IMPACT OF ROBOTICS AND STEM INSTUCTION ON SELF-EFFICACY OF AFRICAN AMERICAN HIGH SCHOOL GIRLS

by

DEBORAH E. SPEAR

(Under the Direction of Roger Hill)

ABSTRACT

This quantitative research study examined the impact of robotics and STEM activities on the STEM self-efficacy of African American high school females from a low socio-economic status enrolled in Early Childhood Education Career and Technical Education classes in a large urban public school system in Jackson, Mississippi using a quasi-experimental 2^k full factorial design with a single repeater. Using the Social Cognitive Career Theory (Lent, Brown & Hackett, 1994), STEM self-efficacy was measured using the Self-efficacy in Technology and Science (SETS) instrument developed by Ketelhut (2010). Overall, girls' STEM self-efficacy improved significantly regardless of the treatment environment. Overall self-efficacy scores in science inquiry, synchronous chat and computer gaming also showed statistically significant increases. When considering the type of treatment, girls' self-efficacy improved greatest as a result of the GoldieBlox only environments compared to all other treatments settings including robotics. An ANCOVA analysis controlling for the type of treatment setting resulted in a statistically significant increase in the videogaming SETS construct.

INDEX WORDS: K-12 engineering education, STEM, robotics, self-efficacy

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DEDICATION

From the beginning, my most treasured guidance has been spiritual and constant. For this reason, I dedicate this work to the glory of the Lord, Jesus Christ, without whom I would not have been able to accomplish such a monumental task. As much as I have attempted to choose my path, entertaining several talents as though they were my sole purpose, engineering education has permeated my life at every juncture, so much so that I have been drawn toward a deeper investment into the broadening the field.

Moreover, this work is dedicated to my core support network beginning with my mother, Ms. Cherrie Spear, my father, Mr. Willie Spear, and the memory of my dear aunt, Ms. Elizabeth Spear who have always encouraged me to reach my highest potential.

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TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

Page

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

African American girls are among many special populations that represent a consistent achievement gap in the fields of science and engineering (National Research Council, 2012). Researchers has found that compared to boys, girls' interest and attitudes towards science and engineering steadily declines as they progress through K-12 education (NRC, 2012; Buck, Cook, Prince & Lucas, 2014; Bystydzienski, Eisenhart, & Bruning, 2015). Many of these same researchers suggest that significantly increasing opportunities for girls to engage in meaningful experiences are needed the K-12 environment especially for schools that serve low socioeconomic and minority students (NRC, 2012). In addition to the amount contact with STEM activities, researchers have found that a supportive non-judgmental inquiry-based environment can increase self-efficacy in African American girls (Buck, et al., 2014).

These researchers have found that compared to boys, girls' interest in science and engineering steadily declines as they progress through K-12. They suggest more opportunities to engage in meaningful experiences are needed the K-12 environment for schools that serve low socioeconomic and minority students. Specifically, the impact on girls' self-efficacy can be positively impacted with exposure to STEM activities (Boston & Cimpoan, 2018).

Compartmentally, many activities can successfully engage K-12 students in STEM. Robotics is one of these effective activities. Some researchers concluded that the best way to incorporate STEM is through robotics in the classroom because of its interdisciplinary nature lending itself more favorably to mathematics, science, and engineering with the use of technology (Cejika, Rogers, & Portsmore, 2006). The incorporation of robotics in K-12 STEM education has shown to increase student interest in STEM related fields (Robinson & Stewardson, 2012; Sahin, Ayer, & Adiguzel, 2014). Moreover, robotics competitions that emphasize the use of applied mathematics have resulted in higher student achievement in mathematics and science (Chung, Cartwright, & Cole, 2014). Robotics in the classroom has enhanced engineering thinking and applied science concepts in education that are critical components of STEM education (Rockland, Bloom, Carpinelli, Burr-Alexander, Hirsch, & Kimmel, 2012). Robotics activities have been included in teacher pre-service programs as a means to motivate STEM inclusion in elementary classrooms (Kim, Kim, Yual, Hill, Doshi & Thai, 2015). Hands-on elementary level STEM interventions have had a positive impact on attitudes and self-efficacy of teachers (Wendt, Isbell, Fidan, & Pittman, 2015; Wigfield, Tonks, & Klauda. 2009).

Some researchers concluded that the best way to incorporate STEM is through robotics in the classroom because of its interdisciplinary nature lending itself more favorably to mathematics, science, and engineering with the use of technology (Cejika, Rogers, & Portsmore, 2006). Robotics and other hands on STEM activities are based on sound theory partially developed by Jean Piaget’s learning by doing, and expanded by Seymour Papert’s constructionist concept that highlights the production of a physical artifact stimulates our best learning. Specifically at the elementary level, integrated STEM education with robotics has been proven to significantly increase students’ engineering knowledge and perception (Yoon, Dyehouse, Lucietto, Diefes-Dux, & Capobianco, 2014).

Further, educational robotics, and other STEM hands-on activities, “offers students physical manipulatives that are familiar and easy to work with as they engage in the engineering design process (Ortiz, Bos, & Smith, 2015).” Robotic design and construction activities illustrate applied science concepts with its inclusion of combining simple machines and basic electrical concepts for an intended design purpose (Rockland et al., 2010). The current national publication, *Standards for Technological Literacy,* calls for students as early as K-2 to engage in learning many of the basic simple machines that are the mechanical basis of robotics. It states, “through hands-on activities students will learn that technological activity required tools, materials, movement, safety and planning” and that “Systems have parts or components that work together to accomplish a goal (National Science Foundation, 2007).”

Several researchers have already integrated robotics into current curricula of elementary, middle and high school programs (Chung, et al., 2014; Robinson & Stewardson, 2012; Sahim et al., 2014). Robotics has been used in the classroom to enhance engineering thinking and applied science concepts in education which are critical components of the STEM education (Kim et al., 2015; Rockland et al., 2012; Sullivan & Bers, 2016). Over time, using robotics and other STEM hands on activities in the elementary classroom has proven to have a significantly positive impact on students’ attitudes towards STEM (Karp & Maloney, 2013). Understanding these concepts and how they interact offers insight in the application of interventions or learning experiences.

Statement of Purpose

This research attempted to determine the impact of an elementary level science, technology, engineering and mathematics (STEM) and robotics intervention module on the self-efficacy in STEM of African American girls enrolled in an Early Childhood Education Career and Technology Education (CTE) class in a larch urban school district in Jackson, Mississippi. Self-efficacy is defined as “people’s judgement of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986). Self-efficacy is governed by four basic subcomponents: performance accomplishments, vicarious learning, social persuasion and the combination of physiological states and affective reactions (Bandura, 1997). The purpose of this research study is to determine the impact of an elementary level robotics and STEM intervention module on high school girls' self-efficacy in STEM fields.

Research Question and Hypotheses

Using the Social Cognitive Career Theory (SCCT) as a guiding theory, this study attempted to answer the following research question: What is the impact of a STEM and robotics intervention module on girls' STEM self-efficacy?

This question was broken down into a series of hypotheses based on the research designed for this study in order to effectively address the possible impacts from the STEM intervention. Those resulting hypotheses are listed below.

1. There is no statistically significant difference overall in STEM self-efficacy of participants in this study regardless of the treatment condition.
2. There is no significant difference between the effects of time and STEM self-efficacy of participants in the control group.
3. There is no significant difference between the effects of the Hour of Code STEM activity and STEM self-efficacy of participants in the Hour of Code only group.
4. There is no significant difference between the effects of the GoldieBlox STEM activity and the STEM self-efficacy of participants in the GoldieBlox only group.
5. There is no significant difference between the effects of the combination of GoldieBlox and Hour of Code STEM activities and STEM self-efficacy of participants in the GoldieBlox/Hour of Code group.

6. There is no significant difference between the effects of the combination of the Robotics STEM activities and STEM self-efficacy of participants in the Robotics only group.
7. There is no significant difference between the effects of the combination of Robotics and Hour of Code STEM activities and STEM self-efficacy of participants in the Robotics/Hour of Code group.
8. There is no significant difference between the effects of the combination of GoldieBlox and Robotics STEM activities and STEM self-efficacy of GoldieBlox/Robotics group.
9. There is no significant difference between the effects of the combination of GoldieBlox, Hour of Code and Robotics STEM activities and STEM self-efficacy of participants in the GoldieBlox/Hour of Code/Robotics group.
10. There is no significant difference between the effects of the overall intervention and the SETS science inquiry construct.
11. There is no significant difference between the effects of the overall intervention and the SETS videogaming construct.
12. There is no significant difference between the effects of the overall intervention and the SETS computer gaming construct.
13. There is no significant difference between the effects of the overall intervention and the SETS general construct.
14. There is no significant difference between the effects of the overall intervention and the SETS problem solving construct.
15. There is no significant difference between the effects of the overall intervention and the SETS synchronous chat construct.

Significance of Study

The significance of this research could be that it would add to the existing body of research relating to the possible opportunities to effectively integrate STEM into a non-traditional high school classroom environment. Moreover, the target population bears significance in that this particular subset of African American girls enrolled in an Early Childhood Education Career and Technology course has not been the subject of prior STEM integration research.

Theoretical Framework

The theoretical framework guiding this research is the social cognitive career theory (SCCT). It was developed by Lent, Brown and Hackett, and it was used to study the application of Albert Bandura's (1986) social cognitive learning theory to career behavior attempting to explain the underrepresentation of women in male-dominated careers. This theory provides insight on several critical areas of career development, namely, the development of career interest, career and academic choice, and an individual's resolve to complete an academic or career related educational pursuit (Lent et al., 1994). It contends that self-efficacy is influenced by learning experiences while at the same time it directly influences outcome expectations, interests, goals and actions. Moreover, the theory posits that person inputs (e.g. gender, race, etc.) and background contextual affordances impact learning experiences. The combination of person inputs and contextual influences proximal to choice behavior, impacts goals and actions (Lent & Brown, 2003). Succinctly, this theory holds that learning experiences directly impact self-efficacy and outcome expectations.

As applied to this study's fundamental theory basis, SCCT contends that one could expect the independent variable elementary STEM intervention to influence or explain the dependent variable self-efficacy in STEM because of the link learning experiences directly impact self-efficacy. Within the same vein, the independent variable elementary STEM intervention should influence the dependent variable attitude because of its connection to learning experiences. Researchers have determined a direct relationship between a person's attitude and self-efficacy through their experiences (Kundu & Ghose, 2016) which correlates to SCCT's person inputs, or attitude, etc., and its connection to self-efficacy through learning experiences.

Experimental Treatment – STEM Learning Experience

Integrated STEM research opportunities should be designed to ensure that STEM connections to current learning goals are cohesive and do not impede the student's course knowledge requirements (NRC, 2014). The selection of the pre-kindergarten activities serves a tri-fold purpose: (a) appropriate content connection to current Early Childhood Education curriculum subject matter, (b) exposure to integrated STEM content appropriate during Career and Technical Education courses and (c) provides an opportunity to engage students of varying levels of STEM through play. Students enrolled in the Early Childhood Education Career and Technical Education course have a requirement to design and develop an age appropriate activities and lesson plans that will be administered during the lab portion of the course. Integrating the STEM intervention within the content of this course designed for application allows for the explicit requirement set forth by the Council to be met and provides an avenue for assessment. There is consensus among early childhood education scholars that the most effective learning is best achieved when children are at play and discovering of new concepts and adults maintain a support role in the process (Kinzie, Vick Whittaker, McGuire, Lee, & Kilday, 2015). The pre-kindergarten activities take into account both the curriculum content as well as consideration of students who may have extremely limited exposure to STEM-related material.

Expectations of Impact on Self-Efficacy

According to SCCT's proposition one, career interest develops and is reflective in large part from self-efficacy and outcome beliefs. As a result of this proposition, Lent et al., (1994) hypothesizes that the disparity in self-efficacy and outcome beliefs, with respect to race and gender, is a result of access to opportunities, support and socialization processes. Lent believes that this disproportion will be significantly reduced if opportunities, supports, social systematic barriers are controlled. Likewise, proposition 10 of the SCCT states that self-efficacy beliefs derive from performance accomplishments, vicarious learning, social persuasion, and physiological reaction (e.g. emotional arousal) in relation to particular educational and occupations relevant activities. Lent goes on to state that self-efficacy will develop more when the individual has direct engagement with the career related activities (Lent et al., 1994). With this concept in mind, student participants were exposed to each subcomponent of self-efficacy embedded strategically during the intervention.

Performance Accomplishments. According to Lent et al. (1994), the most influential component of self-efficacy is performance accomplishments. Since self-efficacy is dynamic and affected by learning experiences, the successful completion of tasks reinforces one's ability thereby theoretically increasing self-efficacy. Conversely, unsuccessful attempts of the completion of tasks would yield a negative impact on self-efficacy thereby lowering the individual's sense of ability to accomplish those types of tasks. The intervention in this study was designed such that high school girls will engage in hands-on STEM activities that are designed for children as young as pre-kindergarten age. It is expected that the opportunities for the successful completion of these activities is high.

Vicarious Learning. Vicarious learning is instructional learning through observation of an instructional situation (Bandura, 1986). In this case the learner has the opportunity to learn by watching others engage in the learning process through hands-on interactions. Opportunities for vicarious learning is built into the design of the treatment due in large part to the open classroom setting and the small group format. The classroom is an open area with little obstruction to allow ample space for the engagement of hands on projects. Groups will have a chance to observe other groups interacting with the instructor engaged in completing hands-on projects.

Social Persuasions. Social persuasions are the verbal motivation feedback received when learning a task and can result in a person trying harder to succeed (Bandura, 1997). Both positive and negative feedback affect self-efficacy (Bandura, 1997, Rittmayer & Beier, 2008). Social persuasion is most effective when students succeed in tasks while at the same time receiving positive feedback (Bandura, 1997). Sources for social persuasion will derive from other students and the instructor during the completion of each activity. Opportunities for social persuasion will occur during the hands-on tasks as well as during open class discussions.

Physiological States and Affective Reactions. The emotional state of a person has an impact on self-efficacy in the form of stress reactions and mood (Bandura, 1994). Creating and maintaining an environment that nurtures a positive emotional state can alleviate stress reactions and allow the students to focus on the learning task (Brand & Wilkins, 2007). Opportunism for a reduced stressful environment could occur given that the activity level of the projects that high school student groups will be engaged in are designed for students as young as four years-old. The classroom environment will be an important setting in which the students will be familiar.

Theory of Change Summary

Using the *W.K. Kellogg Foundation Logic Model Development Guide*, the essential components of the theory of change model are: problem or issue, community needs/assets, influential factors, strategies, and assumptions. The Kellogg Foundation cites this process as a means for assisting researchers and others in laying out a plan of action for their intended research.

Problem or Issue. The underrepresentation of girls and women in STEM education and STEM fields is a persistent problem for the United States. As indicated by the National Science Board in their most recent publication, *Science & Engineering Indicators* (2016). This document pointed out that the science and engineering workforce is composed of about 29% women even though 39% of degrees attained in STEM fields were by women. Girls' attitudes about STEM, play a role in their decision to enter STEM or STEM-related careers (Else-Quest, Mineo, & Higgins, 2013).

Jackson Public Schools has been historically assessed as a low performing school district earning an F-rating from the Mississippi Department of Education in 2018 when compared to the overall performance of the school districts in state of Mississippi. Student achievement in mathematics and science has consistently rated lower than the state's average. The school system has a high level of chronic absenteeism at 22% as compared to other school districts within the state.

Another need to address is girls' self-efficacy with respect to STEM activities. Although interest in STEM can be influenced positively though intervention (Nugent, Barker, Grandenett, & Adamchuk, 2010), other barriers, such as fear of failure, impede minority girls from pursuing STEM careers (Bystydzienski, Eisenhart, & Bruning, 2015). There are many negative social stereotypes that are associated with STEM activities that further impress upon and encourage reluctance for girls to engage in STEM. Researchers have shown that girls can develop a preference for STEM if given adequate exposure in the educational environment (Boston & Cimpian, 2018). The purpose of this research study was to determine the impact of an elementary level STEM intervention on high school girls' self-efficacy in STEM fields.

Community needs/Assets. The necessity for American students' involvement in STEM has reached national significance. The underrepresentation of girls and women in STEM education and STEM fields is significant so much so that it demands strong attention from the STEM education community to act to increase involvement of this endangered special population while in high school (National Research Council, 2007; National Science Board, 2016). Several researchers have attempted to determine how to combat this persistent problem in this country (Bystydzienski et al., 2015; Cooper & Heaverlo, 2013; Tseng, Chang, Lou, & Chen, 2011). One response to the national concern to increase interest in careers related to STEM is its integration in all P-12 classrooms (Brophy, Klein, Portsmore, & Rogers, 2008). Rockland, and his colleagues (2013) found that robotics in the classroom can be an effective STEM educational tool in that it contains all four components of the STEM approach in addition to promoting an increase in motivation to engage in STEM projects. In an effort to increase the number of K-12 students entering STEM-related fields, there needs to be more STEM exposure at the K-12 level (National Research Council, 2014).

Desired Results. The primary desired results from exposure to the intervention are two-fold: statistically significant positive change in self-efficacy in STEM concepts and statistically significant positive change in attitudes towards STEM related careers. The selection of the pre-kindergarten activities serves a tri-fold purpose: (a) appropriate content connection to current

Early Childhood Education curriculum subject matter, (b) exposure to integrated STEM content appropriate during Career and Technical Education courses and (c) provides an opportunity to engage students of varying levels of STEM through play. Integrated STEM research opportunities should be designed to such that STEM connections to current learning goals are cohesive and do not impede the student's course knowledge requirements (NRC, 2014). Students enrolled in the Early Childhood Education Career and Technical Education course have a requirement to design and develop an age appropriate activities and lesson plans that will be administered during the lab portion of the course. Integrating the STEM intervention within the content of this course designed for application allows for the explicit requirement set forth by the Council to be met and provides an avenue for assessment. Finally, there is consensus among early childhood education scholars is that the most effective learning is best achieved when the children are at play and initiate the discovery of new concepts while adults maintain a support role in the process (Kinzie et al., 2015). The pre-kindergarten activities consider both the curriculum content as well as consideration of students who may have extremely limited exposure to STEM-related material.

Influential Factors. There is a need to positively influence girls' attitudes and self-efficacy with respect to STEM education and STEM careers (Else-Quest et al., 2013). There is a need to positively influence teachers' attitudes and self-efficacy in elementary STEM education (Palardy & Rumberger, 2011). Factors influencing these groups' attitude and self-efficacy include first-hand learning experiences with STEM activities (Wendt et al., 2015). Robotics has been used in the classroom to enhance engineering thinking and applied science concepts in education which are critical components of the STEM education. Rockland et al. (2010) attribute the lagging interest in STEM careers to the lack of exposure of students to topics related to these fields early on in their schooling. These researchers found a serious deficiency in the adequate preparation of K-12 teachers to teach STEM as an integrated component of their curriculum. They believe that robotics is a solution to the integration problem that K-12 teachers face. In their recent study of best practices for K-12 teachers to incorporate STEM into their classrooms, robotics was highlighted as having the potential to enhance engineering thinking and applied science concepts in education which are critical components of the STEM education.

Strategies. This research study will expose high school girls from a Title 1 school enrolled in an Early Childhood Education Career and Technical Education course to a set of elementary level STEM hands-on activities in an effort to allow them the opportunity to demonstrate basic STEM content mastery. Using a hands-on elementary level STEM intervention consisting of robotics and integrated STEM activities can have a positive impact on attitudes and self-efficacy (Lent et al., 1994; Wendt et al., 2015; Wigfield et al., 2009). Specifically, at the elementary level, integrated STEM education has been proven to significantly increase students' engineering knowledge and perception (Yoon et al., 2014).

While working closely with the classroom instructors, the researcher will administer an elementary level STEM intervention to high school girls that will be used to develop lesson plans for pre-kindergarten children during the laboratory portion of the course. The intervention is designed such that opportunities to build attitude and self-efficacy through positive performance accomplishments, vicarious learning, favorable social persuasions, and positive physiological reactions will be integrated throughout the learning experience.

Assumptions. Robotics can be successfully used to improve attitudes in STEM education (Kim et al., 2015). Moreover, according to Wendt et al. (2015), modeling, practice and first-hand experiences were effective in increasing self-efficacy and attitudes towards STEM education.

The target population for this study is adolescent female students who have expressed through their choice of enrollment in a high school Early Childhood Education Couse offered through a Career and Technical Education Center a desire to become teachers. Based on Lent's SCCT theory, positive results in STEM self-efficacy and attitude can be obtained as a result of exposure to positive learning experiences.

Logic Model. Using the *W.K. Kellogg Foundation Logic Model Development Guide*, the essential components of the logic model are: resources, activities, outputs, outcomes, and impacts (see Table C).

Resources. The resources essential to this project include elementary level robotic kits, hands on pre-kindergarten level STEM activity and desktop computers with internet access. In addition to classroom space for performing hands on group activities.

Activities. Exposure of high school girls who have enrolled in an Early Childhood Educational CTE Course to various age appropriate elementary STEM related hands on projects including robotics, coding and fundamental simple machines. The activities should align with the content requirements of the course's main objective in relation to pre-kindergarten age lessons.

Outputs. Student participants created a portfolio of their projects and activities in each of the target STEM areas: robotics projects, simple machine exercises, and coding activities. Students will develop age appropriate lesson plans using STEM related activities while incorporating appropriate child development topics (e.g. indoor/outdoor space, parental involvement, maintaining a healthy and effective learning environment, etc.).

Outcomes. Student participants reflected on the application of the activities in the classroom in order to create Elementary STEM lesson plans showing how they will infuse STEM activities into an Early Childhood Education classroom laboratory setting within their current

CTE course. Student participants were expected exhibit positive attitudes and self-efficacy with respect to STEM activities and STEM related careers.

***Impacts*.** The anticipated impact was a positive change in self-efficacy in STEM content and careers. Statistically significant positive change in self-efficacy of elementary STEM concepts were expected to be observed using standard measures. Additionally, statistically significant positive change in attitudes towards teaching elementary STEM concepts and STEM related careers should be observed using standard measures.

Table 1.1: Theory of Change Summary - Program Implementation Plan

Resources/Inputs	Activities	Outputs	Outcomes	Impacts
- Funds to purchase robot kits - Funds to purchase GoldieBlox kits - Computers with internet access to run Code.org - Access to target population	Expose high school girls who plan to enter elementary education to STEM concepts for elementary level students: - Robotics - GoldieBlox - Hour of Code - Create Lesson plans to teach component	Student work/portfolio including: - Completed Robotics Activities - Completed GoldieBlox kits - Completed coding exercises - Elementary STEM Lesson Plans	- Positive change in self-efficacy of elementary STEM concepts	When entering college level teacher preparation programs, student-teachers will be better able to grasp teaching STEM concepts for elementary students.

Note. Taken from Kellogg's Logic Model Development.

CHAPTER 2

LITERATURE REVIEW

Since its inception, the field of engineering and technology education in K-12 education has undergone several iterations from its foundational concept as industrial arts to technology education and finally, to its current direction as engineering and technology education. The application of vocational education determines its placement on the scale between vocational education and general education. The early philosophical focus of the application of industrial arts in the United States was debated heavily between many in the educational field post World War II. Notably, the debate between Charles Prosser and John Dewey captured two major perspectives on the application of industrial arts (Scott & Sarkees-Wircenski, 2004).

Charles Prosser had a belief that industry should be the driving force in the education of its future workers. He supported vocational education with the concept of “social efficiency” giving support to its idea of a social obligation of the individual to contribute to the common good of society and industry (Foster, 1997). His approach to the problem presented by the industrial revolution and its demand for skilled workers was to focus on industry. With industry leaders providing guidance for vocational curricula, students who may not be considered “college material” would be able to contribute to society and its needs by learning specific skills to maintain industrial progress as a common worker. His educational platform was founded on the needs of the industry rather than the needs of the individual (Foster, 1997). His belief that vocational education should at the very least meet the immediate need of the rapid growth of technology in industry seemed to dominate the legislative body as demonstrated in the Smith-Hughes Act of 1917 (Scott & Sarkees-Wircenski, 2004).

Prosser believed that students would benefit from vocational education by gaining specific marketable skills. However, Dewey went more in depth with his belief that students should gain life and adaptability skills along with fundamental workforce skills (Scott & Sarkees-Wircenski, 2004). Dewey maintained that the direction of vocational education should be to fulfill the needs of the individual and be made available to all. He maintained that a set of inherent values must be kept when addressing the inclusion of vocational studies. Succinctly, Dewey believed in the needs of the individual student and how to enhance an educational system that would cater to their growth. As a result, Dewey argued that society would benefit from a better-rounded citizen rather than a citizen who could only contribute one specialized skill. The ability of the individual to adapt to the changing environments was critical. His view of the individual's impact on life, family and community was that it would naturally be improved if sufficient investment were made in their ability to cope and adapt to life's changes. Dewey understood that the individual should be taught to think and solve problems rather than complete a task well, repetitively (Scott & Sarkees-Wircenski, 2004).

