessment

many times the wheels spin!" *[With child(ren), sing one verse of song, while holding up one finger to count each time "round and round" is sung]* The wheels on the bus spin round and round four times! I want to make a robot that is a bus, and I want my wheels to spin around four times, just like in the song. How would I do that? First, I want the robot bus to turn on. Next, I want the robot to spin its wheels, and to keep doing it four times. Then, I want the bus to stop spinning its wheels, and last, to turn off." *Repeat explanation once more*. "Can you imagine the program my robot needs? Are you ready to try to make the program for my robot?"

Solve-It #6: Goodnight

In an animated voice: "In this game, my robot is going to sleep. I want my robot to say goodnight to everyone in the house. I have a brother, and a sister, and a mommy. First, I want my robot to turn on. Next, I want the robot to make a noise – Beep! – when it is telling us 'Goodnight!' I want the robot to say goodnight to three people, so it has to keep beeping three times. Then, I want the robot to stop beeping, and last, to turn off." *Repeat explanation once more*. "Can you imagine the program my robot needs? Are you ready to try to make the program for my robot?"

Solve-It #7: Washing Machine

In an animated voice: "In this game, my robot is actually a washing machine! Have you ever seen a washing machine shake the clothes to make them clean? Shake shake shake! First, I want my washing machine to turn on. Then I want it to shake and wash the clothes, and keep doing it for four minutes. Then, I want the robot to stop shaking when the clothes are clean, and to make a noise – Beep! – to let me know that it is done! Last, I want the washing machine robot to turn off." *Repeat explanation once more*. "Can you imagine the program my robot needs? Are you ready to try to make the program for my robot?"

Solve-It #8: Microwave

In an animated voice: "In this game, my robot is actually a microwave! Have you ever seen a microwave spin food around to heat it up? First, I want my microwave to turn on. Then I want it to spin and heat up my food, and keep doing it for four seconds. After four seconds, I want the robot to stop spinning, and to make a noise – Beep! – to let me know that my food is ready! Last, I want the microwave robot to turn off." *Repeat explanation once more*. "Can you imagine the program my robot needs? Are you ready to try to make the program for my robot?"

Solve-It #9: Extra Blocks Forward

In an animated voice: "This game is a little bit tricky. I have a robot, and I just want it to move forward four times. It needs to turn on first, and then keep going straight ahead four times. After that, the robot needs to stop moving straight ahead, and then turn off. BUT! There are extra blocks that I am about to give you. You do not need to use all of these pieces of paper, and some of them will not help you make a program to move my robot forward four times." *Repeat explanation once more*. "Can you imagine the program my robot needs? Are you ready to try to make the program for my robot?"

Solve-It #10: Extra Blocks Beep

In an animated voice: "This game is a little bit tricky. I have a robot, and I just want it to make a noise four times. It needs to turn on first, and then beep four times. After that, the robot needs to stop beeping, and then turn off. BUT! There are extra blocks that I am about to give you. You do not need to use all of these pieces of paper, and some of them will not help you make a program to move my robot forward four times." *Repeat explanation once more*. "Can you imagine the program my robot needs? Are you ready to try to make the program for my robot?"

Appendix III. Gender & Technology Attitudes Assessment

Technology Attitudes Assessment

Directions:

Sit down with the child and follow the script below as closely as possible. The purpose of this interview is to gather information about the child's attitudes, opinions, and gender associations with different forms of technology. You will be showing them a variety of different tech tools to determine whether they associate them with girls or boys. Record their answers on the attached sheet. Use the suggested follow-up questions to help gain more information about the child's rationale.

Script:

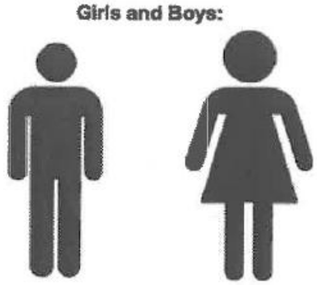
Interviewer: "I got all these toys mixed up and I need your help! I want to know which toys you think the girls in your class would choose to play with and which toys the boys in your class would choose to play with. I have these different signs…" [Show the signs to the child]. "You'll put the toys that the girls would play with the most under the girl sign, the toys the boys would play with the most under the boy sign, and the ones you think both boys and girls would play with equally under the sign for boys and girls"

Use large versions of the following symbols for the signs:

Girls:

Boys:

Girls and Boys:



Interviewer: "Do you think you can help me with this? Okay, I'll start showing you some toys."

Interviewer shows each group of toys and asks the child to decide where they think each toy belongs: under the girls sign (meaning girls would play with it the most), under the boys sign (meaning boys would play with it the most), or under the boys and girls sign (meaning boys and girls would play with this toy equally). Show toys in the following five groupings:

1) **Traditional toys:** Barbie, Toy Car, Small football, Jump Rope

2) **Building Materials:** LEGOS, Craft/Art Materials, Building Blocks, Play-Doh

3) **Robotic/Engineering Materials**: Wedo Robot Built, KIWI Robot Built, Rcx Robot

4) **Digital:** Ipad and Computer

5) **Image-Making**: Digital Camera, Sketchpad w/ crayons

Interviewer: "Place each toy underneath the sign that shows who you think would play with that toy the most: girls, boys, or both exactly the same. It's okay to have more than one toy under the same sign."

Interviewer uses follow-up prompts to get more information about why the child categorizes the toys the way they have chosen. Prompts such as the following can be used:

"What makes you say girls would like this toy more than boys?"

"Do you ever see boys using this toy?"

"Have you ever used this kind of toy?"

"If you could choose one of these toys to play with, which one would you choose?

Record responses on the following sheet

TECHNOLOGY ATTITUDES ASSESSMENT

CHILD'S NAME:____________________

SCHOOL:____________________

CLASS:____________________

DATE:____________________ PRE or POST:____________________

Place checkmark under "Boy" "Girl" or "Boy/Girl" depending on the child's choice for each toy. Use the final column for notes as necessary.

Item	Boy	Girl	Boy/Girl	Rationale/Notes
Barbie				
Car				
Football				
Jump-rope				
Legos				
Arts/Crafts				

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Building Blocks				
Play-Doh				
Wedo Robot				
KIWI Robot				
RcX Robot				
Ipad				
Computer				
Camera				
Sketchpad				

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Child's Top Three Toys

Interviewer should circle the child's choices

Barbie	WeDo Robot
Car	KIWI robot
Football	Rcx Robot
Jump- rope	Ipad
Legos	Computer
Arts/Crafts	Camera
Building Blocks	Sketchpad
Play-Doh	

Child's Favorite Robot

The interviewer should also ask the child to select his or her favorite of those 3. Circle that choice below:

WeDo Robot	KIWI Robot	RcX Robot

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