Essentially, the battle of the philosophical theories between progressivism and essentialism resulted in a proverbial back and forth between the two (Foster, 1997). Although the foundation of the industrial arts was forged by the essentialist concept proposed by Prosser; over time, it evolved into technology education having progressivism emerge as its new direction. Further igniting the discussion of how best to apply vocational education came with the inclusion of the career education infusion into traditional vocational education. The introduction of engineering as a general career emphasis of technology education expanded the vocational concept to one with career intent, hence engineering and technology education (Foster, 1997). Currently, there are many proponents for the career focused educational approach.

The introduction of the career education idea for vocational education presented more directional evidence of the placement of technology education leaning more towards being inclusive in general education. Wicklein (2006) presented a strong argument for engineering and engineering design as the focus of technology education. He states clearly that this new focus places technology education squarely in the realm of general education. Moreover, it adds the support of more community members and school administration because of their familiarity and value of the field of engineering.

Today's direction of engineering and technology education has progressed from the development of technological literacy as defined more precisely by the International Technology and Engineering Education Association (ITEEA) with the release of their *National Standards for Technological Literacy* to its migration into science, technology, engineering, and mathematics (STEM) education as identified as one of the sixteen career clusters adopted by the Association of Career and Technical Education. These career clusters are a result of a consortium of state CTE directors and based on an industry with common traits and applications which directly evolves from the industry need (Scott & Sarkees-Wircenski, 2004).

Current trends in the United States workforce show the need for more individuals prepared to enter and engage in STEM related career fields (NSF, 2007). As a response to the industry, education makes changes to meet the needs of society. According to Wicklein (2006), engineering and technology education is the best stage for integrating STEM education and as a result all students can benefit from this type of content. Kimmel, Carpinelli, and Rockland

(2007) found that students in K-12 education lack sufficient exposure to engineering and the guidance of qualified educators to facilitate those specific STEM experiences.

Student exposure to STEM education and STEM related career fields in K-12 schools is directly related to student interest in corresponding career fields (Hall, Dickerson, Batts, Kauffmann & Bosse, 2011). Evidence gathered from a study conducted and reported by Yoon et al., (2014), indicated that integrated science, technology and engineering education had a positive impact on elementary students' knowledge of engineering as well as their engineering identity. The researchers in that study supported the use of integrated STEM lessons at the elementary level; however, teacher preparation is necessary for such exposure to continue. Kimmel, et al, (2007) further implores the development of qualified teachers through appropriate teacher preparation programs specifically with STEM activities incorporated into the program.

Many argue for the inclusion of STEM education for all students (Denson, & Lammi, 2014; Kimmel et al., 2007; Wicklein, 2006). Nonetheless, there are questions as to how best to implement STEM that would broaden its impact. For example, the demands of current science education (i.e. high stakes testing, content demands and teacher training) limit the availability of project-based collaboration and renders the move for complete infiltration and integration practice suppressed (Anderson-Rowland, Baker, Secola, Smiley, Evans, & Middleton, 2002). Although engineering education has been attempted in several other subjects such as social studies (Pryor et al., 2015), science and math, engineering and technology education remains an effective and readily available pathway for incorporating robotics and STEM because the hands-on activities correlate to current practices in engineering and technology education classrooms (Denson & Lammi, 2014).

A constant theme of many STEM integration education researchers is the need for adequately prepared teachers (Brophy et al., 2008; Denson & Lammi, 2014; Fantz, De Miranda, & Siller, 2011; Kimmel, et al, 2007; Pryor et al., 2015; Kim et al., 2015; Wicklein, 2006). Wicklein (2006) and Denson and Lammi (2014) make the case for technology education becoming a mainstream core subject because it provides an appropriate means for integrating STEM education. Denson and Lammi (2014) cite logistical issues as a limitation for current core teachers to adequately engage in STEM education at the same level as engineering and technology education teachers. For these reasons, engineering and technology education is more suited for mainstream content in a general education setting than in vocational education. Moreover, Strimel and Grubbs (2016) argue that the pathway forward for today's STEM education centralizes the inclusion of its platform and delivery in engineering and technology education. Currently, there is an intersection of progressivism and essentialism as reflected in the national push and maintenance of a more qualified workforce in STEM along with its inclusion at all levels of education from K-12 to enhance the individual student to be better prepared in a technological society. STEM education has permeated general education and thereby following the original Dewey philosophy of a progressive approach to vocational education.

Robotics in the Elementary Classroom

One response to the national pressing need to increase interest in careers related to STEM is its integration in all P-12 classrooms (Brophy et al., 2008). Brophy and his colleagues (2008) presented a summary of current instructional models of STEM integration that have one common challenge, adequate teacher preparedness. They contend that teachers elude subject matter instruction when they do not believe that they are sufficiently prepared to teach that subject. Models of professional development were presented, however the overarching high stakes testing and current core curriculum requirements continue to challenge teachers' introduction of STEM in their classrooms.

In order to increase teachers' participation in STEM, many teacher pre-service preparation programs have integrated a STEM component into their curriculum for teachers in training (Kim et al., 2015; Wendt et al., 2015). Educational practices are altered when teachers have the skills, insight, and assurance to effectively apply new content (Kimmel et al, 2007). Specifically, at the elementary level, integrated STEM education has been proven to significantly increase students' engineering knowledge and perception (Yoon et al., 2014).

Bers, Flannery, Kazakoff and Sullivan (2014) evaluated an early childhood education curriculum targeted for kindergarteners. They found that the use of the STEM concept using robotics, in particular, resulted in the kindergarten aged children developing programming skills, using an iterative process to develop robots, work in groups to share ideas and overall engage in the problem solving process. They found that teachers with little prior knowledge were able to integrate this developmentally appropriate robotics curriculum into their classrooms successfully.

Robotics as a School Activity

There are several key aspects of working with robotics that qualifies its use as a school activity. First, its application is based on sound theory with respect to an interdisciplinary approach to learning science, technology, engineering and mathematics. Cejika et al. (2006) indicated in their research to determine the best way to incorporate this powerful learning tool, that concepts of robotics in the classroom is interdisciplinary nature lending itself to mathematics, science, and engineering with the use of technology. It is based on sound theory developed by Jean Piaget explaining our learning by doing, and expanded by Seymour Papert's constructionist concept that highlights the production of a physical artifact stimulates our best learning.

Secondly, robotics lessons are generally hands-on and require the student to create a solution. Ortiz et al. (2015) stated that educational robotics “offers students physical manipulatives that are familiar and easy to work with as they engage in the engineering design process.” Robotic design and construction activities illustrate applied science concepts with its inclusion of combining simple machines and basic electrical concepts for an intended design purpose (Rockland et al., 2010). The current national publication, *Standards for Technological Literacy,* calls for students as early as K-2 to engage in learning many of these basic simple machines. It states, “through hands-on activities students will learn that technological activity required tools, materials, movement, safety and planning” and that “Systems have parts or components that work together to accomplish a goal” (NSF, 2007).

Robotics in the classroom is not a new concept. Several researchers have already integrated robotics into current curricula of elementary, middle and high school programs. For instance, Sahim et al. (2014) developed a STEM curriculum using robotics in an after-school setting in a K-12 charter school to determine student learning outcomes. These researchers found that robotics was an effective tool in increasing student interest in STEM related fields. Students in this program also learned several twenty-first century skills including cooperative learning through a project based structure essential to engineering design using robotics.

Robotics can be used to motivate students to work through a multi-step problem and apply high level processes like the Engineering design process. Another set of researchers, Robinson and Stewardson (2012), evaluated a STEM based curriculum developed through VEX robotics. They tested this curriculum with middle and high school students. They found that the robotics design project increased student motivation as they engaged in the various phases of robot design and development. In the VEX skill set builder curriculum, students learned to build STEM based concepts, such as drift chasses and drive trains, all in preparation for the overall design of a competitive robot. These researchers found that the curriculum resulted in increased student participation each year of its existence until the program participation had to be capped.

Using robotics in the classroom can improve STEM understanding. Nugent et al. (2010) determined that robotics instruction can be effectively used to advance STEM learning. These researchers developed two intervention curricula using robotics to determine its impact on STEM learning and attitudes. One intervention was an intensive week-long summer camp and the intervention was a short-term three-hour course. They found that both the short-term intervention and the week-long summer camp had a positive impact on students' STEM attitudes. However, the week-long intensive camp was found to have made a positive impact on student STEM learning and had a greater impact on students' self-efficacy than the short-term intervention.

Student achievement has been impacted by robotics programming and development projects. Chung, et al. (2014) compared the mathematics achievement scores of students who participated in a competitive based robotics curriculum developed by Robofest which emphasizes the use of applied mathematics and with students who did not participate in the robotics competition. They developed a pre-test/post-test structured study to determine student achievement in mathematics and engineering. They found that students who participated in the Robofest competition classes had higher achievement scores in mathematics and science than students who did not participate.

Robotics has been used in the classroom to enhance engineering thinking and applied science concepts in education which are critical components of the STEM education. Rockland et al. (2012) attribute the lagging interest in STEM careers to the lack of exposure of students to topics related to these fields early on in their schooling. These researchers found a serious deficiency in the adequate preparation of K-12 teachers to teach STEM as an integrated component of their curriculum. They believe that robotics is a solution to the integration problem that K-12 teachers face. In their recent study of best practices for K-12 teachers to incorporate STEM into their classrooms, robotics was highlighted as having the potential to enhance engineering thinking and applied science concepts in education which are critical components of the STEM education. To further expand on the current STEM best practices, the use of robotics in elementary education has been explored by researchers (Kim et al., 2015). Kim and her colleagues found that pre-service teachers were positively receptive to using robotics to facilitate STEM inclusion in their elementary classrooms giving possible light to its inclusion in elementary education.

Robotics concepts are not merely reserved for high level applications of math and physics but also can be used at all levels of P-12 education. Sullivan and Bers (2016) developed an eight-week robotics curriculum used with pre-kindergarten through second grade students administered within their regular classroom. These researchers determined that pre-kindergarten students were able to successfully accomplish basic robotics and programming tasks. Students in the upper level classes, kindergarten through second grade, were given more advanced lessons. They found that children as young as seven years old were able to successfully use conditional programming statements to program a robot. They found that construction kits specifically designed for young learners can be a useful tool in early elementary school classes. They found the robotics activity to be fun and engaging to the students as well as positive learning outcomes.

Over time, using robotics in the elementary classroom has proven to have a significantly positive impact on students' attitudes towards STEM. Karp and Maloney (2013) conducted a six year study of the impact of an annual low-cost robotics program offered during in an afterschool format. These researchers reported an increase in student diversity and participation over the course of six years. In addition, they reported students showed a significant increase in confidence level for successfully solving robotics problems.

Coding in the Elementary Classroom

Studies have shown that coding concepts can successfully be introduced to elementary-aged learners (Asad, Tibi & Raiyn, 2016; Coding with Scratch: Vaca-Cardenal, Bertacchini, Tavernise, Gabriele, Valenti, Olmedo, Pantano & Bilotta, 2015; Saez-Lopez, Roman-Gonzalez & Varques-Cano, 2016; Valenzuela, 2018). Coding at the elementary level can improve students' problem solving skills (Asad, et al., 2016; Meccawy, 2017). Students as young as five and six years-old exhibit higher order thinking skills when engaged in programming (Falloon, 2016). Researchers suggest that coding at an early age could improve computational thinking skills (Shein, 2014).

Rationale for Activity Selection

Although there is a national platform proposing the integration of science, technology, engineering and mathematics (STEM) education at all levels of public schooling, there is a lack of consensus nationally amongst stakeholders over what that looks like, including the pre-kindergarten (pre-k) level (Bagiati, Yoon, Evangelou, & Ngambeki, 2010; Brophy et al., 2008; Howes, Burchinal, Pianta, Bryant, Early, Clifford & Barbarin, 2008; Kinzie et al., 2015). Several states have identified science and mathematics pre-kindergarten curricular standards that promote critical thinking and scientific inquiry (Howes et al., 2008) leaving the introduction of engineering and technology to be addressed at other grade levels. Scholars have defined an appropriate integrated STEM activity should contain at minimum elements of at least two of the disciplines that comprise STEM (Biagati et al., 2010; Kelley & Knowles, 2016; NRC, 2014). There is evidence that by using an integrated STEM approach to the curricular content, STEM can be applied adequately in a formal pre-kindergarten classroom (Bagiati et al., 2010; Kelley & Knowles, 2016).

The 2014 report entitled *STEM Integration in K-12 Education: Status, Prospects, and an Agenda for Research (2014)* produced by the National Academy of Engineering (NAE) and the National Research Council (NRC) takes another look at the current field of STEM education and goes further to craft a systematic approach defining solid framework from which curricula development, potential research and other stakeholders may use as a common guide to assess integrated STEM experiences. The framework identified four features that every STEM program experience should incorporate, namely, goals, outcomes, nature of integration and implementation. Although there has been an increase in the development of STEM activities at the pre-kindergarten level (Biagati et al., 2010), the listing of exemplar programs that included cohesive curricula designed with pre-kindergarten content highlighted in the 2014 National Research Council report only included four of twenty-eight programs total while the bulk of the remainder focused on K-12 grade levels. Of the four programs, two formal and two informal, age-appropriate STEM content and activities were identified as possible use for an Early Childhood Education course for high school students.

Formal Programs. From the formal listing of programs, Harrisonburg Public Schools offered a three-lesson STEM curriculum featuring the following lessons: (a) Gingerbread trap, (b) Shadows and Light, and (c) Waterway. The latter two activities directly address the State’s pre-k science standards. However, the Gingerbread trap Activity involves the development of a student designed artifact (the trap) and its demonstration of functionality. In keeping with the two discipline standard, this lesson could be considered a STEM lesson highlighting science and engineering because of its design activity element.

WISE Engineering is the only other formal program that offered activities designed for the pre-k level through its *Hand-On Standards: STEM in Action PK-5 Learning Modules* curriculum. This curriculum was developed and offered through ETA hand2mind as a supplement to enhance the science curriculum. There are five hands-on science lessons included: (a) Ron's Habitat Adventure (Life Science), (b) Pam and Ava's Mapping Adventure (Earth Science), (c) Gus and Nia's Shaking Adventure (Earth Science), (d) Ron's Ramp Adventure (Physical Science) and (e) Pam's Camping Adventure (Physical Science). Each lesson embeds an element of design within the activity.

Informal Programs. CSTEM Challenge offers a curriculum combining STEM and art within a total of four separate lessons. Two of these lessons would be considered STEM while the other two are arts and crafts projects. The two STEM lessons are (a) computer programming and (b) robotics. The cost associated with each module was $290 and $480, respectively.

Finally, The Tinkerer's Workshop was listed as an informal program that catered to children of all ages. According to the same document, this program is no longer available. However, the Thinkery (formerly Austin Children's Museum) offers a similar exhibit through its Innovators' Workshop which incorporates art and science with its design activities. This is a 2,500 square-foot exhibit with featured sections entitled Stop Animation Station, Microscopes, Build Landscape, Little Learners' Lab, Painting on Glass, and Simple Machine Wall.

Rationale for Alternative Activity

The selection of the pre-kindergarten activities serves several purposes: (a) appropriate content connection to current Early Childhood Education curriculum subject matter, (b) exposure to integrated STEM content appropriate during Career and Technical Education courses and (c) provides an opportunity to engage students of varying levels of STEM through play. Integrated STEM research opportunities should be designed such that STEM connections to current learning goals are cohesive and do not impede the student's course knowledge requirements (NRC, 2014). Students enrolled in the Early Childhood Education Career and Technical Education course have a requirement to design and develop age appropriate activities and lesson plans that will be administered during the lab portion of the course. Integrating the STEM intervention within the content of this course designed for application allows for the explicit requirement set forth by the Council to be met and provides an avenue for assessment. Finally, there is consensus among early childhood education scholars is that the most effective learning is best achieved when the children are at play and initiate the discovery of new concepts while adults maintain a support role in the process (Kinzie et al., 2015). The pre-kindergarten activities take into account both the curriculum content as well as consideration of students who may have extremely limited exposure to STEM-related material.

Robotics for STEM Intervention. The purpose of the intervention is to examine the impact of an elementary level STEM module on self-efficacy and attitudes for a target population assumed to have a limited background in this subject area while at the same time accommodating their required in-class thematic lesson development assignment. Scholars have determined that robotics used in the classroom can be an effective STEM educational tool in that it contains all four components of STEM in addition to increasing motivation for engagement

(Rockland et al., 2010). At the elementary level, integrated STEM education, such as robotics, has been shown to significantly increase students' engineering knowledge and perception (Yoon et al., 2014). For elementary education, the primary focus of STEM education and the use of robotics in the classroom is towards exciting students, sparking interest and exposing them to the foundational questions related to robotics (Mead, Thomas, & Weinburg, 2012). There is sufficient evidence that a hands-on robotics unit will serve as a complete introduction to all components of STEM (Rockland et al., 2013) rather than a piecewise attempt using the majority of programs outlined below which do not contain any hands-on robotics units.

Various methods to integrate robotics into the K-8 environment through afterschool programs have achieved this increase in excitement and interest (Karp & Maloney, 2013; Nugent et al., 2010; Robinson & Stewardson, 2013). According to the National Research Council (2014), a main issue facing STEM integration into mainstream education is the financial commitment and necessary investments to adequately supply material, teacher STEM professional development, time and sufficient planning. For this reason, the programs identified as examples of formal and informal curriculum were selected.

Several of the programs listed on the National Research Council's informal and formal list are competition based programs. Johnson and Londt (2010) have devised a set of key characteristics that would most assist in determining the program that fits the existing educational application. Robotics programs included on the list are the following: Jr. FIRST LEGO, FIRST LEGO League, FIRST Tech Challenge, FIRST Robotics Competition, Manor New Tech High, Camp Invention, CSTEM Challenge and Waterbotics. All of these programs use competition based robotics teams to design and build robots for classroom instruction and beyond. Johnson and Londt (2010) argue that several factors should be considered when choosing a program namely, adequate funding, student interest in robotics, physical spatial resources, adult coaches with appropriate skills, partner organizations' ability to supply effective assistance, and attend competitions to gain experience and insight.

Age-Appropriate Content. The anticipated target population are high school girls enrolled in an Early Childhood Education Career and Technology Education course of study. In considering their current curriculum, it is appropriate to introduce STEM material that would easily integrate into their course of study thereby eliminating the upper level programs such as Active Physics, MathAlive!, and TechBridge, Moreover, the skills that will be acquired will be applied in the development and application of a thematic unit whose intended audience are four year-old children enrolled in an in-house daycare.

STEM Activities

The breakdown for the STEM Intervention (see Appendix E) included activities from three areas: Robotics, Simple Machines and Coding. Each area was designed for pre-readers and beginning readers.

Robotics. The robotics component selected for this study was LEGO WeDo™ which included a pre-kindergarten curriculum, "The Playground," developed by Divtech Research Group. The robotics kits and curriculum were designed to introduce children to the fundamental concepts of robotics and programming using basic LEGOs and a software package designed specifically for pre-kindergarten students. The week-long intensive program presents the engineering design process using robotics activities in a whole class setting where pre-kindergarten students are assigned to groups or teams. Within each team, different roles are assigned to each participant. Teachers guide the teams to help facilitate the generation of ideas to solve the overarching problem.

Simple Machines. GoldieBlox™ is a toy company that develops STEM educational toys geared towards encouraging girls to learning STEM by using a girl engineer lead character in the story component of the individual games. The pre-kindergarten hands-on STEM component selected for this study was adopted from the GoldieBlox™ and the Spinning Machine developed by Debbie Sterling. This kit is recommended for children aged four to nine. Student participants used the GoldieBlox™ kits to engage in hands-on learning and application of simple machines with a specific focus on drive trains. GoldieBlox™ and the Spinning Machine allows students to read and follow along a simple story line to provide application context for each activity.

There were a total of ten activities that student participants engaged in to apply the drive train concept. The first task was to identify the wheel and axel pieces and place them in the peg board provided. As the story line progressed more activities were included. One activity included using a ribbon to spin a wheel and axel system in a star formation and character pieces atop each wheel. Another activity was Benjamin's Treadmill which used several wheels and axels to develop a model of a miniature treadmill. In total, there were ten different pre-designed activities included in the accompanying kit booklets which demonstrated various uses of the drive train concept. Student participants were expected to complete each activity and encouraged to develop activities of their own for their culminating lessons.

Coding. The pre-kindergarten coding component selected for this study was Kodable App from Hour of Code™ from Code.org. The first set of lessons is Smeeborg which was designed for pre-readers as early as four years old. The Smeeborg activities are divided in to four separate sections: Sequence Selector, Condition Canyon, Loopy Lagoon and Function Junction. Each subsection is intended to introduce a specific area of coding, namely sequencing instructions, condition statements, loops and basic functions. Student participants engaged in learning basic coding by directing a fuzz ball through a maze-like board by using directional arrows in sequences. There are several levels of activities with various levels of mazes that are designed to challenge the students to build on the complexity of the mazes and directional arrows to guide the fuzz balls out of the maze. As each level is completed, participants get closer to unlocking a higher level of complexity.

Timeframe for Effective Learning and Change

Effective learning is the ability of the learner to engage in an activity of construction while applying the knowledge to problem solving acquired during instruction (Walkins, Carnell, & Lodge, 2007). This form of learning engages monitoring during the learning process to ensure that goals and objectives are being met using current strategies and provides for opportunities to adjust strategies when necessary. Effective learning can occur after failing at a task then adjusting strategies to make another approach to complete the task.

Effective learners are proactive and engaged in their own learning by self-regulation (Sternberg, 2003). Teacher are not the focal point in this type of classroom. Effective learning occurs in classrooms where teachers have created an atmosphere of positivity and student-driven engagement (Walkins et al., 2007). According to Walkins and his colleagues (2007), the timeframe for effective learning can vary, however the assessment practices of the teacher can regulate this process by providing checkpoints for success and task completion.

Existing curriculum time constraint. There are several components of a robust learning activity that indicate the length of time required to accomplish its intended goals. The first of which would be the available time allowed in the curriculum for exploration of the topic. This curriculum time constraint can inform the instructional designer of the level of understanding that can be achieved thus allowing learning goals of the activity to be clearly defined. Interventions should be seamless when integrated into an existing curriculum as not to disrupt the flow of the course content.

Establish the learning goals to be addressed. Once any existing time constraints have been identified, then the learning goals can be established. The learning goals are clearly stated within the context of the Mississippi State curriculum (Unit 9) in that thematic lessons plans detailing age appropriate activities must be developed by student participants in the Early Childhood Education courses. This intervention afforded opportunities for students to become exposed to various types of STEM activities that could later be used to support the curriculum development portion of their course requirements.

Level of Content to be learned. According to Sweller, Ayers, & Kaluga (2011), when determining the amount of time needed for effective learning the cognitive load theory provides much needed research-based guidance in designing instructional content. These researchers found that there are limitations to processing information in working memory. Administering too much information at one time could lead to a condition of cognitive overload. In discovery learning, students must be monitored constantly to prevent such a condition.

Kalyuga (2012) found that exploratory lessons can have the reverse effect on learning with respect to the cognitive load if it is not managed well. If left unchecked, this researcher found that novice learners can result in reduced learning. However, he found that as learner experiences increase then the cognitive load declines offering the learner the opportunity to grasp more knowledge in the subject matter.

Reynolds and Caperton (2011) tracked student engagement in a discover-based game design learning program. These researchers found that novice learners are susceptible to frustration under excessive cognitive load. Thus, they determined that there was a direct relationship between cognitive load and frustration.

Shane and Wojnowski (2007) declared that effective learning as evidenced by active integration into the classroom as standard practice takes time. They go on to indicate institutionalization of new practices could take anywhere between three to four years of implementation. However, Husti (1994) found that using a flexible-time instruction format could be beneficial to students. This researcher continued by indicating that the duration of an instructional unit should adapt to the lesson's content and the needs of the target population. For example, Xu, Padilla and Silva (2014) compared the learning achievement of two groups of Mandarin level 3 high school students in two program designs: an intensive four-week (85.5 hours) summer program and a 22-week (88 hours) regular semester program. Although student in the regular semester program displayed better oral fluency, there was no difference for oral comprehension, vocabulary, pronunciation, and grammar usage between the two course formats. These researchers concluded that the short term intensive summer program was effective with respect to student achievement as the traditional semester format.

Evaluation of the Learning Goals. There will be included in the learning activity the ability to assess the initial activity goals. Students will be using the intervention topic and activities to complete a portfolio resulting in a set of lesson plans. The final lesson plans will be evaluated by the course instructor according to the standards set forth by the District for that class.

Rationale for Two-Week Intervention Duration

Jonassen (1991) identified levels of a learner as being: introductory, advanced and expert. According to Jonassen, an introductory learner has limited prior knowledge about the subject matter, whereas an advanced learner is the middle phase between the beginner and expert levels. Finally, the expert in this approach to professional development is one who is able to make appropriate choices in the learning environment.

The focus population of this study was considered introductory since none of the participants are trained educators nor have held a teaching license. Based on this constructivist theory, teacher outcomes as identified by Garet, Porter, Desimone, Birman, & Kwang Suk, (2001) would only include knowledge and skill acquisition rather than change in classroom teaching practice. Short-term professional development can have a significant impact on teacher self-efficacy (Stains et al., 2015).

In the case of middle school students in a geography class using a two-week unit Baker and White (2003) found that a significant impact on self-efficacy and attitudes can be observed in an introductory project based learning unit designed to introduce the GIS map tool. These researchers also found that a significant improvement on student achievement can be observed with such a short term unit.

This research study had limitations for administration given that the course is designed with three-week rotations between the classroom and lab environments. In addition, student sections rotated between meeting days on a bi-weekly basis (see Table 2.1).

Table 2.1: Sections of Early Childhood Education at Jackson Public Schools Career Development Center

1st Year – A-Day (AM)	2nd Year – A–Day (PM)	2nd Year – B-Day (AM)	1st Year - B-Day (PM)
Smith	Smith	Smith	Smith
Jones	Jones	Jones	Jones

Sample three-week rotation for each section under each teacher is outlined prior to the beginning of the school term (see Table 2.2).

Table 2.2: Class/Laboratory Rotations for Early Childhood Education Classes

Monday	Tuesday	Wednesday	Thursday	Friday
Smith **LAB** 1A(AM) / 2A(PM)	Smith **LAB** 2B(AM) / 1B(PM)	Smith **LAB** 1A(AM) / 2A(PM)	Smith **LAB** 2B(AM) / 1B(PM)	Smith **LAB** 1A(AM) / 2A(PM)
Smith **LAB** 2B(AM) / 1B(PM)	Smith **LAB** 1A(AM) / 2A(PM)	Smith **LAB** 2B(AM) / 1B(PM)	Smith **LAB** 1A(AM) / 2A(PM)	Smith **LAB** 2B(AM) / 1B(PM)
Smith **LAB** 1A(AM) / 2A(PM)	Smith **LAB** 2B(AM) / 1B(PM)	Smith **LAB** 1A(AM) / 2A(PM)	Smith **LAB** 2B(AM) /1B(PM)	Smith **LAB** 1A(AM) / 2A(PM)
Jones **Classroom** 1A(AM) / 2A(PM)	Jones **Classroom** 2B(AM) / 1B(PM)	Jones **Classroom** 1A(AM) / 2A(PM)	Jones **Classroom** 2B(AM) / 1B(PM)	Jones **Classroom** 1A(AM) / 2A(PM)
Jones **Classroom** 2B(AM) / 1B(PM)	Jones **Classroom** 1A(AM) / 2A(PM)	Jones **Classroom** 2B(AM) / 1B(PM)	Jones **Classroom** 1A(AM) / 2A(PM)	Jones **Classroom** 2B(AM) / 1B(PM)
Jones **Classroom** 1A(AM) / 2A(PM)	Jones **Classroom** 2B(AM) / 1B(PM)	Jones **Classroom** 1A(AM) / 2A(PM)	Jones **Classroom** 2B(AM) / 1B(PM)	Jones **Classroom** 1A(AM) / 2A(PM)

Note. Student participation in STEM treatments did not interrupt the overall schedule.

There is a three-week rotation between the two teacher loads. For three weeks students in Smith's sections would go to the lab to follow the in-house daycare schedule for mornings or afternoon (depending on the class meeting times). During which time, Jones's sections would meet in the classroom learning theory and practice concepts as well as developing lesson plans that would be administered during their scheduled lab days. In an effort to be as least disruptive as possible, the intervention was integrated during a two-week period at the beginning of the normal three-week rotation where participants were stable for two consecutive weeks in one type of class environment. In addition, the same type of environment was available for an additional week to complete the three-week rotation. This allowed for any unforeseen issues (e.g.

absenteeism, school testing, assembly programs, etc.). Students in Smith's class were scheduled to work in the lab environment for the two weeks. During this time, supply teacher was scheduled to attend to the lab and the pre-kindergarten students while the high school girls participated in their assigned intervention. Students in Jones's class were stationed in the classroom environment and did not move during their interventions. This gave students and uninterrupted two-week period to participate in all aspects of the STEM intervention.

How Self-Efficacy Impacts Practice

The impact of attitudes on practice. Attitude is defined as "positive, negative, or neutral feelings toward some object or behavior (Pryor et al., 2015)." The theory of planned behavior developed by Ajzen (1991) describes a connection between attitude and intention which directly drives behavior indicating a direct link from attitude to action. This theory was successfully applied in several studies attempting to understand the connections between teachers' beliefs, attitudes and resulting behaviors (Milner, Sondergeld, Demir, Johnson, & Czerniak, 2011; Pryor et al., 2015).

Constan and Spicer (2015) researched the impact of a physics outreach program on high school participants. They found that students, after completing the STEM outreach program, exhibited positive attitudes and were more likely to pursue future education and career in STEM as evidenced by future educational plans that they were able to develop. Also, these researchers were able to track participants who had completed the program and found that they indeed did achieve careers in STEM.

Hall et al. (2011) found that student exposure to STEM education and STEM related career fields in K-12 schools is directly related to student interest in corresponding career fields. Students were more likely to enter STEM related careers where their personal interest was higher. When participating college students responded to the question of when they decided to enter engineering, more than 65% indicated that they made their decision in or before high school.

Tseng et al. (2011) investigated the impact of a project-based learning activity on the STEM attitudes of freshmen students. They found that the there was a significant positive increase in STEM attitudes after the intervention. Many students involved in the study indicated have a greater appreciated and understanding of the importance of STEM in science and engineering career fields.

The impact of self-efficacy on practice. According to Albert Bandura's (1997) self-efficacy has a direct impact on behavior and/or performance. He further establishes the sources of self-efficacy as: performance accomplishments, vicarious experience, social persuasion and physiological and emotional states. Bandura (1997) declared that people with low self-efficacy will resist challenging jobs.

Lent's (2003) social cognitive career theory expanded on Bandura's social cognitive theory by applying his theory to careers. From Lent (2003), the major source of self-efficacy is learning experiences. For example, in a recent study conducted by Wendt et al. (2015), female teacher candidates' attitudes and self-efficacy for teaching engineering concepts was gauged using Bandura's self-efficacy model. The researchers found that female teachers' efficacy in STEM increased when they were exposed to modeling, practice and first-hand experiences.

Another example of self-efficacy impacting practice can be seen in the research of Jiang and Zhang (2012). These researchers attempted to predict academic goals of vocational technical middle school students by comparing their self-efficacy and outcome expectations to their academic interests. They were successfully able to apply the SCCT to the target population and confirmed that students' academic interest is directly related to their self-efficacy.

Necessity of Positive Attitudes and Self-Efficacy in Teaching

A person's attitude is defined as an internal determination of positive or negative favor towards an entity and can serve to promote or erode self-efficacy (Kundu & Ghose, 2016). Learning experiences are one major source of a person's attitude and also plays a large part in the development of self-efficacy. Self-efficacy is defined as "people's judgement of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986). Self-efficacy is governed by four basic subcomponents: performance accomplishments, vicarious learning, social persuasion and the combination of physiological states and affective reactions (Bandura, 1997).

Teacher attitudes, practices and beliefs have a greater impact on successful student learning than their qualifications (Palardy & Rumberger, 2008). Teachers elude subject matter instruction when they do not believe that they are sufficiently prepared to teach that subject (Brophy et al., 2008). Using hands-on elementary level STEM interventions have had a positive impact on teachers' attitudes and self-efficacy (Kim et al., 2012; Wendt et al., 2015; Lent et al., 1994; Wigfield et al., 2009). Teachers given appropriate scaffolding are able to engage in educational robotics to increase their content knowledge which could result in greater exposure of STEM concepts for students in regular classrooms (Ortiz et al., 2015).

CHAPTER 3

METHOD

This chapter discusses the method used to conduct the overall research study. This research study uses a 2^3 full factorial design with a single replicate model to determine the impact of STEM and robotics activities on the STEM self-efficacy of African American girls from a low socio-economic status enrolled in Career and Technology Education (CTE) classes in a major metropolitan school district in Jackson, Mississippi.

Population

The target population for this study was African American girls from low socioeconomic families in a large urban school district. The sample was African American high school girls enrolled in the Early Childhood Education CTE classes at the Jackson Public Schools Career Development Center. The course is available to all 11^{th} and 12^{th} grade students from all high schools in the Jackson Public Schools school district. However, students in 10^{th} grade are able to enter the two-year program based on availability. Historically, the vast majority of students enrolled in the Early Childhood Education CTE course at the Jackson Public Schools Career Development Center have been from the African American and female demographics.

On average the course includes four sections of first year students and four sections of second year divided between two teachers. Although they teach the same curriculum and co-plan all activities, the lead teacher delivers the instruction for all class sections. The sample size, on average, is projected to be between 20 to 25 students per class section and eight sections of the course with a total approximate sample size between 160 to 200 girls.

Participant Selection Process and Justification. All students enrolled in the secondary course were recruited to participate. However, initial entry into Early Childhood Education course is selected based on student interested and availability. There are two first-year sections and two second-year sections per instructor giving a total of eight classes of potential participants. The courses are scheduled to meet on alternate weekdays in an AM or PM two and a half hour time block. This group was selected because these girls have selected a non-STEM related career education course for a two-year pathway. Also, the CTE course selected by these students is consistent with a traditional American gender career role for a female as nurturer and caregiver (Domenico & Jones, 2006).

Sample. The participants do not represent a random sample of the population. Choice of course section is beyond the control of the researcher. However, once a section (i.e., AM or PM) is selected, the participants' section will be assigned at random to the type of treatment they will be required to participate in. Populations were grouped according to their assigned classes and received the assigned treatment during those blocks so as not to disrupt the normal school schedule.

Determination of Sample Size. This study used a modified 2^3 full factorial with a single replicate design with a level of two and power of three. Collins, Dziak, Kugler and Trail (2014) described factorial design using similar guidelines having three factors and two levels. As in Collins, et al, (2014), this research study used three interventional elementary level STEM activities that will serve as components: robotics, GoldieBlox and Code.org activities. Collins and his colleagues recommend using the effect size (Cohen standardized difference) of .5 as in their example with an alpha level (α) of .5.

On average, a class section has approximately 15 students enrolled giving a total of 120 students enrolled for both 1st year and 2nd year combined form all eight sections. Using a confidence interval of 95%, a maximum student enrollment population of 120 students and a 5 % margin of error, the sample size can be calculated by hand using the following formula:

$$Sample\ size = \frac{\frac{z^2 * p(1-p)}{e^2}}{1 + \frac{z^2 * p(1-p)}{e^2 N}}$$

where p is the estimate of sample population, N is the population size, e is the margin of error, and z is the z-score. The z-score for a 95 % confidence interval is 1.96. In this formula, p is unknown and therefore estimated to be 50%. After calculation, the minimum sample size needed for this study is 92 students. To guard against type 1 and Type 2 errors, it is standard practice to set $\alpha = .05$ and $\beta = 0.8$ (Prajapati, Dunne, & Armstrong, 2010).

Quasi-Experimental Design

A quasi-experimental design is defined as “experimental situations in which the researcher assigns, but not randomly, participants to groups because the researcher cannot artificially create groups for the experiment (Creswell, 2012).” Quasi-experimental design studies lack randomization in its purest form because of the use of intact groups (Creswell, 2012). The lack of randomization is generally rooted in circumstances surrounding the experimental design that are beyond the researcher’s control. An example of this condition may be that the target population is already in a pre-determined fixed group such as membership in a section of a class. Internal validity can be affected by the use of quasi-experimental designs in contrast to using a standard experimental design (Research Methods Knowledge Base, 2006). When determining the impact of the intervention treatment (elementary STEM projects) on the outcome variables (adolescent girls’ self-efficacy and attitude) other factors inherent to the pre-existing group dynamic could affect the outcome. In sharp contrast, a traditional experimental design affords the researcher the ability to actively assign participants randomly to a level or variation in treatment.

There are specific cases wherein a quasi-experimental design is more appropriate than the traditional experimental design format. For example, in cases where the target populations are members of a pre-existing assigned group and interjecting a change would disrupt the normal flow of an existing process or condition (i.e. school schedule). Another circumstance where a target population cannot be randomly assigned based on a pre-existing condition is when attempting to use matched groups as a focal guide to the outcome of the research effort. Matching groups with respect to some natural condition or correlation prevents a true random sample. For instance, if a researcher wanted to compare SAT scores of adolescents based on their birth order as one of the variables, then a quasi-experimental design is a viable option for conducting this type of study. In particular, the nonequivalent groups design (NEGD) will serve to provide the format for this quasi-experimental design.

Advantages and disadvantages of Quasi-Experimental Design. An advantage of using a quasi-experimental design will allow the researcher to keep the class intact to provide as little disruption to the flow of school/student scheduling. According to Collins, Dziak and Li (2009), another advantage of the factorial design is that researchers can determine interactions between individual characters and experimental factors.

One disadvantage of using a quasi-experimental design is that it leaves the study vulnerable to error in that student selection is not purely random with a limitation being random selection of participants. Participation is based on class schedule availability and student interest.

Potential Errors. There are inherent threats to validity with respect to participants and procedure contained within a quasi-experimental study (Creswell, 2012). Inherent threats related to participants include history, maturation, regression, selection, mortality or a combination of the aforementioned (Creswell, 2012). Similarly, with respect to procedure, inherent threats exist in testing and instrumentation. In contrast, many of these threats are controlled in a pre-test/post-test format if conducted under a factorial design as in the case of this research. Intact groups predetermined by the school registrar were randomly assigned to one of eight treatment variations. Because of this randomization, all potential inherent threats to participants would be controlled (Creswell, 2012). However, the factorial design does not control for instrumentation and testing in the pre-test/post-test format. Potential threats in procedure with respect to instrumentation and testing was factored into the conclusions.

Extraneous Variability. Extraneous variability was controlled by randomly assigning classrooms to the basic treatment. Classrooms were assigned randomly to one of the eight conditions listed below. For example, classroom A could have been assigned to experimental condition five which would mean that this section would engage in the robotics component only. Another classroom, classroom B, could have been assigned to experimental condition three, therefore this section would only participate in the GoldieBlox component. Table 3.1 below contains all possible experimental conditions to which a classroom was randomly assigned.

Table 3.1: Experimental Conditions for Random Class Participation

Experimental Condition	Robotics (Robo)	GoldieBlox (GB)	Hour of Code (HOC)
Control (1)	-	-	-
HOC (2)	-	-	+
GB (3)	-	+	-
GB/HOC (4)	-	+	+
Robo (5)	+	-	-
HOC/Robo (6)	+	-	+
GB/Robo (7)	+	+	-
HOC/GB/Robo (8)	+	+	+

Note. Exposure to STEM activities is reflected with "+" and non-exposure is identified with "-" based on factorial research design.

Students in each intervention type received the various levels of the treatment based on their section. Students in single intervention groups (i.e. two, three and five) spent the entire two-week (5-day) period engaged in activities related to a single type of intervention. Student dual-type treatment groups (i.e. four, six, and seven) split their time in half. They were exposed to half of the treatment time of students from the singe type intervention groups. For example, students in treatment type four split the treatment time between GoldieBlox (GB) and Hour of Code (HOC) and student in treatment three spent the entire duration of their treatment engaged in only GoldieBlox activities. This resulted in students in treatment three spending twice as much time on the GoldieBlox activities than the students in activity four. Students in treatment type eight divided their time by three ways to give each treatment type equal time and attention. However, they spent less time on each treatment type than any other group.

Intervention Format

The intervention was presented in a classroom/lab environment where each student-teacher was required to engage in each treatment component based on their classroom. Prior to participation, each student participant was required to provide parental consent and student assent. Participants over the age of 18 were able to provide adult consent. Students were required to maintain a portfolio of work with the ultimate intent to design lesson plans to incorporate these items in an elementary classroom. One classroom served as the control being assigned to the first experimental condition listed it Table 3.1. In this classroom, no treatment was assigned. In contrast, students in classroom eight received all three components, robotics, GoldieBlox and Hour of Code. All eight conditions were assigned at random to a participating classroom with a total of eight classrooms that participated.

Students were divided into A-Day block and B-Day block scheduling which alternated continuously throughout the school year. The AM Schedule meets from 8:30 AM - 11:15 AM. The PM Schedule meets from 12:15 PM - 3:00 PM. Students enrolled in first year sections are entering the course for the first time and are assumed to have no prior training in Early Childhood Education. Students enrolled in second year courses come with at least one full year of successfully completing the first year of the two-year CTE Course. They should have basic experience developing lessons for “Centers” and “Group Time” which is administered during lab days.

There were eight total sections of the classes with approximately twenty to twenty-five students in each section divided between two teachers (Smith and Jones). Ms. Smith oversees all eight sections with the aid of two assistants. Please note that the names of the teachers used in this study are pseudonyms and are not the actual teachers’ names.

Table 3.2: Treatment Sections of Early Childhood Education Classes

1st Year – A-Day (AM)	2nd Year – A–Day (PM)	2nd Year – B-Day (AM)	1st Year - B-Day (PM)
Smith (4)	Smith (6)	Smith (1)	Smith (5)
Jones (2)	Jones (8)	Jones (3)	Jones (7)

The two-week intervention format for each group under each teacher is outlined in Table 3.3. Both instructors had access to both classroom and lab environments.

Table 3.3: Intervention Group Schedule for Early Childhood Education Classes

Monday **December 3, 2019**	**Tuesday** **December 4, 2019**	**Wednesday** **December 5, 2019**	**Thursday** **December 6, 2019**	**Friday** **December 7, 2019**
Smith **LAB** (1) / (5)	Smith **LAB** (4) / (6)	Smith **LAB** (1) / (5)	Smith **LAB** (4) / (6)	Smith **LAB** (1) / (5)
Jones **Classroom** (3) / (7)	Jones **Classroom** (2) / (8)	Jones **Classroom** (3) / (7)	Jones **Classroom** (2) / (8)	Jones **Classroom** (3) / (7)
Monday **December 10, 2019**	**Tuesday** **December 11, 2019**	**Wednesday** **December 12, 2019**	**Thursday** **December 13, 2019**	**Friday** **December 14, 2019**
Smith **LAB** (4) /(6)	Smith **LAB** (1) / (5)	Smith **LAB** (4) / (6)	Smith **LAB** (1) / (5)	Smith **LAB** (4) / (6)
Jones **Classroom** (2) / (8))	Jones **Classroom** (3) / (7)	Jones **Classroom** (2) / (8)	Jones **Classroom** (3) / (7)	Jones **Classroom** (2) / (8)

There is a three-week rotation between the two teacher loads. For three weeks students in Smith sections will go to the lab to follow the in-house daycare schedule for mornings or afternoon (depending on the class meeting times). During which time, Jones sections met in the classroom, learning theory and concepts as well as developing lesson plans that will be administered during their scheduled lab days.

Process to Assign Participants. Participants were assigned based on classroom section participation. Intact classrooms were assigned randomly to one of the eight conditions listed below. For example, Section 1 could have been assigned to experimental condition five which would mean that this participant would have engaged in the robotics component only. Another classroom, Section B, could have been assigned to experimental condition three. Section B would only participate in the GoldieBlox component. Table 3.4 contains all possible experimental conditions to which a classroom section could be randomly assigned. An online randomization tool that can randomly shuffle numbers from one through eight was used to generate the associated treatment condition that each section will engage. There are several free online random shuffle programs available.

Table 3.4: Sample Random Treatment Assignment for Intact Class Sections

Class Section	Experimental Treatment
Smith A-Day (AM)	GoldieBlox/Hour of Code (4)
Smith A-Day (PM)	Hour of Code/Robotics (6)
Smith B-Day (AM)	Control (1)
Smith B-Day (PM)	Robotics (5)
Jones A-Day (AM)	Hour of Code (2)
Jones A-Day (PM)	GoldieBlox/Hour of Code/Robotics (8)
Jones B-Day (AM)	GoldieBlox (3)
Jones B-Day (PM)	GoldieBlox/Robotics (7)

Note. A computer-based randomization tool was used to determine sample random assignment.

Number of Components Formed. The design was a 2^3 full factorial design. There were three general STEM activity components to the intervention: elementary level robotics, GoldieBlox and Hour of Code.

Number of Levels of Each Factor. There were two levels to each of the three factors. The two levels represented either the participating section receives the treatment exposure or not (See Table 3.5).

Table 3.5: 2^3 Factorial Design Model for Research Study

- *Factor 1* – STEM activities
  - Level 1- Robotics
  - Level 2- GoldieBlox
  - Level 3- Hour of Code
- *Factor 2* – Level of exposure to activities
  - Level 1-No exposure to the STEM activity
  - Level 2-Exposure to the STEM activity

Note. Three types of STEM activities and two levels of exposure to the activity

STEM Treatments. Prior to any exposure to the STEM treatment, each student participant was given the SETS instrument as pre-tests. Next, each student section was assigned an experimental condition (see Table 3.1). The randomly selected experimental condition indicates which STEM activities student sections participated. One or more of the three selected STEM activities, (a) Robotics, (b) GoldieBlox, or (c) Hour of Code based on the group each section was assigned allotting a single section as a control group. For example, students assigned to the fifth experimental condition were only exposed to the Robotics component. Students in the section apportioned to the eighth experimental condition were exposed to all three STEM activities.

An age-appropriate STEM activity was selected to satisfy the thematic unit requirement. The Robotics activity selected for this study was WeDo™ Kids which is specifically designed to introduce robotics concepts to children aged five to seven. The GoldieBlox Kit is designed for children aged over four years old. These kits introduce basic mechanical principles through the application of simple machines. The final selected activity is the Hour of Code developed by Code.org for the pre-reader.

Student sections were exposed to various STEM activities according to their assigned treatment section for the duration of two-weeks allowing students ample time to manipulate the material and develop project lesson plans. After each section completed the two-week treatment, a post-test using the same instruments with questions in random order, was administered in paper and pencil format due to computer lab usage limitations.

Duration of Exposure to the Treatment. The duration of exposure of the treatment was five calendar days spread over alternate days for each student keeping within the two week module. Each treatment section received adjusted time for each treatment task based on the task combination. Participants enrolled in a single treatment type group (i.e. Hour of Code only, GoldieBlox only and Robotics only) spent the entire treatment time of five days on those tasks only. Participants in two-combination section (i.e. Hour of Code/GoldieBlox, and Hour of Code/Robotics and GoldieBlox/Robotics) split the time for each activity type over the five day period. Essentially, each two-combination group spent two and half days on one activity and the reaming two and a half days on the second activity. Finally, Group eight divided the time spent on each of the three activities over the five-day period.

Nugent et al. (2010) determined that robotics instruction can be effectively used to advance STEM learning. These researchers developed two intervention curricula using robotics to determine its impact on STEM learning and attitudes. One intervention was an intensive week-long summer camp and the other intervention was a short-term three-hour course. They found that both the short-term intervention and the week-long summer camp had a positive impact on students' STEM attitudes. However, the week-long intensive camp was found to have made a positive impact on student STEM learning and had a greater impact on students' self-efficacy than the short-term intervention.

The face-to-face contact hours were two and a half hours every other day which gave a total of twelve and a half hours of direct contact. Then the participants were required to develop lesson plans of each treatment component in an elementary classroom with one final lesson representing the lesson they plan to implement as a final project.

Self-Efficacy Instrument

Measuring self-efficacy in STEM using the Social Cognitive Career Theory (SCCT) framework requires an instrument that is reflective of the target adolescent population and vocational education setting (Fouad & Santana, 2017). Specifically, these researchers indicated that the development of math and science self-efficacy were strong indicators of positive results in the STEM domain for middle and high school minority students. Several instruments were evaluated as potential assessments of self-efficacy in STEM. The Technology Grade Self-Efficacy Scale and Sources of Technology Self-Efficacy Scale (Britner & Pajares, 2006) both focus on technology self-efficacy and confidence in middle school students and was used to determine the technology components of STEM self-efficacy in Spanish high school students (Inda-Caro, Rodriguez-Menendez, & Pena-Calvo, 2016). This instrument is limited to only technology and does not address the other subcomponents of STEM specifically.

For this study, the Self-efficacy in Technology and Science (SETS) instrument developed by researchers was determined to be the stronger instrument given that it is composed of all four strands of STEM and has been effectively used to evaluate six basic constructs: science inquiry, Internet usage for basic research, basic computer skill, video-gaming, synchronous chat use and computer gaming (Ketelhut, 2010). All of these components are reflective in the treatment elements GoldieBlox, elementary robotics and Code.org programming. The SETS instrument uses a Likert-type scale and stem response format. Overall, the internal consistency reliability of the SETS instrument is 0.86 (see Table 3.6). Permission from the instrument developer was granted to use this instrument for this study.

Table 3.6: Number of items and estimated internal consistency reliability for each subsection of SETS (n=98)

Self-Efficacy Subsection	Number of Items	Reliability
General Computer Use	11	.80
Problem-solving Computer Use	5	.79
Videogaming	8	.93
Computer Gaming	5	.84
Synchronous Chat Use	10	.92
Inquiry Science	12	.90

Note. Retrieved from Ketelhut (2010).

Justification of Selected Instruments. The SETS instrument for measuring self-efficacy is divided into six constructs that correlate to the types of activities that are included this research treatment. For Inquiry Science, GoldieBlox and elementary robotics activities were reflected. The remaining constructs are centered on computer use and videogaming which correlates to the activities outlined in the popular Hour of Code programming activities. Although the anticipated target population for the instrument is middle school aged students, instruments designed for middle school students have been used with high school students successfully (Inda-Caro, et al, 2016).

Factorial Design Model

Statistical Model. The design used in this study was the factorial design method. Creswell (2012) defined this model as when the researcher studies two or more categories with each having two or more levels per category. According to Creswell, this model will allow the researcher to determine the impact of individual components (main effects), combinations of components (interaction effects) and the overall treatment to provide a composite view of the intervention.

Advantages and Disadvantages of Selected Model. The advantage for using this type of method is the ability to determine intervention components' impact on the overall treatment as well as in combination with other components (Collins, Dziak, Kugler, & Trail, 2014). Creswell (2012) also stated that this design provides a high level of control over the experiment. Collin et al., (2014) identified one limitation of using the factorial model as a skewed view of impact for a component since the overall intervention with all components may provide the best picture of true outcomes. Another disadvantage pointed out by Creswell is that factorial designs can become complex, making the results difficult to decipher.

Essential Assumptions of Selected Model. According to Statistics Solutions (2017), basic assumptions for the factorial design are that (a) interval data of the dependent variables are a metric measurement, (b) there is an approximation of multivariate normal distribution, (c) there is constant variability of error over the entire sample, and (d) there is no multicollinearity. The interval data of self-efficacy will be measured using an instrument that employs a Likert scale to record variability. Each item of the chosen instrument uses the Likert five-point scale for each item. Multicollinearity does not exist between the independent variables. Each STEM activity is a stand-alone activity and will be presented as such.

Hypotheses

The research question was broken down into two major sections: changes in self-efficacy based on class section and changes in self-efficacy as described by SETS constructs. In breaking down the research question, two basic directions resulted in establishing a hypothesis for each sub-condition. In order to effectively guide this research, certain assumptions were made based on the research design. Each in-tact class was assigned a different treatment condition based on the 2^3 full factorial design with a single replicate. For each of the eight resulting treatment conditions, a statistical null hypothesis was presented. The following listing of null hypotheses for each treatment type indicates an expectation of a non-statistically significant effect on student self-efficacy.

1. There is no statistically significant difference overall in STEM self-efficacy of participants in this study regardless of the treatment condition.
2. There is no significant difference between the effects of time and STEM self-efficacy of participants in the control group.
3. There is no significant difference between the effects of the Hour of Code STEM activity and STEM self-efficacy of participants in the Hour of Code only group.
4. There is no significant difference between the effects of the GoldieBlox STEM activity and the STEM self-efficacy of participants in the GoldieBlox only group.
5. There is no significant difference between the effects of the combination of GoldieBlox and Hour of Code STEM activities and STEM self-efficacy of participants in the GoldieBlox/Hour of Code group.
6. There is no significant difference between the effects of the combination of the Robotics STEM activities and STEM self-efficacy of participants in the Robotics only group.
7. There is no significant difference between the effects of the combination of Robotics and Hour of Code STEM activities and STEM self-efficacy of participants in the Robotics/Hour of Code group.
8. There is no significant difference between the effects of the combination of GoldieBlox and Robotics STEM activities and STEM self-efficacy of GoldieBlox/Robotics group.

9. There is no significant difference between the effects of the combination of GoldieBlox, Hour of Code and Robotics STEM activities and STEM self-efficacy of participants in the GoldieBlox/Hour of Code/Robotics group.
10. There is no significant difference between the effects of the overall intervention and the SETS science inquiry construct.
11. There is no significant difference between the effects of the overall intervention and the SETS videogaming construct.
12. There is no significant difference between the effects of the overall intervention and the SETS computer gaming construct.
13. There is no significant difference between the effects of the overall intervention and the SETS general construct.
14. There is no significant difference between the effects of the overall intervention and the SETS problem solving construct.
15. There is no significant difference between the effects of the overall intervention and the SETS synchronous chat construct.

Data Analysis

The research question for this study was broken down into two potential areas of impact: (a) measuring changes in STEM self-efficacy based on overall data and class section and (b) measuring changes in areas of STEM self-efficacy as described by SETS constructs. To address the first area of impact, the pre-test post-test data for each student was collected and separated based on the student’s class section. An overall analysis was conducted to determine whether there was any change in self-efficacy score as a result of basic participation in the study as a whole. A paired samples T-test is generally used when evaluating mean scores from two different points in time of the same population as in this study's pre-test/post-test data for each class sections. Each member of the population was measured twice to determine any statistical changes in their individual performance data. The paired data collected from each individual participant is averaged across the class section to determine if an overall change occurred for that class section as a whole. Hypotheses 1-9 represent the null assumptions associated with changes in self-efficacy based on the overall performance of the group as a whole and separate performance data based on class section. If a statistically significant result was found, additional paired samples T-tests were conducted to determine which area of the SETS instrument the most growth occurred. If no statistically significant result was found, no additional tests were conducted.

To address the second area of impact regarding changes in overall STEM self-efficacy as described by the SETS constructs, an analysis of covariance (ANCOVA) was used. According to Andy Field (2016), ANCOVA is generally applied to data when a researcher wants to determine if any main and interactive effects of the independent variables have any influence on a dependent variable, controlling for the effects of a covariate. The control variable is the covariate. Simply put, the ANCOVA will determine if the dependent variable is equal over all potential levels of an independent variable and its interactions, in this case, class section.

This is a 2^k full factorial with a single repeater research design which takes into account all possible interactions between three main variables. There were eight resulting possible combinations, including a control group. These combinations represent interactions between the three main components of the STEM intervention: Hour of Code, GoldieBlox and Robotics. The combinations also represent the different treatment types assigned to each class section. In order to learn what influence the main components and their interactions have on STEM self-efficacy based on the SETS constructs, an ANCOVA was run where the independent variable was the class section, the dependent variable was the post-test and the covariate was the pre-test. Only statistically significant results were reported. This research design and the procedures followed were similar to those used by other researchers to answer similar research questions (Leonard, Buss, Gamboa, Mitchell, Fashola, Hubert, T. and Almughyirah, 2016; Nugent, et al., 2010). The hypotheses for 1-9 are not related to the hypotheses for 10-15 because these two sets of hypotheses answer two different impact questions and are treated with separate analyses.

Prior to beginning the treatments, participating students received a pre-test using the SETS 51-question instrument followed by the same instrument as a post-test after receiving the treatment assigned to that class section. An item analysis of each construct of the instrument was collected and inputted into the IBM Statistical Package for Social Sciences (SPSS) software for comparison with post-test data collected immediately following the two-week treatment.

The 51-question instrument is divided into six constructs: science inquiry, videogaming, computer gaming, general, problem solving, and synchronous chat. Each construct was evaluated on changes in self-efficacy overall and based on intervention type. Negatively worded items were recoded prior to calculating any variables. Separate construct variables were created to calculate the mean for each section.

Using an online virtual format, students were surveyed on self-efficacy. The SETS instrument uses a Likert-type response with a range of choices were from 1-5 where “1” represented strongly disagree and “5” represents strongly agree. Students were required to answer all questions in each section prior to moving on to the next question. As an alternative, the paper and pencil version of the SETS survey was used when computer lab access was limited or upon student request. Once all data had been collected and stored in SPSS, a paired samples T-test was used to calculate any change in overall STEM self-efficacy and that of each section representing the separate treatment conditions.

Further analysis to determine the influence that type of intervention may have had on the students' self-efficacy based on the six SETS constructs and overall was conducted using an analysis of covariance (ANCOVA). The independent variable was the section (intervention type) and the dependent variable was the post-test score. The pre-test score was used as the covariate.

There are preliminary assumptions that must be tested and confirmed prior to running an ANCOVA. According to Field (2016), the two main assumptions that must be met prior to considering the ANCOVA are (a) independence of covariate and treatment, (b) homogeneity of regression. The preliminary assumptions for each SETS construct were calculated using SPSS using Levene's test of equity of error variance and the test of between-subjects effects generated from the interaction effects of the overall construct score and section variable by SPSS. In the cases where the preliminary assumptions are not met, a set of descriptive statistics are used to define the results encountered. In those cases where the preliminary assumptions were met, the between-subjects effects ANCOVA was run to determine the construct's final significance level. Finally, if the preliminary assumptions for ANCOVA were met and significant results were shown by the final ANCOVA, a pairwise comparison of the control group with all other treatment conditions for that specific SETS construct was evaluated to determine if any significance occurred as a result of the different treatment conditions. The results are then reported along with the statistical data for that construct.

CHAPTER 4

RESULTS

The primary focus of this study was to determine the impact of STEM and robotics activities on the self-efficacy of African American girls enrolled in an Early Childhood Education Career and Technical Education (CTE) course from a large metropolitan urban school district in Jackson Mississippi. Jackson Public Schools has 100% participation in Title 1 funding. All students receive free or reduced lunch. This section discusses the results of the data produced from the pretest/posttest factorial research design research intervention model. The data collected was analyzed using the IBM SPSS software package.

Data Collection Process

The majority of all high school Career and Technical Education programs for Jackson Public Schools are centrally located at the Jackson Public Schools Career Development Center. Students enrolled in these programs are bussed in and out twice a day from their various high schools to participate in the classes. The two Early Childhood Education teachers encouraged all students to be present each day. One hundred and three students assented and had parental consent to participate in this study within the context of their classroom settings. Several of the students were 18 years old and were able to provide adult consent for themselves. Observations and attendance show that all 103 students participated in the pre-test, however a total of 99 students completed both pre-test and post-test data.

For various reasons, several anticipated participants were eliminated. High absenteeism for the CTE course were a result of home school obligations which prevented students from attending the class. Several students enrolled in the course did not attend the class to complete school district testing. Two students did not complete both pre-test and post-test In addition, four students declined to participate in the study. Three boys were enrolled in the courses; however, their data was not included. Overall, 11% of the potential participants were not included in the study results.

Table 4.1: Participants by Class Section

Class Section	Number of Participants (Smith)		Number of Participants (Jones)	
	Pre-Test	*Post-Test*	*Pre-Test*	*Post-Test*
A-Day (AM)	*16*	*14*	*10*	*10*
A-Day (PM)	*12*	*11*	*14*	*14*
B-Day (AM)	*16*	*16*	*8*	*8*
B-Day (PM)	*15*	*14*	*12*	*12*
Total	*59*	*55*	*45*	*44*

Note. Data reflects actual participants and not the enrollment count.

Although the dates for the study were scheduled well in advance of arrival, an unplanned field trip was re-scheduled halfway through the treatment. It was eventually cancelled due to transportation issues. However, student participants used more than half of the class time to re-focus on the study materials.

Several students were excused from the study for short periods of time to participate in the Career and Technical Student Organization (HOSA). After these unplanned meetings, students returned to the treatment and continued the study. The students were working towards preparing for their annual induction ceremonies, which also interrupted class briefly.

Analysis

The SETS instrument contains both positive and negative questions. The negative style questions had to be recoded such that the score was reversed. Additional variables were created for the overall pre-post test score and each individual construct of the SETS instrument so that self-efficacy on these subscales could be evaluated. A basic calculation of overall pre-post test mean scores on the overall and individual constructs is presented for each experimental condition in Table 4.2. Further analysis of the impact of the type of intervention on student self-efficacy using ANCOVA testing on the six basic constructs of the SETS instrument is also presented. Each hypothesis is included in this section for evaluation of each condition.

Table 4.2: Mean Pre-test & Post-Test Scores by SETS Construct

Section	**Test**	**N**	**Science Inquiry**	**Videogaming**	**Computer Gaming**	**General**	**Problem Solving**	**Synchronous Chat**
Control	*Pre-Test*	16	3.77	3.75	3.79	4.51	4.04	3.83
	Post-Test	16	3.98	3.7	3.78	4.59	4.03	4.24
Hour of Code	*Pre-Test*	10	3.21	2.95	2.90	3.43	2.22	3.48
	Post-Test	10	3.55	3.36	3.98	3.82	2.58	3.90
GoldieBlox	*Pre-Test*	8	3.47	3.42	3.3	3.83	4.18	3.55
	Post-Test	8	4.16	4.16	4.08	4.74	4.63	4.52
GoldieBlox/Hour of Code	*Pre-Test*	16	3.97	3.94	2.23	4.47	4.3	3.9
	Post-Test	14	4.07	4.33	4.13	4.54	4.1	4.04
Robotics	*Pre-Test*	15	3.64	3.44	3.17	3.59	3.44	3.45
	Post-Test	14	3.67	3.67	3.39	3.65	3.71	3.65
Hour of Code/Robotics	*Pre-Test*	12	3.83	3.77	3.62	4.15	4.28	3.73
	Post-Test	11	3.65	3.88	3.96	4.17	3.85	3.91
GoldieBlox/Robotics	*Pre-Test*	12	3.4	3.41	2.82	3.38	3.82	3.26
	Post-Test	12	3.42	3.38	3.43	3.6	3.43	3.77
GoldieBlox/Hour of Code/Robotics	*Pre-Test*	14	3.45	3.46	3.07	3.7	3.79	3.36
	Post-Test	14	3.59	3.08	3.77	4.01	3.77	3.72

Note: Pre-Posttest scores calculated using SPSS 25.

Overall. The overall null hypothesis stated: There is no statistically significant difference overall in STEM self-efficacy of participants in this study regardless of the treatment condition. Based on general descriptive statistics overall post-test scores showed an increase compared to overall pre-test scores. The overall pre-test mean score was 3.699. The overall post-test score was 3.928. A paired samples T-test was conducted where the overall means of the pre-test and post-test were compared as a whole group. The data showed that overall there was a statistically significant increase in STEM self-efficacy as a result of the intervention treatments with t = 3.231, p = .002 (see Table 4.3). The null hypothesis is rejected.

Overall, with respect to SETS constructs, there was a statistically significant finding in science inquiry (t = 2.730, p = .008), computer gaming (t = 5.862, p = .000) and synchronous chat (t = 3.487, p = .001).

Table 4.3 Overall Self-efficacy Paired Samples T-test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Overall_Pre - Overall_Post	-.22768	.70120	.07047	-.36753	-.08782	-3.231	98	.002
Pair 2	SI_Pre - SI_Post	-.22616	.82432	.08285	-.39057	-.06175	-2.730	98	.008
Pair 3	VG_Pre - VG_Post	-.09657	1.09313	.10986	-.31459	.12146	-.879	98	.382
Pair 4	CG_Pre - CG_Post	-.71717	1.21723	.12234	-.95994	-.47440	-5.862	98	.000
Pair 5	Gen_Pre - Gen_Post	-.16838	1.03805	.10433	-.37542	.03865	-1.614	98	.110
Pair 6	SC_Pre - SC_Post	-.31424	.89667	.09012	-.49308	-.13540	-3.487	98	.001
Pair 7	PS_Pre - PS_Post	.09697	1.16141	.11673	-.13467	.32861	.831	98	.408

The overall self-efficacy scores show a statistically significant gain over the course as a whole after the STEM interventions. Further analysis was needed to determine where the gains occurred. There were non-statistically significant findings in the remaining overall construct areas: videogaming, general and problem solving.

Results based on Class Section

Based on the factorial model, each class received different versions of STEM intervention to give more insight into which STEM activity resulted in the greatest and weakest impact. The results based on this data are included in this section.

Section 1: Control. The control group received no treatment. A total of 16 students participated in this class section. All students took the pre-test and post-test. The pre-test and post-test mean scores overall and for each subsection of the SETS instrument is shown in Table 4.4.

Table 4.4: Control Group Mean Scores by SETS Subsections

	Test	N	Mean	Std. Deviation	Std. Error Mean
Overall_Score	Pre-Test	16	3.9559	.40117	.10029
	Post-Test	16	4.0980	.37464	.09366
Synchronous_Chat	Pre-Test	16	3.8295	.59463	.14866
	Post-Test	16	4.2443	.33807	.08452
Problem_Solving	Pre-Test	16	4.0375	.94154	.23539
	Post-Test	16	4.0250	.99029	.24757
General	Pre-Test	16	4.5114	.47861	.11965
	Post-Test	16	4.5909	.43026	.10757
Computer_Gaming	Pre-Test	16	3.7875	.54391	.13598
	Post-Test	16	3.7750	.64446	.16112
Videogaming	Pre-Test	16	3.7422	.60116	.15029
	Post-Test	16	3.7031	.69653	.17413
Science_Inquiry	Pre-Test	16	3.7708	.51415	.12854
	Post-Test	16	3.9792	.52042	.13010

Based on descriptive statistics, an increase in self-efficacy mean scores was observed in synchronous chat, general, and science inquiry constructs. There was also a slight decline in mean scores in several other constructs: problem solving, computer gaming, and videogaming. A paired samples T-test was used to evaluate the differences with respect to the overall mean scores and each construct (see Table 4.5). Overall, the data failed to reject the null hypothesis. As expected there was no statistically significant difference in the overall score.

Table 4.5: Paired Samples T-test Control Group

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Overall_Pre - Overall_Post	-.16062	.48804	.12201	-.42068	.09943	-1.317	15	.208

Section 2: Hour of Code. This section received the online coding activity created by Code.org entitled Hour of Code. The specific activity was Kodable which has its own educational gaming curriculum. A total of 10 students participated in this class section. All students took the pre-test and post-test. The pre-test and post-test mean scores overall and for each construct for the SETS instrument is shown in Table 4.6.

Table 4.6: Section 2 Group Means Scores by SETS Subsections

	Test	N	Mean	Std. Deviation	Std. Error Mean
Overall_Score	*Pre-Test*	10	3.1400	.25526	.08072
	Post-Test	10	3.5940	.25352	.08017
Science_Inquiry	*Pre-Test*	10	3.2091	.37617	.11896
	Post-Test	10	3.5455	.28102	.08887
Videogaming	*Pre-Test*	10	2.9500	.49371	.15612
	Post-Test	10	3.3625	.37477	.11851
Computer_Gaming	*Pre-Test*	10	2.9000	.73182	.23142
	Post-Test	10	3.9800	.31903	.10088
General	*Pre-Test*	10	3.4273	.45767	.14473
	Post-Test	10	3.8182	.34284	.10842
Problem_Solving	*Pre-Test*	10	2.2200	.49396	.15620
	Post-Test	10	2.5800	.95893	.30324
Synchronous_Chat	*Pre-Test*	10	3.4800	.42374	.13400
	Post-Test	10	3.9000	.45461	.14376

The null hypothesis was that there is no significant difference between the effects of the Hour of Code STEM activity and STEM self-efficacy of participants in the Hour of Code only group. Based on descriptive data, self-efficacy mean scores increased overall. Also, there were observed increases in mean scores for all SETS constructs. To further determine the level of significance of the observed data, a paired samples T-test was used to evaluate the differences in mean scores (see Table 4.7). Overall, the data failed to reject the null hypothesis. The overall self-efficacy score for the Hour of Code only group was t = .784, p = .453).

4.7: Paired Samples T-test for Section 2

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Overall_Pre - Overall_Post	-.20000	.80631	.25498	-.77680	.37680	-.784	9	.453

Section 3: GoldieBlox. This section received the STEM treatment with GoldieBlox only. A total of 8 students participated in this class section. All students took the pre-test and post-test. The pre-test and post-test mean scores overall and for each subsection of the SETS instrument is shown in Table 4.8. The null hypothesis for this section was that there is no significant difference between the effects of GoldieBlox and the stem self-efficacy of participants in this group.

Table 4.8: Section 3 Group Means Scores by SETS Subsections

	Test	N	Mean	Std. Deviation	Std. Error Mean
Overall_Score	Pre-Test	8	3.6152	.50253	.17767
	Post-Test	8	4.3824	.17569	.06212
Science_Inquiry	Pre-Test	8	3.4688	.58746	.20770
	Post-Test	8	4.1563	.47022	.16625
Videogaming	Pre-Test	8	3.4219	.74083	.26192
	Post-Test	8	4.1563	.62945	.22254
Computer_Gaming	Pre-Test	8	3.3000	.74833	.26458
	Post-Test	8	4.0750	.76298	.26976
General	Pre-Test	8	3.8295	.87256	.30850
	Post-Test	8	4.7386	.46719	.16518
Problem_Solving	Pre-Test	8	4.1750	.86479	.30575
	Post-Test	8	4.6250	.48329	.17087
Synchronous_Chat	Pre-Test	8	3.5455	.81166	.28697
	Post-Test	8	4.5227	.21041	.07439

Based on observed data, the mean self-efficacy scores increased overall. Also, there was an increase in mean scores for all other SETS constructs. A paired samples T-test was used to evaluate the differences with respect to the overall mean scores and each SETS construct (see Table 4.9). An overall statistically significant result was found, t = 4.006, p = .005. The null hypothesis was rejected.

Further analysis of the subsections showed statistically significant findings for five of the six SETS constructs: science inquiry (t = -3.999, p = .005), videogaming (t = 3.538, p =.009), computer gaming (t = 2.946, p = .022), general (t = 2.652, p = .033), and synchronous chat (t = 2.866, p = .024).

Table 4.9: Paired Samples T-test Section 3

		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper	t	df	Sig. (2-tailed)
Pair 1	Overall_Pre - Overall_Post	-.77750	.54894	.19408	-1.23643	-.31857	-4.006	7	.005
Pair 2	SI_Pre - SI_Post	-.73125	.51726	.18288	-1.16369	-.29881	-3.999	7	.005
Pair 3	VG_Pre - VG_Post	-.73500	.58754	.20773	-1.22619	-.24381	-3.538	7	.009
Pair 4	CG_Pre - CG_Post	-.77500	.74402	.26305	-1.39702	-.15298	-2.946	7	.022
Pair 5	Gen_Pre - Gen_Post	-.91000	.97057	.34315	-1.72141	-.09859	-2.652	7	.033
Pair 6	SC_Pre - SC_Post	-.88750	.87576	.30963	-1.61966	-.15534	-2.866	7	.024
Pair 7	PS_Pre - PS_Post	-.45000	.92428	.32678	-1.22271	.32271	-1.377	7	.211

Section 4: GoldieBlox/Hour of Code. This section of participants received the treatment combination of GoldieBlox and Hour of Code to determine if there was any significant difference in self-efficacy between-subjects. A total of 16 students participated in the pre-test. However, only 14 students took the post-test. Although all students participated in the activity, two students from this section were not present to take the post-test. This section’s pre-test and

post-test mean scores overall and for each subsection of the SETS instrument is shown in Table 4.10.

Table 4.10: Section 4 Group Means Scores by SETS Subsections

	Test	N	Mean	Std. Deviation	Std. Error Mean
Overall_Score	*Pre-Test*	16	3.9191	.40634	.10158
	Post-Test	14	4.2143	.55195	.14751
Science_Inquiry	*Pre-Test*	16	3.9688	.78107	.19527
	Post-Test	14	4.0655	.71848	.19202
Videogaming	*Pre-Test*	16	3.9375	.79582	.19896
	Post-Test	14	4.3304	.76209	.20368
Computer_Gaming	*Pre-Test*	16	2.2250	.93488	.23372
	Post-Test	14	4.1286	.91687	.24505
General	*Pre-Test*	16	4.4659	.53821	.13455
	Post-Test	14	4.5390	.59822	.15988
Problem_Solving	*Pre-Test*	16	4.3000	.74476	.18619
	Post-Test	14	4.1000	.74730	.19973
Synchronous_Chat	*Pre-Test*	16	3.9000	.77546	.19386
	Post-Test	14	4.0429	.83086	.22206

Based on observed data, self-efficacy scores increased overall. Mean scores increased in several other constructs: science inquiry, videogaming, computer gaming, general, and synchronous chat. There was a slight decline in mean scores for the problem solving construct. A paired samples T-test was used to evaluate the differences with in mean scores overall (see Table 4.11). Overall, the data failed to reject the null hypothesis. The overall self-efficacy score for the Hour of Code only group was t = 1.818, p = .092).

Table 4.11: Paired Samples T-test Section 4

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Overall_Pre - Overall_Post	-.28429	.58519	.15640	-.62216	.05359	-1.818	13	.092

Section 5: Robotics. This section received the robotics only treatment. A total of 15 students participated in the pre-test. However, only 14 students took the post-test. Although all students participated in the activity, one student from this section declined to take the post-test due to illness indicated during class. This section's pre-test and post-test mean scores overall and for each subsection of the SETS instrument are shown in Table 4.12. Based on the observed mean scores for each of the six constructs, self-efficacy mean scores increased overall and within each SETS construct.

Table 4.12: Section 5 Group Means Scores by SETS Subsections

	Test	N	Mean	Std. Deviation	Std. Error Mean
Overall_Score	*Pre-Test*	15	3.4980	.41948	.10831
	Post-Test	14	3.6373	.59333	.15857
Science_Inquiry	*Pre-Test*	15	3.6444	.51608	.13325
	Post-Test	14	3.6667	.84543	.22595
Videogaming	*Pre-Test*	15	3.4417	.44034	.11370
	Post-Test	14	3.6696	.56884	.15203
Computer_Gaming	*Pre-Test*	15	3.1733	.78510	.20271
	Post-Test	14	3.3857	1.00908	.26969
General	*Pre-Test*	15	3.5939	.73202	.18901
	Post-Test	14	3.6494	.82079	.21936
Problem_Solving	*Pre-Test*	15	3.4400	.70993	.18330
	Post-Test	14	3.7143	.88305	.23601
Synchronous_Chat	*Pre-Test*	15	3.4533	.57429	.14828
	Post-Test	14	3.6500	.75422	.20157

A paired samples T-test was conducted to determine if any of the increased mean scores surpassed the level of statistical significance. The results of the independent samples T-test resulted in a non-statistically significant result (see Table 4.13). This group intervention failed to reject the null hypothesis, $t = .670$, $p = .515$.

During the course of this section's study intervention, class time was interrupted. On two separate days, impromptu meetings with the Career and Technical Student Organization (HOSA) were called in preparation for induction ceremonies. Also, several students lost significant engagement with the robotics material to attend these meetings. Another unplanned interruption occurred halfway through the intervention treatment when a re-scheduled field trip was cancelled at the last minute due to transportation issues. Students expended more than half the class period discussing the field trip. They finally regained focus on the study and were able to use the second half of the class time to continue with the treatment.

Table 4.13: Paired Samples T-test for Section 5

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Overall_Pre - Overall_Post	-.13857	.77443	.20697	-.58571	.30857	-.670	13	.515

Section 6: Hour of Code/Robotics. This section received the combination treatment of Hour of Code and robotics. A total of 12 students participated in the pre-test. However, only 11 students took the post-test. Although all students participated in the activity, one student was absent from class and did not take the post-test. This section's pre-test and post-test mean scores overall and for each subsection of the SETS instrument is shown in Table 4.14.

Based on observed data, self-efficacy means scores increased overall. The means scores increased on several SETS constructs: videogaming, computer gaming, general and synchronous chat. There was a decline in self-efficacy mean scores for the science inquiry and problem solving constructs.

Table 4.14: Section 6 Group Means Scores by SETS Subsections

	Test	N	Mean	Std. Deviation	Std. Error Mean
Overall_Score	*Pre-Test*	12	3.8954	.48017	.13861
	Post-Test	11	3.9002	.77784	.23453
Science_Inquiry	*Pre-Test*	12	3.8333	.49365	.14250
	Post-Test	11	3.6515	.74890	.22580
Videogaming	*Pre-Test*	12	3.7708	1.09081	.31489
	Post-Test	11	3.8750	.95688	.28851
Computer_Gaming	*Pre-Test*	12	3.6167	.70043	.20220
	Post-Test	11	3.9636	.88008	.26535
General	*Pre-Test*	12	4.1515	.74092	.21388
	Post-Test	11	4.1736	.94777	.28576
Problem_Solving	*Pre-Test*	12	4.2833	.82884	.23926
	Post-Test	11	3.8545	1.12460	.33908
Synchronous_Chat	*Pre-Test*	12	3.7333	.73526	.21225
	Post-Test	11	3.9091	.94811	.28587

A paired samples T-test was used to evaluate the differences with respect to the overall mean scores and each sub section. No statistically significant result was found (see Table 4.15). This group intervention failed to reject the null hypothesis, t = .189, p = .854.

Table 4.15: Paired Samples T-test for Section 6

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Overall_Pre - Overall_Post	-.05182	.90881	.27402	-.66237	.55873	-.189	10	.854

Section 7: GoldieBlox/Robotics. This section received the combination STEM treatment of GoldieBlox and robotics. A total of 12 students participated in the pre-test and post-test. For this section, there was no statistically significant difference in the overall mean score. This section's pre-test and post-test mean scores for each subsection of the SETS instrument is shown in Table 4.16. Based on observed data, self-efficacy mean scores increased in several SETS

constructs: videogaming, computer gaming, general and synchronous chat. There was a decline in mean scores for science inquiry and problem solving.

Table 4.16: Section 7 Group Means Scores by SETS Subsections

	Test	N	Mean	Std. Deviation	Std. Error Mean
Science_Inquiry	*Pre-Test*	12	3.3958	.51385	.14834
	Post-Test	12	3.4167	.63365	.18292
Videogaming	*Pre-Test*	12	3.4063	.57189	.16509
	Post-Test	12	3.3750	.66572	.19218
Computer_Gaming	*Pre-Test*	12	2.8167	.52886	.15267
	Post-Test	12	3.4333	.85635	.24721
General	*Pre-Test*	12	3.3788	.87955	.25390
	Post-Test	12	3.5985	.73902	.21334
Problem_Solving	*Pre-Test*	12	3.8167	.86322	.24919
	Post-Test	12	3.4333	1.04040	.30034
Synchronous_Chat	*Pre-Test*	12	3.2583	.91895	.26528
	Post-Test	12	3.7667	.78316	.22608

A paired samples T-test was used to evaluate the differences with respect to the overall mean scores and each sub section. No statistically significant result was found (see Table 4.17). This group intervention failed to reject the null hypothesis.

Table 4.17: Paired Samples T-test Section 7

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Overall_Pre - Overall_Post	-.19833	.89682	.25889	-.76815	.37148	-.766	11	.460

Section 8: Hour of Code/GoldieBlox/Robotics. This section received the full combination STEM treatment of Hour of Code, GoldieBlox and robotics. A total of 14 students participated in the pre-test and post-test. This section's pre-test and post-test mean scores for each subsection of the SETS instrument is shown in Table 4.18. Based on observed data, there

was in increase in self-efficacy mean scores overall. Also, there was an increase in mean scores for synchronous chat, general, computer gaming, and science inquiry. A decline in self-efficacy mean scores was observed in problem solving and videogaming.

Table 4.18: Section 8 Group Means Scores by SETS Subsections

	Test	N	Mean	Std. Deviation	Std. Error Mean
Synchronous_Chat	Pre-Test	14	3.3643	.55692	.14884
	Post-Test	14	3.7214	.76176	.20359
Problem_Solving	Pre-Test	14	3.7857	.73365	.19608
	Post-Test	14	3.7714	1.01635	.27163
General	Pre-Test	14	3.7013	.85980	.22979
	Post-Test	14	4.0130	.79960	.21370
Computer_Gaming	Pre-Test	14	3.0714	.64977	.17366
	Post-Test	14	3.7714	.94089	.25146
Videogaming	Pre-Test	14	3.4554	.68747	.18373
	Post-Test	14	3.0804	.93619	.25021
Science_Inquiry	Pre-Test	14	3.4464	.55045	.14711
	Post-Test	14	3.5893	.58238	.15565
Overall_Score	Pre-Test	14	3.4832	.48340	.12919
	Post-Test	14	3.6625	.60899	.16276

A paired samples T-test was used to evaluate the differences with respect to the overall mean scores and each sub section. A non-statistically significant result was found overall, t = 1.341, p = .203 (see Table 4.19). The data failed to reject the null hypothesis.

Table 4.19: Paired Samples T-test for Section 8

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Overall_Pre - Overall_Post	-.20571	.57418	.15346	-.53724	.12581	-1.341	13	.203

Table 4.20: Overall Significance for Experimental Conditions

Experimental Condition	T	P
Overall*	-3.231	.002*
Control	-1.317	.203
HOC	-.784	.453
GB*	-4.006	.005*
Robo	-.670	.515
HOC/Robo	-.189	.854
HOC/GB	-1.818	.092
GB/Robo	-.766	.460
HOC/GB/Robo	-1.431	.203

*Result is statistically significant.

Interaction effects of the various STEM components did not yield a statistically significant result (see Table 4.20).

ANCOVA Analysis of SETS Constructs

In order to further evaluate the impact of the overall STEM treatments on student self-efficacy controlling for the pre-test score with the treatment section used as the fixed factor, an ANCOVA was conducted for each SETS construct. The dependent variable was the post-test, the independent variable was section and the covariate was pre-test. The first step in conducting the ANCOVA included evaluating the data to pass preliminary assumptions.

Overall Post-Test. The overall pre-test data did not pass the preliminary assumption for homogeneity of variance. The Levene's test yielded a statistically significant result which indicated there is a heterogeneous result across section based on the overall pre-test score (See Table 4.21: Levene's Test of Equality of Error Variance Pre-Test).

Table 4.21: Levene's Test of Equality of Error Variances[a] –Pre-test

Dependent Variable: Post_Test

F	df1	df2	Sig.
4.367	7	91	.000

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Pre-Test+ Section

The second assumption concerning the homogeneity of regression slopes passed as indicated in the Table 4.22. The results showed there was a non-statistically significant difference between sections after controlling for the pre-test, F(7, 83) = .575, p = .774.

4.22: Tests of Between-Subjects Effects – Pre-Test

Dependent Variable: Post_Test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	8.661[a]	15	.577	1.791	.050
7Intercept	18.009	1	18.009	55.875	.000
Section	1.339	7	.191	.593	.760
Pre_Test	.113	1	.113	.350	.556
Section * Pre_Test	1.297	7	.185	.575	.774
Error	26.752	83	.322		
Total	1562.965	99			
Corrected Total	35.413	98			

a. R Squared = .245 (Adjusted R Squared = .108)

Since both assumptions were not met, the ANCOVA results controlling for the pre-test are not included in this report.

Science Inquiry Construct. An ANCOVA for the science inquiry construct pre-test and post-test scores for each section was conducted to determine the impact of the treatment by section on students’ overall self-efficacy in the science inquiry domain. The science inquiry scores are represented by the mean scores of student responses to questions 1-12 on the overall

SETS instrument. Preliminary assumptions for running the ANCOVA were met. According to the Levene's test for homogeneity of variance (see Table 4.23), a non-statistically significant result was found indicating the data is homogeneous across the data levels.

4.23: Levene's Test of Equality of Error Variances[a] – Science Inquiry

Dependent Variable: SI_Post

F	df1	df2	Sig.
.826	7	91	.568

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + SI_Pre + Section

The second assumption for a non-statistically significant result for the homogeneity of regression slopes was met, $F(7, 83) = 1.116$, $p = .361$ (see Table 4.24).

4.24: Tests of Between-Subjects Effects
Dependent Variable: SI_Pre

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6.071[a]	15	.405	1.208	.282
Intercept	14.921	1	14.921	44.544	.000
Section	3.044	7	.435	1.298	.261
SI_Post	.379	1	.379	1.131	.291
Section * SI_Post	2.617	7	.374	1.116	.361
Error	27.803	83	.335		
Total	1353.021	99			
Corrected Total	33.874	98			

a. R Squared = .179 (Adjusted R Squared = .031)

With both assumptions being met, the ANCOVA was assessed. There was no significant effect on self-efficacy in science inquiry controlling for the treatment section, $F(7, 90) = 1.792$, $p = .098$ (see Table 4.25).

4.25: Tests of Between-Subjects Effects – Science Inquiry

Dependent Variable: SI_Post

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4.860[a]	8	.608	1.642	.124	.127
Intercept	32.789	1	32.789	88.631	.000	.496
SI_Pre	.008	1	.008	.023	.881	.000
Section	4.642	7	.663	1.792	.098	.122
Error	33.295	90	.370			
Total	1525.826	99				
Corrected Total	38.155	98				

a. R Squared = .127 (Adjusted R Squared = .050)

Videogaming Construct. An ANCOVA for the videogaming construct pre-test and post-test scores for each section was conducted to determine the impact of the treatment by section on students' overall self-efficacy in the videogaming domain. The videogaming scores are represented by the mean scores of student responses to questions 13-20 on the overall SETS instrument. Preliminary assumptions for running the ANCOVA were met. According to the Levene's test for homogeneity of variance (see Table 4.26), a non-statistically significant result was found indicating the data is homogeneous across the data levels.

4.26: Levene's Test of Equality of Error Variances[a] - Videogaming

Dependent Variable: VG_Post

F	df1	df2	Sig.
.959	7	91	.466

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + VG_Pre + Section

The second assumption for a non-statistically significant result for the homogeneity of regression slopes was met, $F(7, 83) = .887$, $p = .521$ (see Table 4.27).

4.27: Tests of Between-Subjects Effects – Videogaming

Dependent Variable: VG_Post

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	18.627[a]	15	1.242	2.015	.023
Intercept	42.572	1	42.572	69.093	.000
Section	5.272	7	.753	1.222	.300
VG_Pre	.046	1	.046	.075	.785
Section * VG_Pre	3.825	7	.546	.887	.521
Error	51.141	83	.616		
Total	1452.671	99			
Corrected Total	69.768	98			

a. R Squared = .267 (Adjusted R Squared = .135)

With both assumptions being met, the ANCOVA was assessed. The results show that there was a statistically significant effect of videogaming by treatment sections, $F(7, 90) = 3.451$, $p = .003$ (see Table 4.28).

4.28: Tests of Between-Subjects Effects - Videogaming

Dependent Variable: VG_Post

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	14.802[a]	8	1.850	3.029	.005	.212
Intercept	55.531	1	55.531	90.924	.000	.503
VG_Pre	.307	1	.307	.503	.480	.006
Section	14.754	7	2.108	3.451	.003	.212
Error	54.966	90	.611			
Total	1452.671	99				
Corrected Total	69.768	98				

a. R Squared = .212 (Adjusted R Squared = .142)

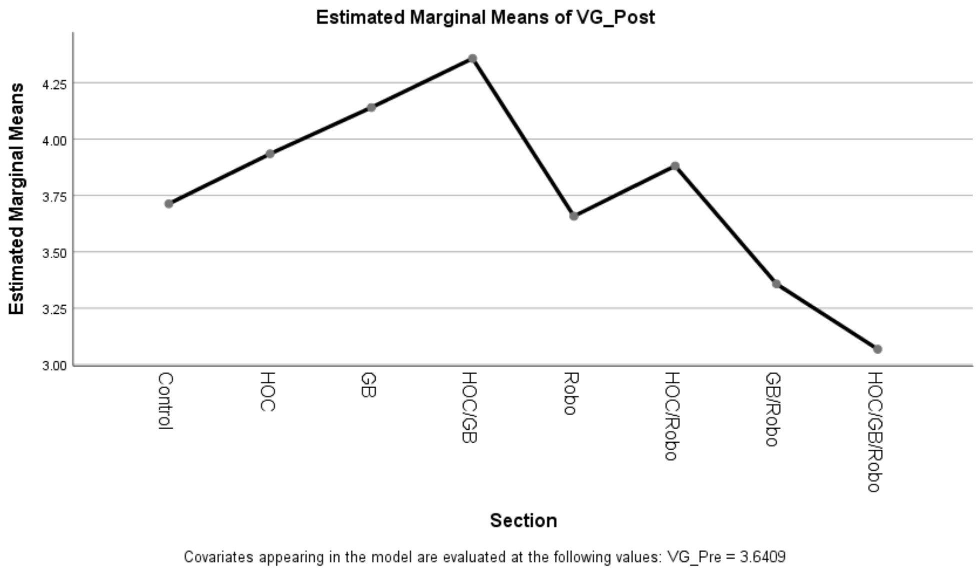


Figure 4.1. Estimated Marginal Means of VG_Post

The mean for videogaming declined in the GB/Robo and HOC/GB/Robo sections. Student participants' scores increased in all other sections for this construct (see Figure 4.1).

4.29: Section - Videogaming

Dependent Variable: VG_Post

Section	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Control	3.713[a]	.196	3.324	4.102
HOC	3.934[a]	.249	3.440	4.429
GB	4.140[a]	.277	3.588	4.691
HOC/GB	4.357[a]	.212	3.936	4.779
Robo	3.658[a]	.210	3.241	4.075
HOC/Robo	3.881[a]	.236	3.413	4.349
GB/Robo	3.358[a]	.227	2.906	3.809
HOC/GB/Robo	3.068[a]	.210	2.651	3.485

a. Covariates appearing in the model are evaluated at the following values: VG_Pre = 3.6409.

4.30: Pairwise Comparisons

Dependent Variable: VG_Post

(I) Section	(J) Section	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
Control	HOC	-.222	.316	.484	-.848	.405
	GB	-.427	.340	.213	-1.103	.249
	GB/HOC	-.644*	.287	.027	-1.215	-.074
	Robo	.055	.288	.849	-.517	.627
	HOC/Robo	-.168	.306	.584	-.776	.440
	GB/Robo	.355	.301	.241	-.243	.953
	GB/HOC/Robo	.645*	.288	.028	.073	1.217

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

A pairwise comparison for the videogaming construct shows a statistically significant difference in the performance of the GoldieBlox/Hour of Code group and the GoldieBlox/Hour of Code/Robotics group compared to the control group (see Table 4.30).

Computer Gaming Construct. An ANCOVA for the computer gaming construct pre-test and post-test scores for each section was conducted to determine the impact of the treatment by section on students' overall self-efficacy in the computer gaming domain. The computer gaming scores are represented by the mean scores of student responses to questions 21-25 on the overall SETS instrument. Preliminary assumptions for running the ANCOVA were met. According to the Levene's test for homogeneity of variance (see Table 4.31), a non-statistically significant result was found ($p = .416$) indicating the data is homogeneous across the data levels.

4.31: Levene's Test of Equality of Error Variances[a] – Computer Gaming

Dependent Variable: CG_Post

F	df1	df2	Sig.
1.030	7	91	.416

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + CG_Pre + Section

4.32: Tests of Between-Subjects Effects – Computer Gaming

Dependent Variable: CG_Post

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	11.313[a]	15	.754	1.005	.458
Intercept	51.637	1	51.637	68.801	.000
Section	3.068	7	.438	.584	.767
CG_Pre	.265	1	.265	.353	.554
Section * CG_Pre	2.697	7	.385	.513	.822
Error	62.294	83	.751		
Total	1516.880	99			
Corrected Total	73.607	98			

a. R Squared = .154 (Adjusted R Squared = .001)

The second assumption for a non-statistically significant result for the homogeneity of regression slopes was met, $F(7, 83) = .887$, $p = .513$ (see Table 4.32). With both assumptions being met, the ANCOVA was assessed.

4.33: Tests of Between-Subjects Effects – Computer Gaming

Dependent Variable: CG_Post

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	8.617[a]	8	1.077	1.492	.171	.117
Intercept	64.939	1	64.939	89.929	.000	.500
CG_Pre	.437	1	.437	.605	.439	.007
Section	8.594	7	1.228	1.700	.119	.117
Error	64.991	90	.722			
Total	1516.880	99				
Corrected Total	73.607	98				

a. R Squared = .117 (Adjusted R Squared = .039)

There was a non-statistically significant effect on self-efficacy in computer gaming based the treatment section, F(7, 90) = 1.700, p = .119 (see Table 4.33).

General Construct. An ANCOVA for the general construct pre-test and post-test scores for each section was conducted to determine the impact of the treatment by section on students' overall self-efficacy in the general domain. The general scores are represented by the mean scores of student responses to questions 26-36 on the overall SETS instrument. Preliminary assumptions for running the ANCOVA were not met. According to the Levene's test for homogeneity of variance (see Table 4.34), a statistically significant result was found (p = .000) indicating the data is heterogeneous across the data levels.

4.34: Levene's Test of Equality of Error Variances[a] - General

Dependent Variable: Gen_Post

F	df1	df2	Sig.
4.458	7	91	.000

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Gen_Pre + Section

The second assumption condition also resulted a non-statistically significant result, F(7, 83) = .522, p = .816 (see Table 4.35).

4.35: Tests of Between-Subjects Effects - General

Dependent Variable: Gen_Post

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	17.536[a]	15	1.169	2.117	.017
Intercept	34.239	1	34.239	61.995	.000
Section	1.945	7	.278	.503	.830
Gen_Pre	.008	1	.008	.015	.903
Section * Gen_Pre	2.018	7	.288	.522	.816
Error	45.840	83	.552		
Total	1785.712	99			
Corrected Total	63.376	98			

a. R Squared = .277 (Adjusted R Squared = .146)

Since both assumptions were not met, an ANCOVA was not assessed for this construct.

Problem Solving Construct. An ANCOVA for the problem solving construct pre-test and post-test scores for each section was conducted to determine the impact of the treatment by section on students' overall self-efficacy in the problem solving domain. The problem solving scores are represented by the mean scores of student responses to questions 37-41 on the overall SETS instrument. Preliminary assumptions for running the ANCOVA were met. According to the Levene's test for homogeneity of variance (see Table 4.36), a non-statistically significant result was found (p = .373) indicating the data is homogeneous across the data

4.36: Levene's Test of Equality of Error Variances[a] – Problem Solving

Dependent Variable: PS_Post

F	df1	df2	Sig.
1.096	7	91	.373

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + PS_Pre + Section

The second assumption was tested and resulted in a non-statistically significant result between the interaction of the problem solving construct with respect to the treatment section, F(7, 83) = .486, p = .842 (see Table 4:38).

4.38: Tests of Between-Subjects Effects – Problem Solving

Dependent Variable: PS_Post

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	12.507[a]	15	.834	.904	.563
Intercept	34.237	1	34.237	37.119	.000
Section	3.360	7	.480	.520	.817
PS_Pre	1.325	1	1.325	1.437	.234
Section * PS_Pre	3.138	7	.448	.486	.842
Error	76.558	83	.922		
Total	1589.400	99			
Corrected Total	89.065	98			

a. R Squared = .140 (Adjusted R Squared = -.015)

With both assumptions being met on the problem solving construct, an ANCOVA was conducted.

4.39: Tests of Between-Subjects Effects – Problem Solving

Dependent Variable: PS_Post

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	9.369[a]	8	1.171	1.323	.243	.105
Intercept	41.218	1	41.218	46.547	.000	.341
PS_Pre	.945	1	.945	1.067	.304	.012
Section	7.220	7	1.031	1.165	.331	.083
Error	79.696	90	.886			
Total	1589.400	99				
Corrected Total	89.065	98				

a. R Squared = .105 (Adjusted R Squared = .026)

Based on the ANCOVA (see Table 4.39), there is no statistically significant effect on self-efficacy in problem solving based on the type of treatment, F(7, 90) = 1.165, p = .331.

Synchronous Chat Construct. An ANCOVA for the synchronous chat construct pre-test and post-test scores for each section was conducted to determine the impact of the treatment by section on students' overall self-efficacy in the synchronous chat domain. The synchronous chat scores are represented by the mean scores of student responses to questions 42-51 on the overall SETS instrument. Preliminary assumptions for running the ANCOVA were met. According to the Levene's test for homogeneity of variance (see Table 4:40), a non-statistically significant result was found (p = .000) indicating the data is heterogeneous across the data.

4.40: Levene's Test of Equality of Error Variances[a] – Synchronous Chat

Dependent Variable: SC_Post

F	df1	df2	Sig.
4.220	7	91	.000

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + SC_Pre + Section

The second assumption was tested and resulted in a non-statistically significant result between the interaction of the problem solving construct with respect to the treatment section, F(7, 83) = 1.556, p = .160 (see Table 4.41). Therefore, the test for homogeneity of regression slopes passed.

4.41: Tests of Between-Subjects Effects – Synchronous Chat

Dependent Variable: SC_Post

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	12.304[a]	15	.820	1.800	.048
Intercept	31.923	1	31.923	70.055	.000
Section	5.382	7	.769	1.687	.123
SC_Pre	1.718	1	1.718	3.770	.056
Section * SC_Pre	4.962	7	.709	1.556	.160
Error	37.823	83	.456		
Total	1592.800	99			
Corrected Total	50.127	98			

a. R Squared = .245 (Adjusted R Squared = .109)

Since both assumptions were not met, the data was not assessed for ANCOVA results.

Summary of Results

The first hypothesis is rejected. There is a statistically significant difference overall in STEM self-efficacy of participants in this study regardless of the treatment condition. Additional, paired samples T-tests were performed for further analysis. Statistically significant results were found overall in science inquiry, computer gaming and synchronous chat.

The data failed to reject the second hypothesis. There is no significant difference between the effects of time and STEM self-efficacy of participants in the control group.

The data failed to reject the third hypothesis. There is no significant difference between the effects of the Hour of Code STEM activity and STEM self-efficacy of participants in the Hour of Code only group.

The fourth hypothesis was rejected. There is a statistically significant difference between the effects of the GoldieBlox STEM activity and the STEM self-efficacy of participants in the GoldieBlox only group.

The data failed to reject the fifth hypothesis. There is no significant difference between the effects of the combination of GoldieBlox and Hour of Code STEM activities and STEM self-efficacy of participants in the GoldieBlox/Hour of Code group.

The data failed to reject the sixth hypothesis. There is no significant difference between the effects of the combination of the Robotics STEM activities and STEM self-efficacy of participants in the Robotics only group.

The data failed to reject the seventh hypothesis. There is no significant difference between the effects of the combination of Robotics and Hour of Code STEM activities and STEM self-efficacy of participants in the Robotics/Hour of Code group.

The data failed to reject the eighth hypothesis. There is no significant difference between the effects of the combination of GoldieBlox and Robotics STEM activities and STEM self-efficacy of GoldieBlox/Robotics group.

The data failed to reject he ninth hypothesis. There is no significant difference between the effects of the combination of GoldieBlox, Hour of Code and Robotics STEM activities and STEM self-efficacy of participants in the GoldieBlox/Hour of Code/Robotics group.

The length of the treatment for each area was shortened due to pre-planned and un-planned school field trips. Section 2 (HOC) and section 4 (GB/HOC) had a pre-planned re-scheduled field trip halfway through the treatment. However, the trip was cancelled at the last minute due to bus availability. Students were unable to focus on the study related materials. Even though all activities were completed, time allotted for reflection and discussion was shortened due to the unexpected school interruptions.

Due to various reasons four of the initial 103 students' results were excluded in the overall data set leaving the final number of the sample size, 99. The overall pre-post test scores were compared using a paired samples T-test revealing a statistically significant result overall. Additionally, results from the paired samples T-test on each treatment condition revealed a statistically significant growth in self-efficacy in the GoldieBlox only group,

With respect to hypothesis 10-15, using ANCOVA to determine the existence of any significant differences between overall self-efficacy scores on SETS constructs and type of intervention, the data found that only the videogaming construct rejected the null hypothesis and had statistically significant main effects based on the treatment section, $F(7,90) = 3.451$, $p = .003$ with an effect size, $r^2 = .142$. The data failed to reject all other null hypotheses based on SETS constructs.

CHAPTER 5

CONCLUSION

The National Academy of Sciences in their *Framework for K-12 Science Education* encourages educators to expose students to adequate opportunities to learn STEM within the context of K-12 education. As a result of gaps in educational opportunities to engage in STEM, schoolchildren miss chances to learn and apply STEM in meaningful ways. This study introduced STEM and robotics activities into a new setting within some Early Childhood Education Career and Technical Education classes. Although students used technology on a routine basis to complete class-related tasks, the meaningful application of STEM in the course of study was not present prior to this research.

Summary of Research Study

This study informed the researcher about the impact of STEM and robotics activities on the self-efficacy of African American girls enrolled in an Early Childhood Education Career and Technical Education (CTE) course from a large metropolitan urban school district in Jackson Mississippi. During the course of this investigation, underrepresented girls were exposed to STEM and robotics activities in a non-traditional setting. This section will discuss conclusions determined by the findings. The results supported several outcomes with respect to the introduction of STEM and robotics activities into an Early Childhood Education CTE class. Potential threats in procedure with respect to instrumentation and testing was factored into the conclusions.

Summary of Findings

The first finding from the overall paired samples T-tests and for each treatment section shows an increase in STEM self-efficacy in several sections. Overall, participants' self-efficacy in general increased significantly. There were several unexpected interruptions in class time thereby shortening the treatment exposure to students. A concerted effort to compensate for potential classroom interruptions was accounted for in the design of the research study, however certain interruptions could not have been foreseen, e.g. rescheduled field trip. In addition to interruptions, issues with regular attendance for several students also could have impacted student results. Students were able to complete the robotics curriculum, but had little time to reflect on their new skillsets because of these interruptions and issues with attendance.

The second finding was the GoldieBlox only group showed the greatest influence on student self-efficacy overall and on five of the six SETS constructs: science inquiry, videogaming, computer gaming, general, and synchronous chat. Students in this group remained solely on GoldieBlox activities. Once they completed their activities, they were encouraged to design and develop an original idea activity using GoldieBlox. This gave students in this group access to greater time on task thereby increasing the opportunity for deeper learning and understanding. This reasoning is supported by Nugent, Barker, Grandgenett and Adamchuk (2010).

The third finding is that the robotics activity did not show a statistically significant change in student self-efficacy in any of the treatment settings. Although, many students commented on how exciting the activity was, the data did not show any change in their STEM self-efficacy as a result of this activity. Several interruptions throughout the course of the study prevented students from being able to complete the robotics curriculum. This could have accounted for the non-statistically significant results. This finding is supported by Kalyuga (2012) whose findings showed that exploratory lessons can result in reduced learning due to cognitive overload.

The fourth finding is participants' STEM self-efficacy in videogaming increased significantly in this study. Exposure to videogaming elements could be observed directly in the curricula presented for activities in Hour of Code and Robotics. Students in these treatment environments were introduced to programming the Lego robots to achieve a task. The software interface used pictures to describe actions, much like a videogame format. For instance a picture could represent a motor turning in one direction and another picture would represent a motor turning in the opposite direction. There was a learning curve experienced when getting an understanding of the robotics programing software coupled with several classroom interruptions that could have accounted for inconsistent data across the treatment environments. However, overall students showed an increase in self-efficacy in this particular construct. When developing future interventions for use within the school environment, activities should take into account possible issues with absenteeism and classroom interruptions. Overall, the amount of time students were exposed to STEM activities during this two week intervention was reduced and this might have impacted self-efficacy scores. This conclusion is supported by Walkins, et al., 2007.

When evaluating the possibility of STEM activity interactions between the three main STEM factors, no statistically significant effect was found in any of the combination treatments. The GoldieBlox Only group was the only group that showed statistically significant results in STEM self-efficacy. It can be concluded that the GoldieBlox is an effective treatment for Early Childhood Education in a setting like this and worthy of further exploration and research.

Discussion

Time on task. When engaged in the treatment conditions with a single type of STEM activity, more time on task to observe, reflect and engage on the material was noticeable in the attempts to design and develop original lessons. Students in combination treatment groups were limited by the time allowed to engage in the STEM activities. Those treatment sections with two activity type combinations were expected to split the two-week time allotted for participation in each activity in half. Although the participants completed their tasks, they were limited in the amount of reflection time by almost half that of those students in the single task group. The single section with the combination of three activity elements was expected to split their time allotted for each task by thirds. The cognitive load theory suggests that when engaging in new endeavors, more time is needed to prevent or overcome cognitive overload. Participants assigned to the combination treatment types did not show a significant change in self-efficacy scores and this could be attributed to time constraints limiting their opportunity to grasp a greater level of self-efficacy in STEM. This conclusion is supported by Sternberg (2003).

Moreover, more coaching and evaluations throughout the lessons by the classroom instructors could have yielded a higher return on student self-efficacy for interactive treatment interventions. During the class time, the instructor initially demonstrated the activities as a means of getting set up to begin the curriculum, however, most of the initial time was taken up as students completed the individual activities, following the directions listed. If they came to an issue, the teachers and researcher assisted in guiding them through the issue. However, a more proactive approach to guidance could have been implemented. This conclusion is supported by Walkins, Carnell, and Lodge, (2007).

Finally, extending the time frame for the interactive intervention types might have resulted in greater self-efficacy results. The combination treatment types with two types of STEM activities were designed to spend half of the two-week time period on each activity. The combination treatment type with all three STEM activities was designed to divide the treatment time in thirds. However, it was observed that none of the students in these groups designed new activities or deviated from the curriculum they engaged in originally. When completing the final lesson plans to be used with the daycare children, most students decided to replicate their favorite activity or the activity they considered the easiest. This result indicated more time was needed to interact with the curriculum material to develop greater self-efficacy. This conclusion is supported by Xu, Padilla and Silva (2014). In their study they compared the short intense summer program with a semester long program, however the time allotted for the curriculum was similar. They found that achievement scores were about the same. However, in this study, the time was truncated for those groups that had combination STEM activities. Therefore, the time allotted was shortened and possibly resulted in the non-statistically significant result in overall STEM self-efficacy.

STEM Self-Efficacy Intervention design. Although the initial overall theory of change outcome was successful, in that the majority of STEM self-efficacy scores increased positively, there was only one area in which this increase was statistically significant. Despite concerted efforts to introduce elements attributed to ensuring positive results in self-efficacy, very little change in self-efficacy scores were observed quantitatively in most of the treatment settings.

With respect to social persuasion content for all treatment settings, especially those groups that included robotics, a peer-coaching learning style and consistent teacher involvement was employed and maintained throughout the STEM interventions. Many of the student groups were larger in size than was optimal for the curriculum used. The team sizes averaged four students. During the initial phases of getting setup, many groups began the curriculum the first day of class. This task included laying out the Lego pieces and labels for the container. Students were expected to label and organized their robot kit parts. During this task alone, many students were observed assisting one another in getting their work stations established. Once established, students in the combination treatment settings were encouraged to move faster to allow time for activities that needed to be completed. The excitement of the use of robotics in their classes was consistent throughout the duration of the treatments that included robotics.

Vicarious learning was observed within groups and across group dynamics. Student teams were tasked with completing the same activities all at the same time. Quite often students observed the teachers while they were working with another group in an effort to understand the instructions. Moreover, students from other groups gave presentations of their work during class. These two instances afforded opportunities to gain understanding of the task and to successfully complete each task.

Performance accomplishments were achieved through the group presentations of projects. When student teams discussed their projects and how they would apply them in their upcoming lessons, each team appeared to have gained a better understanding of how to use the activities in instructional settings. Student teams that developed original lessons were able to present those lessons to the class. The class teacher affirmed the application of the original lessons. Several groups from various sections were able to apply their lessons in the daycare setting with the 4 year-old students. They indicated an ease of understanding and manipulation by the daycare students.

Positive physiological states and affective reactions were delivered by maintaining the intervention in a familiar classroom environment along with their assigned instructor. Students were comfortable in the classroom setting with their instructor and classmates as they engaged with their variation of the STEM intervention. The researcher acted in a supporting role while the lead instructor guided student groups to complete each activity. It was observed that most students sought assistance from their classroom instructor when initially creating original lessons. Students in the GoldieBlox Only section were able to design original lessons, present those lessons to their class and engage with the daycare setting to implement the lessons.

Even though overall STEM self-efficacy mean scores showed statistically significant gains across intervention settings, the only treatment setting with statistically significant finding was the GoldieBlox only treatment setting. This hands-on activity set adapted the fundamental drive-train concept to the development of various activities. This activity also incorporated a story format so that the objective for each activity was established and gave each participant an idea of what problem they were trying to solve. This conclusion is supported by research conducted by Baker and White (2003).

Robotics and STEM Self-efficacy. Although several student groups indicated excitement in using robotics in their classrooms, no statistically significant results were found using these materials as a part of STEM instruction. Most student groups completed the curriculum with little trouble. However, in combination treatment settings, several groups were forced to shorten their time in an effort to complete the tasks within the two-week timeframe. This result contradicts the findings of more promising results from several researchers (Kim et al., 2015, Rockland, et al, 2010 and Yoon, et al, 2014). Several interruptions in the learning environments could have caused students to not reflect as deeply on the material. Even though there were several statements from students expressing eagerness to use robotics with the daycare students, the types of lessons they planned to use were the first few lessons which were generally the easier level questions.

One area that could have had an impact on self-efficacy growth was the length of time to work in groups developing ideas for the playground curriculum. Students were observed following the directions line by line with very little deviation from the assigned lesson. When asked if they wanted to design their own lessons, all groups declined in favor of the lesson followed in class. This is different from the resulting lesson from the GoldieBlox students who were able design and develop all ten lessons in one day.

Another area that could have improved the self-efficacy result was the inclusion of adequate technology to program each robotics kit separately. Due to scheduling issues, the school district’s IT department was not able to load the required software on to the students’ laptops. To improvise, the teacher brought in her personal hand held tablet and loaded it with the software. While each group programmed their robots during their lessons, it took longer to verify that the lessons worked. Adding sufficient technology dedicated to the programming portion would have reduced the time required as the tablet had to traverse form table to table programming each groups’ projects.

Research Design. The factorial design implemented in this study intended to determine whether there was a between effects impact based on treatments with combination STEM activities. Although no significant differences in STEM self-efficacy was mathematically observed with respect to specific combination treatments, the single effect of GoldieBlox was the only treatment that yielded a statistically significant result. This indicated that girls responded more favorably to some of the characteristics of this activty as opposed to the robotics and coding activities.

Observations Relevant to Future Applications and Research

As a participant in the on-site research, several observations were made that might enhance future research in the field. The first major issues that we faced included parent consent. Gaining permissions from parents required several conversations about the type of research being conducted. Collecting signed consent forms was also measurably challenging because of the class meeting structure. A student who receives a consent form on one day will not return to the class until two school days later. Once individual consent forms were in place, students were allowed to participate.

Several of the students enrolled in the class were sporadic in attendance. The timing of the study conflicted with other types of district-wide activities, even though the testing affiliated with the Career Development Center had completed by this time. A more careful evaluation of school and district schedules could have offered more favorable options for consistent class attendance.

When taking the online pre-test, several students commented on the length. It took students about 15 minutes to complete the 51-item SETS instrument online. When taking the paper and pencil version, many students took even longer.

Despite interruptions from a rescheduled field trip during the middle of the intervention, the majority of student groups were able to successfully complete all STEM activities for their assigned sections. This task was accomplished with the teacher and researcher coaching the students though the lessons, leaving little time for reflections in combination treatments.

When introducing the GoldieBlox, the enclosed instructions guided students in the expected tasks. Several student groups were able to begin activities almost immediately by following the pictured instructions provided. Once they successfully completed the first exercise, they began the second. During the initial two and a half hour class period, several student groups were able to complete all ten tasks included in the back of the GoldieBlox activity book. During following class sessions, student groups were able to engage in the design and development of their own original activity. Several groups modeled their design after an existing activity from the GoldieBlox Activity book. For instance, one activity calls for students to model the letter G and use the drive train concept to make the toys spin in the form of the letter G. One student group redesigned the activity to model the letter S, N, and O. In their resulting lesson plan objective, they stated that they would have their daycare student model the first letter of their name. Because of the instant success experienced using the activity booklet, students were able to engage quickly and continue the same momentum until completion.

For the Kodable activities on the Hour of Code website, students worked as individuals. Each participant was assigned an in-class laptop to connect to the internet. Once they were guided to the correct link, students were able to complete several maze activities within the first fifteen minutes. There were very few questions regarding what the next activity was to be. While monitoring student progress, it was noted that redirection was not needed during the first full class session. All students remained on task and were engaged in the various levels of the Kodable activity. When designing their lessons, student used the existing activity curriculum from Hour Code. One student decided to add a story line to their coding activity where they would have their daycare student create a scenario describing why they needed to traverse the mazes included in the activity. However, the vast majority of students who developed lessons from Hour of Code did not design new lessons. Students commented often how they liked the activity. One student said “programming is easy.” Another student stated that they believed the Kodable activity was “good for children to learn how to tell the image instructions.” Another student commented, “Adding two arrows to make sure the object keeps moving is easy.” The students seemed to remain engaged with the material as they worked towards completing each level. Although the Kodable activity has its own sound associated with the activity, several students muted the sound from the machine and generated their own sounds which caused the other students to laugh. No difficulties in working with the coding activity were reported

When working with the robotics kits, the first class of students were divided into groups of three to four. Initially, the task of organizing the LEGO kits had to be completed prior to engaging in any of the curriculum activities. This task took the entire first class session to complete. The software was unable to be loaded on the school’s computer. As earlier mentioned, the primary teacher brought her personal electronic tablet from home, which allowed the researcher to load the software without issue. After the initial class organizing the kits, several groups looked for guided lessons but were required to reflect and create based on the trip to the playground. There were some students who did not complete the reflection activities in the time allotted and were given additional time with teacher guidance. The organization of the curriculum required that student groups be divided by engineering roles. When students moved from one lesson to the next, the roles changed to allow teams to experience various positions in an engineering team.

Once the activities were completed, student groups presented their designs to the class. Most students seemed exited to work with the software. One student stated that they found programming to be easy because, “we’re using pictures.” Each of the projects included in the curriculum had pictures that showed step-by-step instructions to complete the lessons. This gave each student group a chance to compare their ideas with the standard answer. After we completed the curriculum lessons, one of the students used their cell phone to research videos on YouTube for the Lego kits. The teacher placed the YouTube videos on the promethean for the class. Student groups began following the YouTube activities affiliated with the Lego kits.

During the downtime after the lessons were over and they completed their comments in their classroom journals, students followed the videos to create and program the basic activities for the Lego kits: the snail, helicopter, car design, etc. The teacher gave the students the choice to design a lesson from the Lego kit or the DivTech curriculum.

Limitations of Study

Treatment instruction was interrupted by re-planned and unplanned class functions causing the treatment to be shortened and thereby potentially impacting the overall self-efficacy scores in robotics. Several class sections were scheduled to visit a local daycare to take field data, however the field trip was rescheduled to the same week of the research data collection. The second field trip was cancelled because of the travel issues. Even though the trip was cancelled, it took the majority of the class time to successfully redirect the class's attention to begin the research activities.

The results of this study reflected the specific environment where it was conducted. More research is needed on a broader scale with more students to adequately support these findings for the target population. There were several limitations with respect to this type of study. Generalizable results could be obtained with a larger number of student participants. Many students who were enrolled in the class did not regularly attend the class. Some students withdrew from the study after taking the pre-test and opted to not take the post-test.

The structure of the Career and Technical Education environment within the school system may have played a role in student participation. The structure of the central CTE high school caused students to be bussed from their home schools to the secondary location which could account for missing students. Many students indicated that they had seen enrolled students at their home school, but they were not attending the CTE class for various reasons. Future research in a more school-centered environment may yield more information by potentially eliminating high absenteeism.

The perception of the Jackson Public Schools Career Development Center as a non-essential vocational education school could have played a role in student enrollment and participation. Several students remained at their home schools to take District required tests and other home school obligations. Many students were given excused absences from their home school to participate in home school functions. High absenteeism at the Career Development Center is a persistent issue.

Implications of Study

The implications of this study include the need for more research into the most effective methods of incorporating robotics into the classroom. Many researchers have supported the inclusion of robotics (Kim, et al, 2015; Nugent, et al, 2010), however the correct combination between time necessary for effective learning and self-efficacy intervention strategies should be thoroughly investigated using modern educational robotics programs, taking into consideration the career intent of the student. Many of the students in the Early Childhood Education CTE class did not indicate a future in a traditional STEM field. In fact, many students indicated teaching as a potential career choice. However, educational designers should include more options for curriculum integration in various untouched educational pockets.

The significance of this research is that it adds to the existing body of research relating to the possible opportunities to effectively integrating STEM into a non-traditional high school classroom environment. Moreover, the target population bears significance in that this particular subset of African American girls enrolled in an Early Childhood Education Career and Technology course has not been the subject of prior STEM integration research.

Implications for Career and Technical Education

This research design specifically yielded results from a single population source of quantitative survey data. This type of research can provide direction to other researchers in Career and Technical Education such that potential methods of delivery could better be evaluated as well as possible between effects impacts using various types of STEM activities. The incorporation of qualitative data and mixed methods approaches would have a starting point based on current research trends in STEM education thereby broadening the body of knowledge to the integration of STEM into Early Childhood Education programs and beyond.

The importance of reaching under-represented groups coincides with missed opportunities to promote interest in STEM fields. Students enrolled in the Early Childhood Education courses could one day choose to enter the teaching field. The exposure they experience at the high school introductory level could shape their abilities and open their potential to teaching STEM. Increased STEM self-efficacy can result in a greater pools of talent entering the teaching field which was one of the highlighted recommendations from the National Research Council (NRC, 2012).

It has been well documented that girls have begun to close the achievement gap with boys, but there remains work to be done with respect to cultural barriers that hinder them from entering STEM fields (Hill, Corbett, & Rose, 2010). According to Hill, et al, (2010), lack of sufficient funding and teacher bias have been clear obstacles to African American girls, in particular. The findings from this research can only support the conclusions of Hill, et al. in that African American girls in this specific population of Jackson, Mississippi are faced with similar cultural barriers. The lack of adequate funding to pursue the latest developments in STEM education exist primarily due to the focus of supporting local industry demands rather than the development of the child's talent. As industry grows and develops, more attention to the needs of having an adequate workforce take precedence over any needs that conflict with this paradigm. With respect to teacher bias, there is a concerted effort to increase the number of non-traditional students, namely boys, in the Early Childhood Education class. Beyond this observation, there was little evidence of teacher bias noted during the research period.

CTE can be more effective in reaching these students by encouraging their exposure to the meaningful applications of STEM concepts in a career setting. Budget allocations are made with the best interest of the school or school district in mind while at the same time considering the local or statewide industries they serve. Career course offerings can respond to the variables of STEM exposure and industry-focused labor support by designing or investigating current research that would enhance STEM contact while addressing the needs of the community. More focus on Career and Technical Student Organizations (CTSOs) could also be an avenue for bridging this connection.

Implications for Policymakers. When guiding the practical applications of CTE through adequate funding, it is imperative that current research is reviewed to determine the potential success of targeted goals. Policymakers can assist the CTE classes by encouraging STEM learning experiences for all areas of CTE courses. Along this this encouragement, the allocation of funding to incorporate current STEM curricula should accompany policy recommendations and planning. In this research study, it was clear that STEM opportunities could have existed in greater depth, however the lack of understanding of current research trends and the ability to embrace STEM projects were barriers for this sample.

Implications for CTE Administrators. CTE administrators should consider providing adequate STEM professional development that offers tools to apply STEM concepts meaningfully in a career education setting. A primary responsibility for CTE administrators is the on-going maintenance of qualified staff in all areas that reflect the current trends in CTE education. Developing a plan to incorporate STEM in as many areas as possible can be addressed with proper teacher professional development.

Implications for Current and Future CTE teachers. During the course of this study, the researcher found that the teachers that maintained positive attitudes were able to coach their students to completion. This technique is extremely powerful when married with adequate professional development in the latest research trends. It was observed that the more comfortable the teachers were with the material, the more receptive students were to completing their projects. Also, teachers stated how they would try more projects from online social media to gain a broader understanding of the capabilities of the kits (robotics and GoldieBlox).

Recommendations for Future Research

Further research is needed to validate these conclusions on a broader scale with more participants. Results from this research was limited to the small number of participants. Expanding this number could yield a more generalizable result. Also, researching the type of career and technical education delivery setting that best supports the introduction of STEM activities could be beneficial.

More research is needed to determine the impact of increasing the exposure to treatment conditions on student STEM self-efficacy. This study was limited to two weeks, however if students had more time to interact with STEM material, a deeper understanding could be achieved and thereby potentially greater self-efficacy results.

Finally, combining qualitative data along with the quantitative inputs could yield a broader scope of understanding and expand the individual students' thought processes and perceptions of new material. This could help guide the researchers on research design to gauge a more authentic and balanced response to physiological states and affective reactions. Qualitative information collected could provide suggestions for future curriculum development and activity selection.

Conclusion

In conclusion, providing STEM activities as part of an Early Childhood Education CTE course had an impact on girls' STEM self-efficacy. STEM can be integrated successfully in this non-traditional environment offering more opportunities for exposure to traditionally underrepresented populations. Careful consideration to time and sources of STEM activities play a vital role in developing a successful intervention design. Expanding this study to other non-traditional CTE courses could enhance the body of knowledge for the profession and result in a potential solution to lack of equal representation in STEM fields by traditionally underserved segments of the population.

APPENDICES

Appendix A

STUDENT PERMISSION TO PARTICIPATE

Career and Information Studies
The University of Georgia
Athens, Georgia

RE: Research Participation Consent

Title of Study: *Impact of Robotics and STEM Interventions on Girls' STEM Attitudes and Self-Efficacy*

Dear Parent/Guardian,

I am a graduate student at The University of Georgia. I am conducting a study entitled *The Impact of Robotics and STEM Interventions on Girls' STEM Attitudes and Self-efficacy*. This study will attempt to determine the impact of a pre-kindergarten level science, technology, engineering and mathematics (STEM) and Robotics intervention module on African-American girls enrolled in the **Early Childhood Education Career and Technical Education (CTE) course** offered through the **Jackson Public Schools Career Development Center**.

Your child has been selected to participate in this 2-week co-curricular exercise because of her enrollment in this CTE course. In conjunction with study participation, the project activities will assist her in completing the development of a required thematic unit for pre-kindergarten students. This required project will be graded and count towards her final course grade.

Participation in this study is encouraged but completely voluntary and all efforts to protect their identity and keep the information confidential will be taken.

If you agree to your child's participation please complete the attached ***Research Participation Consent Form***. Your child's participation is greatly appreciated.

Regards,

Deborah E. Spear
Graduate Student
The University of Georgia

UNIVERSITY OF GEORGIA
PARTICIPANT INFORMATION FORM

IMPACT OF ROBOTICS AND STEM INSTRUCTION ON SELF-EFFICACY OF AFRICAN AMERICAN HIGH SCHOOL GIRLS

Researcher's Statement
You/Your child has been selected to take part in a research study. Before you decide to participate in this study, it is important that you understand why the research is being done and what it will involve. This form is designed to give you the information about the study so you can decide whether to be in the study or not. Please take the time to read the following information carefully. Please ask the researcher if there is anything that is not clear or if you need more information. When all your questions have been answered, you can decide if you want to be in the study or not. This process is called "informed consent." A copy of this form will be given to you.

Principal Investigator: *Roger Hill*
Career and Information Studies
706-542-4100 (office)
rbhill@uga.edu

Graduate Student Assistant: *Deborah Spear*
Graduate Student
404-447-4121 (cell)
dwill@uga.edu

Purpose of the Study
This study will attempt to determine the impact of a pre-kindergarten level science, technology, engineering and mathematics (STEM) and Robotics instruction on the self-efficacy of African-American girls enrolled in the Early Childhood Education Career and Technical Education (CTE) course offered through the Jackson Public Schools Career Development Center.

Study Procedures
If you agree to participate, you/your child will be asked to:

- *Commit to attending and participating in each class during the two (2) weeks allotted.*
- *Prior to beginning the study each student participant will take a brief STEM self-efficacy survey. This same survey will be given at the end of the two week data collection period.*
- *Develop a thematic unit based on a STEM activity designed for pre-kindergarten students. Currently, the curriculum only asks for a thematic lesson. This study will provide curriculum suggestions in STEM and/or robotics activities for pre-kindergarten students to* ***most of the sections*** *leaving one section without intervention suggestions to be a* ***control group****.*
- *OPTIONAL: Based on the course section, students will be exposed to any one of eight combinations of different STEM and/or robotics activities ranging from no activity exposure up to engaging in all three suggested activities. There will be one class section that will not alter the current curriculum. They will be the control group. As for the remaining seven sections, the type of activity combinations will be randomly assigned.*

Risks and discomforts
No risk is anticipated from participating in this research.

Benefits
The results of this study are important to the field of Engineering and Technology Education and could provide information to expand the breadth of research.

Incentives for participation
In conjunction with study participation, the project activities will assist you/your child in completing the development of a required thematic unit for pre-kindergarten students.

Privacy/Confidentiality
Data collected will include information that will be collected anonymously via online access to survey. The project's research records may be reviewed by departments at the University of Georgia responsible for regulatory and research oversight. Researchers will not release identifiable results of the study to anyone other than individuals working on the project without your written consent unless required by law.

Taking part is voluntary
You/Your child's involvement in the study is voluntary, and you/she may choose not to participate or to stop at any time without penalty or loss of benefits to which you are otherwise entitled. Any information recorded in the investigation will remain confidential and no information that identifies you/your child will be made publicly available. If you decide to withdraw from the study, the information that can be identified as yours/hers will be kept as part of the study and may continue to be analyzed, unless you make a written request to remove, return, or destroy the information. The decision of whether or not to participate in the research will have no impact on grades or class standing.

If you have questions
The main researcher conducting this study is Dr. Roger Hill, a professor at the University of Georgia, and Deborah Spear, a graduate student at the University of Georgia. Please ask any questions you have now. If you have questions later, you may contact *Roger Hill* at *rbhill@uga.edu* or at *706-542-4100 (office).* If you have any questions or concerns regarding your rights as a research participant in this study, you may contact the Institutional Review Board (IRB) Chairperson at 706.542.3199 or irb@uga.edu.

Acknowledgement of Receipt of Participant Information:
To acknowledge receipt of basic participant information, you must sign on the line below. Your signature below indicates that you have read or had read to you this entire study information form, and have had all of your questions answered.

___________________________	_________________________	__________
Name of Researcher	Signature	Date
___________________________	_________________________	___________
Name of Participant/Parent/Guardian	Signature	Date

Please sign both copies, keep one and return one to the researcher.

Research Participation Consent Form

(Adult Student Consent)

Early Childhood Education Career and Technical Education Students
Jackson Public Schools Career Development Center
Jackson, Mississippi

Title of Study: ***Impact of Robotics and STEM Instruction on Self-Efficacy of African American High School Girls***

You acknowledge that you have read and understand the information about the project as provided in the ***Participant Information Sheet*** on November 26, 2018

You acknowledge that you have had the opportunity to ask questions and the researcher has answered any questions about the study to your satisfaction.

You understand that your participation is voluntary and that you are free to withdraw from the project at any time, without having to give a reason and without any consequences.

You understand that the decision of whether or not to participate in the research will have no impact on grades or class standing.

You understand that you can withdraw your data from the study at any time.

You understand that any information recorded in the investigation will remain confidential and no information that identifies you will be made publicly available.

You consent to the use of the data in research, publications, sharing and archiving as explained in the ***Participant Information Sheet***.

I agree / do not agree to take part in the above study.

________________________	________	__________________
Name of Adult Student	Date	Adult Student Signature

________________________	________	__________________
Researcher	Date	Researcher’s Signature

Research Participation Consent Form
(Minor Assent)

Early Childhood Education Career and Technical Education Students
Jackson Public Schools Career Development Center
Jackson, Mississippi

Title of Study: ***Impact of Robotics and STEM Instruction on Self-Efficacy of African American High School Girls***

You acknowledge that you have read and understand the information about the project as provided in the ***Participant Information Sheet*** on November 26, 2018.

You acknowledge that you have had the opportunity to ask questions and the researcher has answered any questions about the study to your satisfaction.

You understand that your child's participation is voluntary and that you are free to withdraw from the project at any time, without having to give a reason and without any consequences.

You understand that the decision of whether or not to participate in the research will have no impact on grades or class standing.

You understand that you can withdraw your child's data from the study at any time.

You understand that any information recorded in the investigation will remain confidential and no information that identifies you will be made publicly available.

You consent to the use of the data in research, publications, sharing and archiving as explained in the ***Participant Information Sheet***.

I agree / do not agree to take part in the above study.

Name of Parent/Guardian	Date	Parent/Guardian Signature
Name of Student Participant	Date	Student Participant's Signature
Researcher	Date	Researcher's Signature

Appendix B

TEACHER COMMITMENT LETTER

Career and Information Studies
The University of Georgia
Athens, Georgia

RE: Research Participation – Teacher Commitment

Title of Study: *Impact of Robotics and STEM Interventions on Girls' STEM Attitudes and Self-Efficacy*

Dear Early Childhood Education Teacher,

I am a graduate student at The University of Georgia. I am conducting a study entitled *The Impact of Robotics and STEM Interventions on Girls' STEM Attitudes and Self-efficacy*. This study will attempt to determine the impact of a pre-kindergarten level science, technology, engineering and mathematics (STEM) and Robotics intervention module on African-American girls enrolled in the **Early Childhood Education Career and Technical Education (CTE) course** offered through the **Jackson Public Schools Career Development Center**.

Your classroom has been selected to participate in this 2-week co-curricular exercise. In conjunction with study participation, the project activities will assist your students in completing the development of the required thematic unit for pre-kindergarten students. This research study has been approved by the Jackson Public Schools District Superintendent and the principal of the Jackson Public Schools Career Development Center.

The results of this study are important to the field of Engineering and Technology Education and could provide information to expand the breadth of research.

Your participation in this two-week study will be guided by a set of Classroom Guidelines that should be consistent throughout. There will be a short training prior to the course that you will be required to attend in order to ensure consistent application of the study guidelines. This brief training will be held during an approved date and time set by the principal.

Again, your assistance is greatly appreciated.

Regards,

Deborah E. Spear
Graduate Student
The University of Georgia

Appendix C

SELF-EFFICACY ASSESSMENT INSTRUMENT

Self-Efficacy in Technology and Science (SETS) Instrument

Thu 3/15/2018 11:19 AM

To:Deborah Spear Avery <dwill@uga.edu>;

1 attachments (299 KB)

final version sets.pdf;

HI, Deborah!
Thanks for your interest in my survey. You are definitely welcome to use it.

I'm attaching a copy of the published chapter in which its development is detailed and the final scales are in the appendix. You can use them individually or altogether. The citation information is below.

Ketelhut, D.J. (2010). Assessing gaming, computer and scientific inquiry self-efficacy in a virtual environment. In L.A. Annetta and S. Bronack (Eds.), *Serious Educational Game Assessment: Practical Methods and Models for Educational Games, Simulations and Virtual Worlds*. Amsterdam, The Netherlands. Sense Publishers. p. 1-18.

Thanks for your interest and good luck on your dissertation!
Diane
****

Diane Jass Ketelhut
Associate Professor, Science, Technology and Mathematics Education
Director, Center for Science and Technology in Education
PI, *Exploring the Integration of Computational Thinking into Preservice Elementary Science Teacher Education (CT→PSTE)*
Department of Teaching and Learning, Policy and Leadership
University of Maryland
djk@umd.edu

From: Deborah Spear Avery <dwill@uga.edu>
Sent: Wednesday, March 14, 2018 4:13 PM
To: Diane@alumni.brown.edu
Subject: Self-efficacy in Technology and Science (SETS) instrument

Hello,

My name is Deborah Spear. I am a doctoral student in the Career and Information Studies Department of The University of Georgia. My dissertation title is: Impact of Robotics and STEM Interventions on STEM Girls' STEM Attitudes and Self-efficacy. I would like to use the SETS instrument you developed to collect data specific to self-efficacy. Please provide feedback on the process to obtain permission to use this tool for educational research.

Regards,

Deborah Spear
Graduate Student

Science Inquiry

		STRONGLY DISAGREEE	DISAGREE	SOMEWHAT AGREE	STRONGLY AGREE	NEUTRAL
1	I can write an introduction to a lab report.	O	O	O	O	O
2	I can use graphs to show what I found out in my experiment.	O	O	O	O	O
3	It is hard for me to write a report about an experiment.	O	O	O	O	O
4	I know how to use the scientific method to solve problems.	O	O	O	O	O
5	It is hard for me to look at the results of an experiment and tell what they mean.	O	O	O	O	O
6	When I do an experiment, it is hard for me to figure out how the data I collected answers the question.	O	O	O	O	O
7	When I do my work in science class, I am able to find the important ideas.	O	O	O	O	O
8	Once I have a question, it is hard for me to design an experiment to test it.	O	O	O	O	O
9	I can design an experiment to test my ideas.	O	O	O	O	O
10	I have trouble figuring out the main ideas of what my science teacher is teaching us.	O	O	O	O	O
11	I can tell the difference between observations and conclusions in a story.	O	O	O	O	O
12	It is easy for me to make a graph of my data.	O	O	O	O	O

Videogaming

		STRONGLY DISAGREEE	DISAGREE	SOMEWHAT AGREE	STRONGLY AGREE	NEUTRAL
13	I am certain that I can master any videogame I play.	O	O	O	O	O
14	No matter how hard I try, videogames are too difficult for me to learn.	O	O	O	O	O
15	Even when I try hard, I don't do well at playing videogames.	O	O	O	O	O
16	Video games are hard to figure out for me even when I try.	O	O	O	O	O
17	Even when I try hard, learning how to play a new videogame is complicated for me.	O	O	O	O	O
18	I am sure that I can learn any videogame.	O	O	O	O	O
19	I can do well at even the most challenging videogame.	O	O	O	O	O
20	I am sure that I can succeed at playing videogames.	O	O	O	O	O

Computer Gaming

		STRONGLY DISAGREEE	DISAGREE	SOMEWHAT AGREE	STRONGLY AGREE	NEUTRAL
21	No matter how hard I try, I do not do well when playing computer games.	O	O	O	O	O
22	I can keep winning at computer games for a long time.	O	O	O	O	O
23	I can learn how to play any computer game if I don't give up.	O	O	O	O	O
24	I am very good at building things in simulation games.	O	O	O	O	O
25	I can figure out most computer games.	O	O	O	O	O

General

		STRONGLY DISAGREEE	DISAGREE	SOMEWHAT AGREE	STRONGLY AGREE	NEUTRAL
26	I know the steps necessary to use the computer to create a presentation.	O	O	O	O	O
27	I can turn the computer on and off.	O	O	O	O	O
28	Learning how to use a computer is not hard for me.	O	O	O	O	O
29	I know how to sign on to the Internet.	O	O	O	O	O
30	I know I can find a specific website if I have the address (URL).	O	O	O	O	O
31	I can open and close software programs on a computer.	O	O	O	O	O
32	No matter how hard I try, I cannot learn how to use computers.	O	O	O	O	O
33	I find it difficult to learn how to use the computer.	O	O	O	O	O
34	Whenever I can, I avoid using computers.	O	O	O	O	O
35	I can learn how to write papers on any computer.	O	O	O	O	O
36	If I need to learn how to do something on a computer, I can do it.	O	O	O	O	O

Problem Solving

		STRONGLY DISAGREEE	DISAGREE	SOMEWHAT AGREE	STRONGLY AGREE	NEUTRAL
37	It is hard for me to look for answers to questions on the Internet.	O	O	O	O	O
38	It is hard for me to use a computer to do my homework.	O	O	O	O	O
39	When using the Internet, I usually have trouble finding the answers I am looking for.	O	O	O	O	O
40	Even if I try very hard, I cannot use the computer as easily as paper and pencil.	O	O	O	O	O
41	I can find information on the web by using a search engine.	O	O	O	O	O

Synchronous Chat

		STRONGLY DISAGREEE	DISAGREE	SOMEWHAT AGREE	STRONGLY AGREE	NEUTRAL
42	If I need help, I can talk to my friends online.	O	O	O	O	O
43	I can create and use a new username on chat programs whenever I want.	O	O	O	O	O
44	I can use chat programs online.	O	O	O	O	O
45	When I need an answer to a question, I cannot find it by ‘chatting’ with a friend online.	O	O	O	O	O
46	I can show how I am feeling online by using happy or sad faces.	O	O	O	O	O
47	I can chat online with people.	O	O	O	O	O
48	I am very good at carrying on conversations with my friends online.	O	O	O	O	O
49	It is hard for me to talk with my friends online.	O	O	O	O	O
50	I am sure that I can join a chat room and talk with several people at the same time.	O	O	O	O	O
51	I can use Instant Messenger.	O	O	O	O	O

Appendix D

PERMISSION TO USE ROBOTICS CURRICULUM

Re: Educational Use of Curriculum ("The Playground")

aasullivan86@gmail.com on behalf of Amanda Sullivan <amanda.sullivan@tufts.edu>

Mon 5/14/2018 3:39 PM

To:Deborah E. Spear <dwill@uga.edu>;

Hi Deborah,

Please fill out this form and I will send you a packet with all of the KIBO robotics research and curricula we have available for sharing.

The Playground unit for Wedo which I believe you are referring to, we have up on the web here, you may also use. We would require you to cite that it was developed by the Devtech Research Group in any places where you write about it (your dissertation, any subsequent publications, etc.).

Good luck!

Best,
Amanda

On Wed, May 9, 2018 at 2:07 PM, Bers, Marina <Marina.Bers@tufts.edu> wrote:

> Hi Deborah,
>
> I am connecting you with Amanda Sullivan, who did her doctoral work on STEM and gender with me. Also she will be able to send you the form to complete for doing research and using some of our tools.
>
> Good luck with your work!
>
> Marina
> ~~~~~~~~~~~~~**~~~~~~~~~~~~~**~~~~~~~~~~~~~**~~~~~~
>
> Marina Umaschi Bers, PhD
> Professor,
> Eliot-Pearson Department of Child Study and Human Development
> Department of Computer Sciences
>
> Tufts University
> Office #166
> 105 College Ave.
> Medford, MA 02155
>
> e-mail:Marina.Bers@tufts.edu
> phone: (617) 627-4490
> fax: (617)627-3503
> website: http://www.tufts.edu/~mbers01/
> twitter: @marinabers
>
> On May 9, 2018, at 4:47 PM, Deborah E. Spear <dwill@uga.edu> wrote:

> Hello,
>
> My name is Deborah Spear. I am a doctoral student in the Career and Information Studies Department of The University of Georgia. My dissertation title is: Impact of Robotics and STEM Interventions on STEM Girls' STEM Attitudes and Self-efficacy.
> I plan to use the LEGO WeDo robotics kits for the robotics component of my study. Also, I would like to use your PreK-Kindergarten Curriculum Unit, "The Playground," as the activity sequence for the robotics portion of my study. Please provide feedback on the process to obtain permission to use this Curriculum Unit for education research purposes.
>
> Regards,
>
> Deborah Spear
> Graduate Student

--
Amanda Sullivan, Ph.D.
The DevTech Research Group
Dept. of Child Study and Human Development
Tufts University

Appendix E

ROBOTICS AND STEM INTERVENTION

Schedule	***Teacher***	***Activities***	***Materials***
Day 1	***Smith*** (1) (5) ***Jones*** (3) (7)	***ALL SECTIONS*** ***Complete Pre-Test Surveys (Self-Efficacy & Attitudes) (1 hour***) (1) No treatment (5) Distribute Robotics Kits (Organize Kit parts) (3) Distribute GoldieBlox Kits - Read lesson and begin Activity 1 (7) Distribute GoldieBlox Kits - Read lesson and begin Activity 1	1. Computers for pre-tests 2. Robotics kits only 3. GoldieBlox Kits: GoldieBlox and the Spinning Machine 4. Student Journals
Day 2	***Smith*** (4) (6) ***Jones*** (2) (8)	***ALL SECTIONS*** ***Complete Pre-Test Surveys (Self-Efficacy & Attitudes) (1 hour***) (4) Distribute GoldieBlox Kits - Read lesson and begin Activity 1 (6) Logged into Hour of Code and begin Kodable Activity (level 1-99) (2) Logged into Hour of Code and begin Kodable Activity (8) Logged into Hour of Code and begin Kodable Activity (level 1-99)	1. Computers for pre-tests 2. Robotics kits only 3. GoldieBlox Kits: GoldieBlox and the Spinning Machine 4. Student Journals
Day 3	***Smith*** (1) (5) ***Jones*** (3) (7)	(1)No activity (5)Robotics – The Playground Lesson 1-2 (3) Complete GoldieBlox Activities #1-#10 (7) Complete GoldieBlox Activities #1-#10	1. Computers for Kodable Activities 2. GoldieBlox Kits: GoldieBlox and the Spinning Machine 3. Student Journals

Day 4	***Smith*** (4) (6) ***Jones*** (2) (8)	(4) Complete GoldieBlox Activities #1-#10 (6) Complete Kodeable Activities (45 minutes) (2) Complete Kodeable Activities (45 minutes) (8) • Complete Kodeable Activities (45 minutes) • Complete GoldieBlox Activities #1-#10	1. Computers for Kodable Activities 2. GoldieBlox Kits: GoldieBlox and the Spinning Machine 3. Student Journals
Day 5	***Smith*** (1) (5) ***Jones*** (3) (7)	(1)No treatment (5)Robotics Lesson 3-4 (3) Complete GoldieBlox Activities #1-#10 (7) Robotics Playground Lessons 1-2	1. Computers for Kodable Activities 2. Robotics Kits 3. GoldieBlox Kits: GoldieBlox and the Spinning Machine 4. Student Journals
Day 6	***Smith*** (4) (6) ***Jones*** (2) (8)	(4) Logged into Hour of Code and begin Kodable Activity (6) Robotics-The Playground - Lesson 1-2 (2) Complete Kodeable Activities (45 minutes) (8)Robotics Playground lesson 1-2	1. Computers for Kodable Activities 2. Robotics Kits 3. GoldieBlox Kits: GoldieBlox and the Spinning Machine 4. Student Journals
Day 7	***Smith*** (1) (5) ***Jones*** (3) (7)	(1) No treatment (5) Robotics-The Playground - Lesson 5-6 (3)Create GoldieBlox Activities (7) Robotics Playground Lessons 3-4	1. Computers for Kodable Activities 2. Robotics Kits 3. GoldieBlox Kits: GoldieBlox and the Spinning Machine 4. Student Journals

Day 8	***Smith*** (4) (6) ***Jones*** (2) (8)	(4) Complete Kodeable Activities Level (1-99) (6) Robotics-The Playground - Lesson 3-4 (2) Complete Kodeable Activities Level (1-99) (8)Robotics Playground lesson 3-4	1. Computers for Kodable Activities 2. Robotics Kits 3. GoldieBlox Kits: GoldieBlox and the Spinning Machine 4. Student Journals
Day 9	***Smith*** (1) (5) ***Jones*** (3) (7)	(1) No treatment (5) Robotics – The Playground Lesson 7 (3) Present GoldieBlox Activities to class (7) Robotics Playground lesson 5-7 ***ALL SECTIONS*** • ***Complete Thematic Unit Lesson Plan (30 minutes)*** • ***Complete Post-Test Surveys (Self-Efficacy and Attitudes) (60 minutes)***	1. Computers for Kodable Activities 2. Robotics Kits 3. GoldieBlox Kits: GoldieBlox and the Spinning Machine 4. Student Journals
Day 10	***Smith*** (4) (6) ***Jones*** (2) (8)	(4) Complete Kodeable Activities Level (1-99) (6) Robotics Playground lesson 5-7 (2) Complete Kodeable Activities Level (1-99) (8) Robotics Playground lesson 5-7 ***ALL SECTIONS*** • ***Complete Thematic Unit Lesson Plan (30 minutes)*** • ***Complete Post-Test Surveys (Self-Efficacy and Attitudes) (60 minutes)***	1. Computers for Kodable Activities 2. Robotics Kits 3. GoldieBlox Kits: GoldieBlox and the Spinning Machine 4. Student Journals

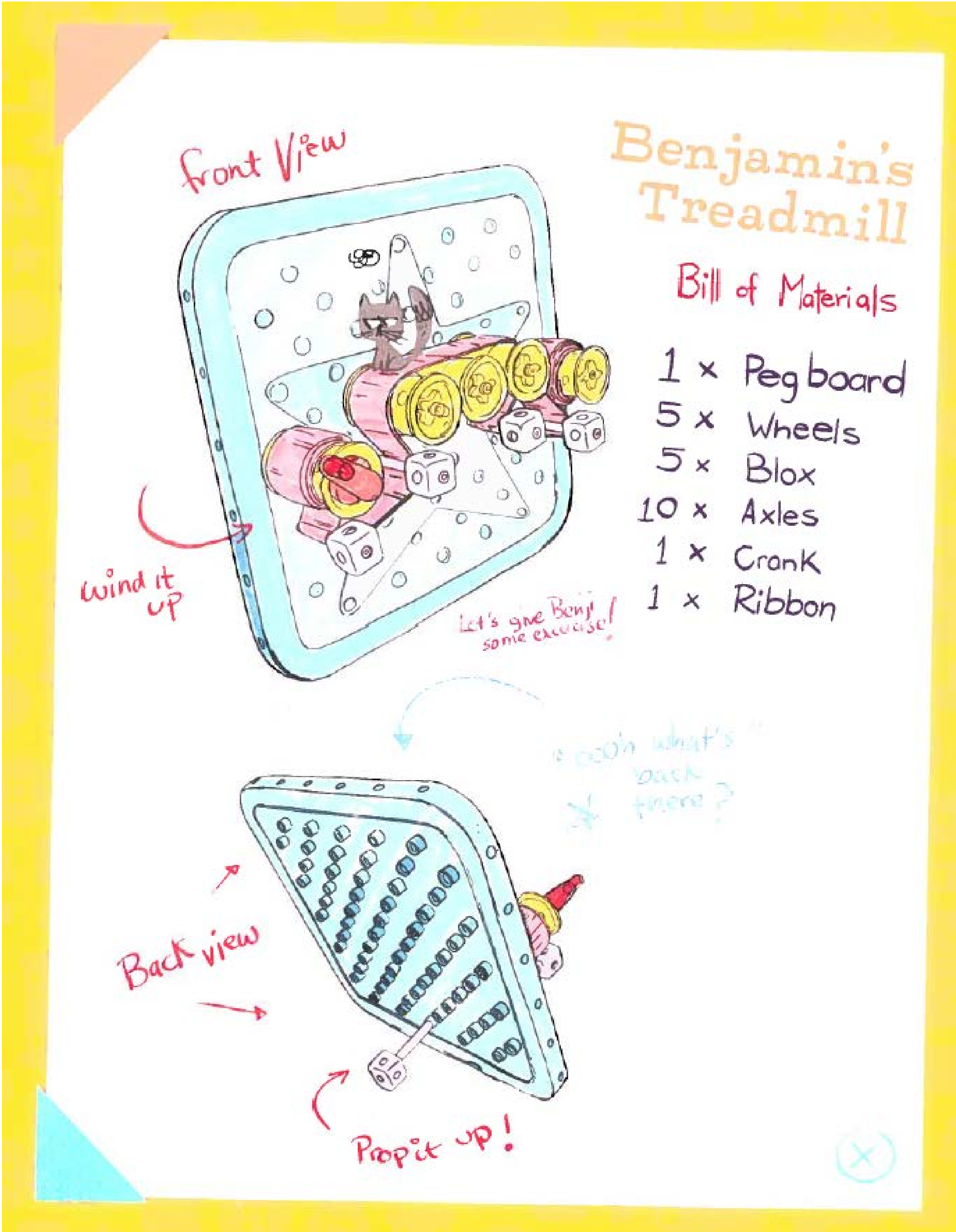
GoldieBlox Activities

Student Groups will read the story from GoldieBlox and the Spinning Machine Created by Debbie Sterling and follow along using the kits provided. (10 minutes)

Students will build and verify each of the activities included at the end of the booklet.

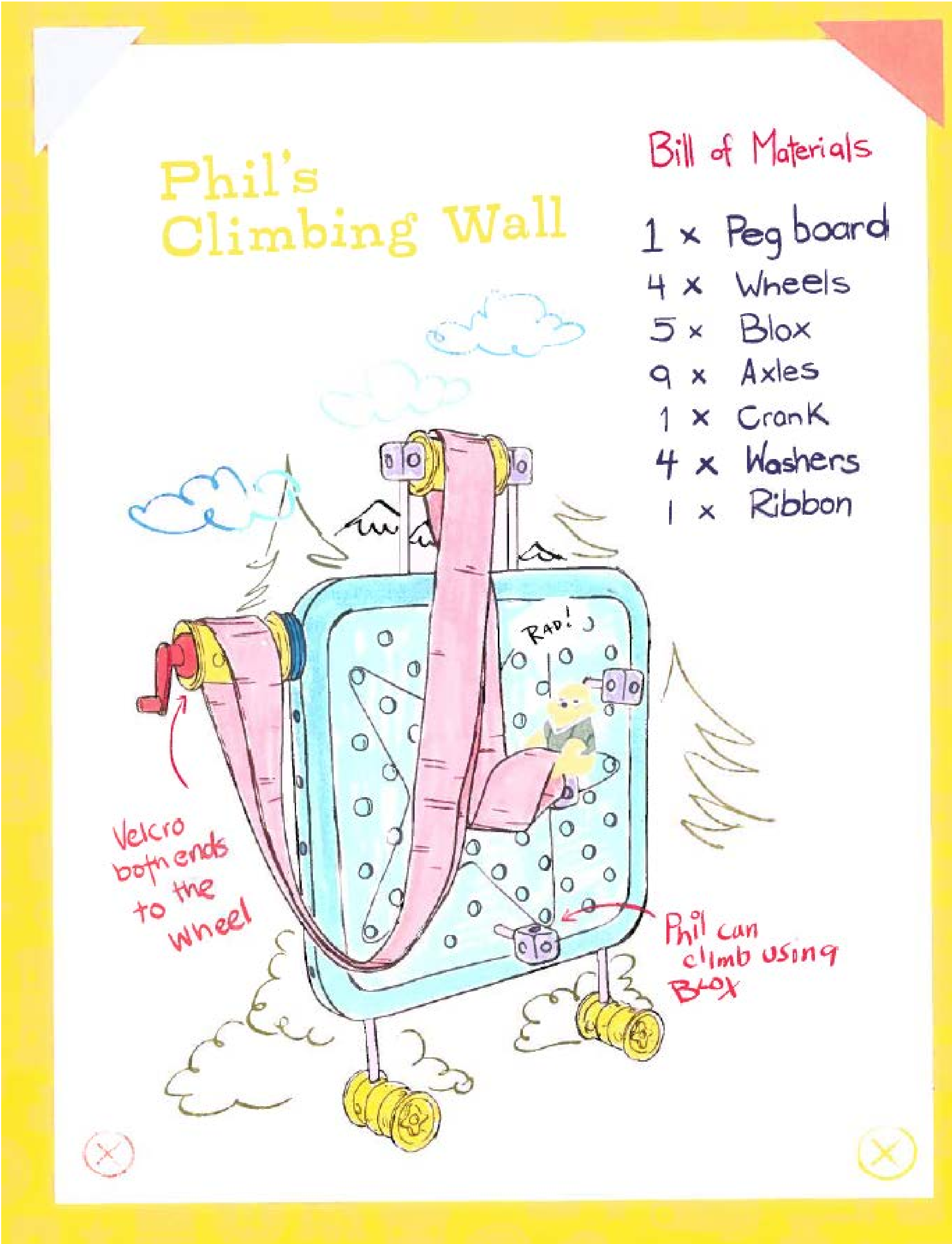
Activity 1: Star Spinning Machine (Based on storyline)

Activity 2: Benjamin's Treadmill

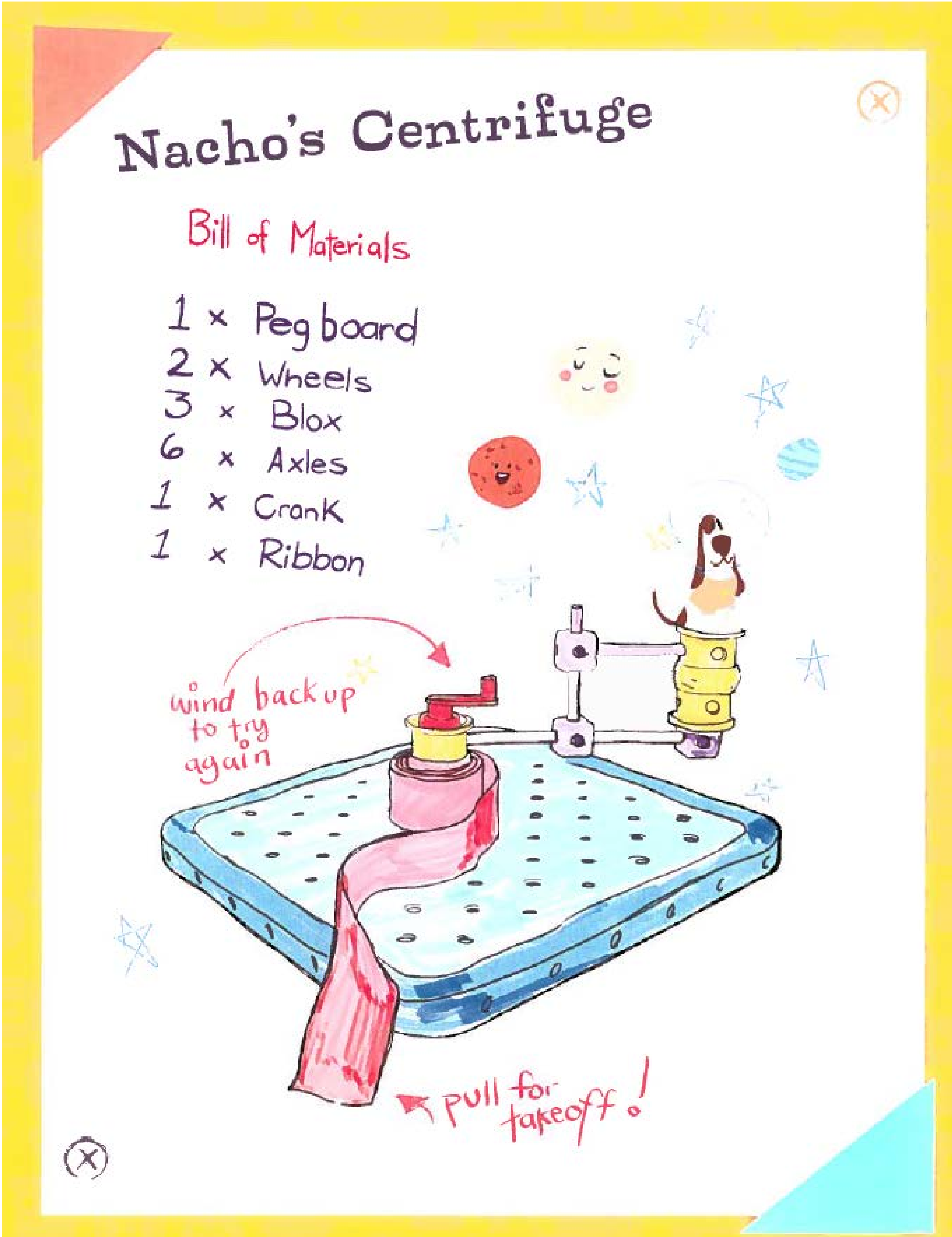


Activity 3: Double See-Saw

Activity 4: Phil's Climbing Wall

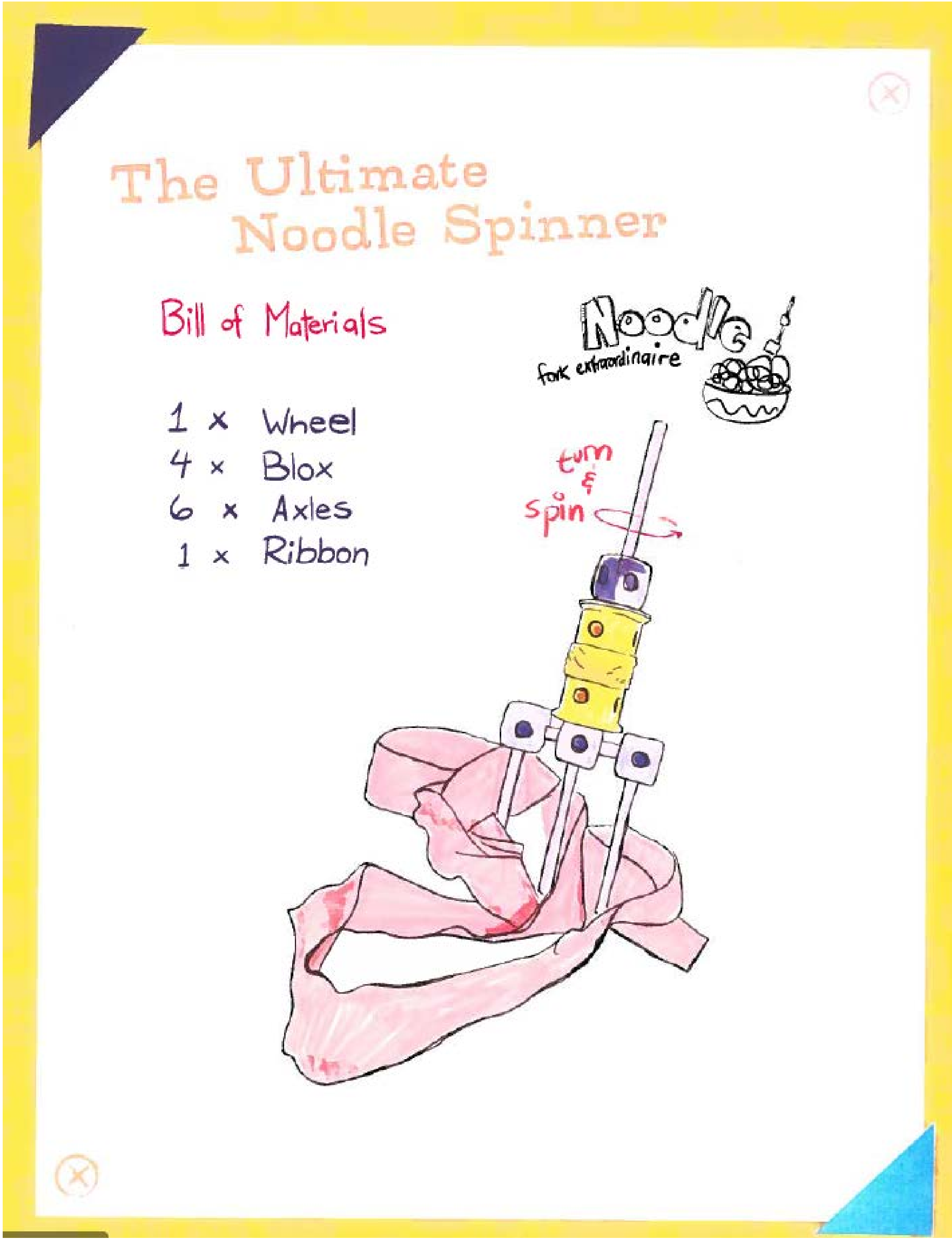


Activity 5: Nacho's Centrifuge

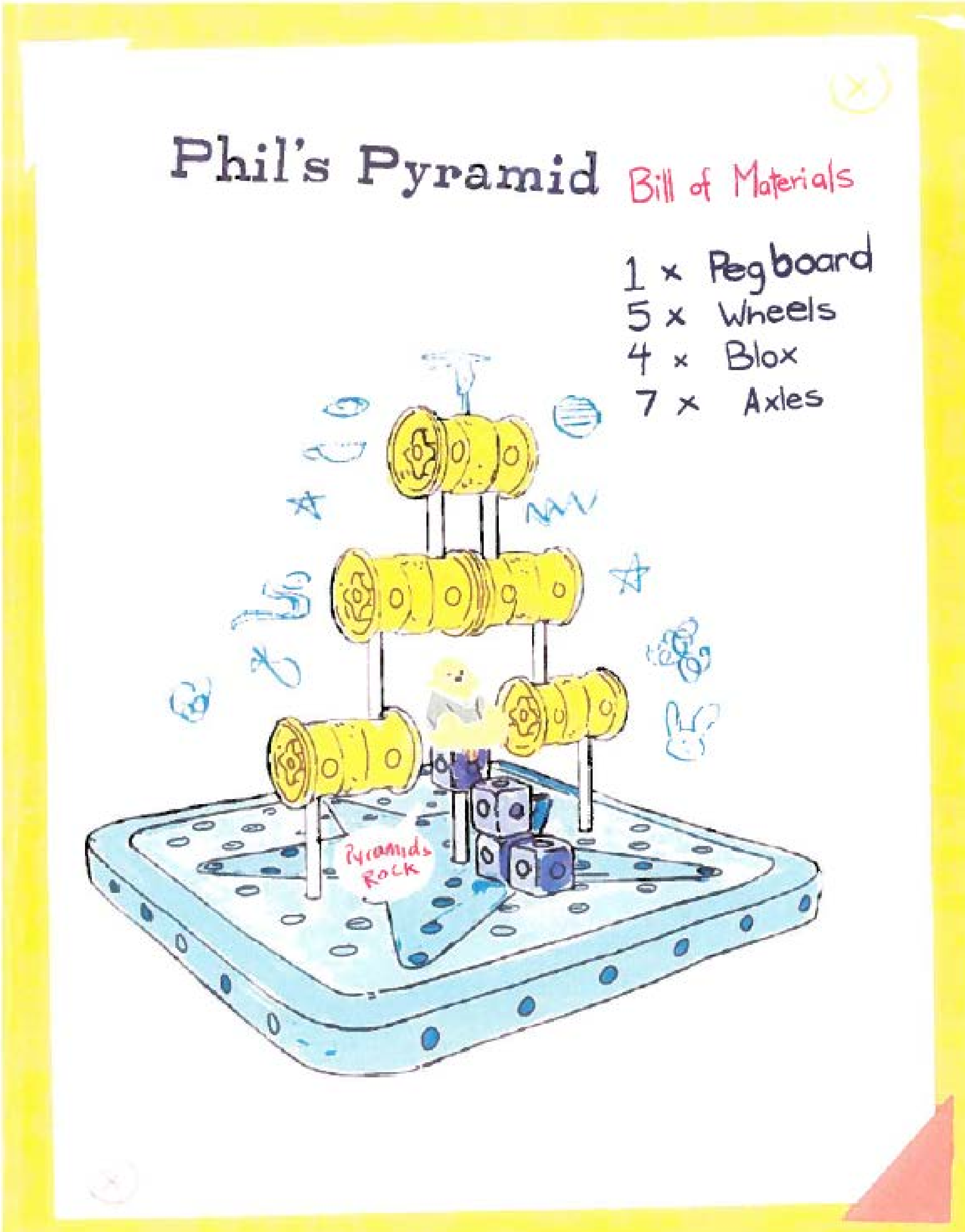


Activity 6: Katinka's Whipper Snapper

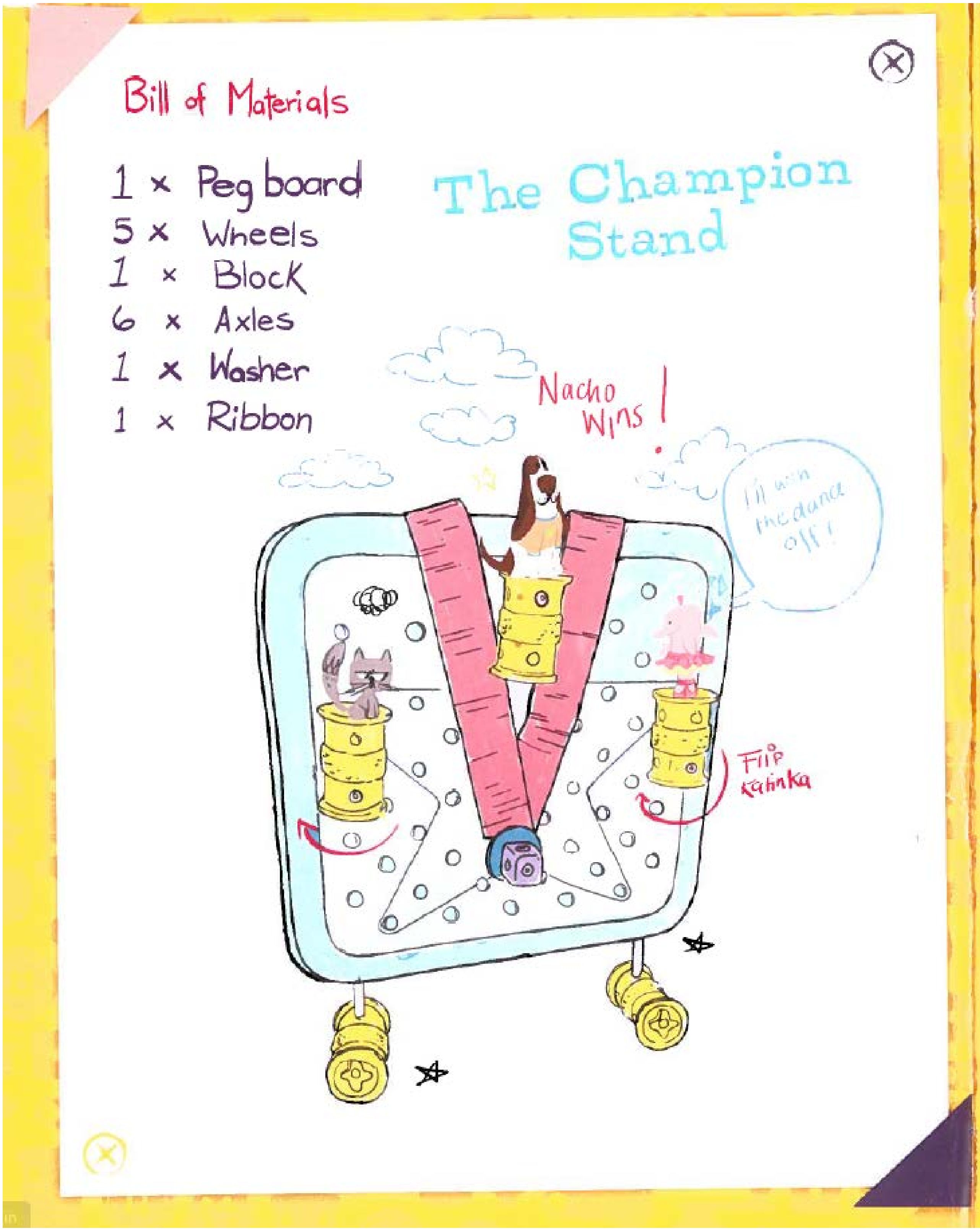
Activity 7: The Ultimate Noodle Spinner



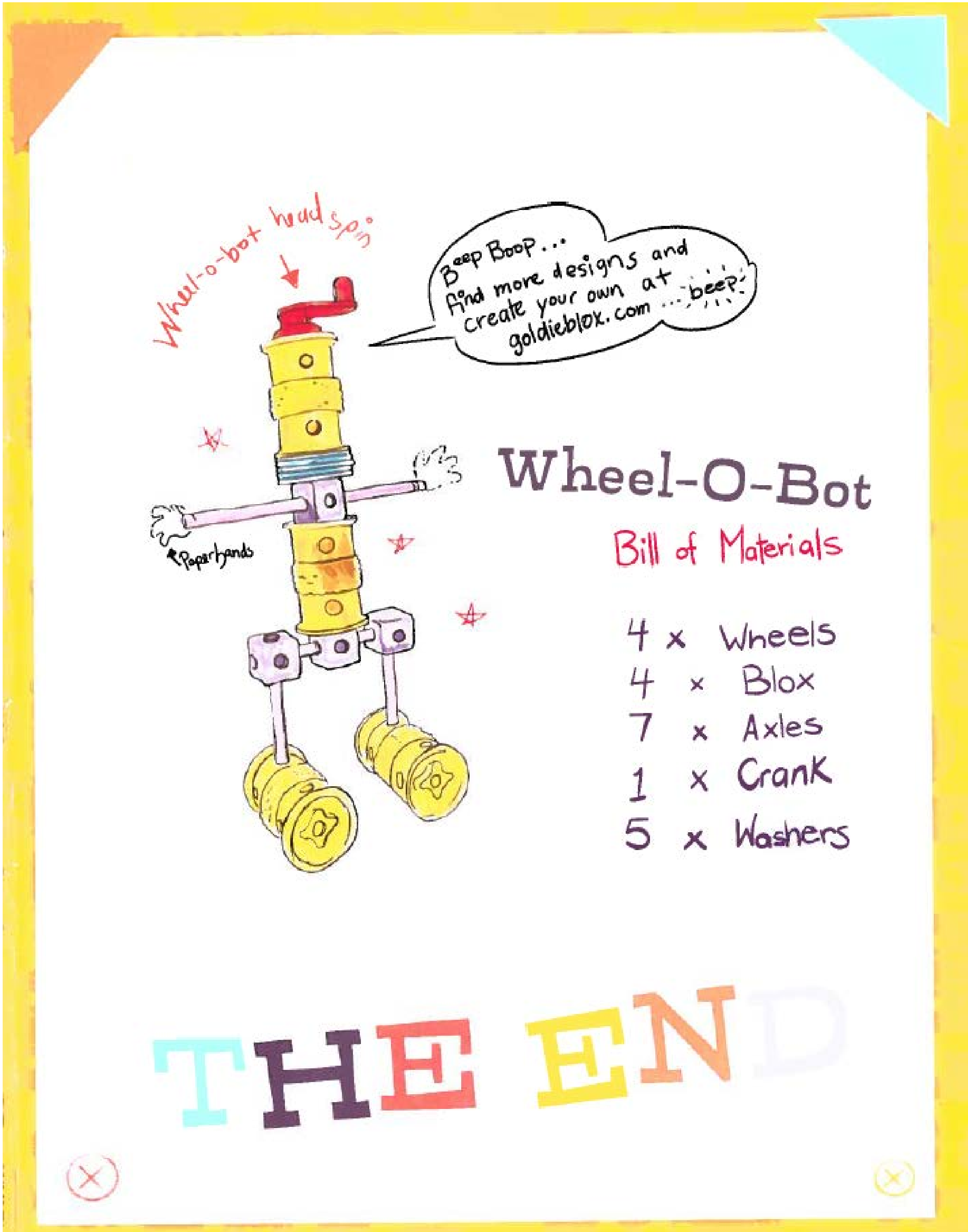
Activity 8: Phil's Pyramid



Activity 9: The Champion Stand



Activity 10: Wheel-O-Bot



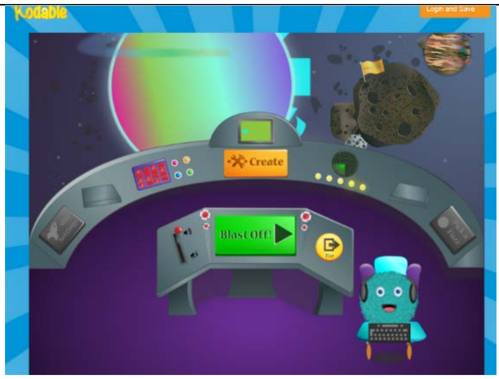
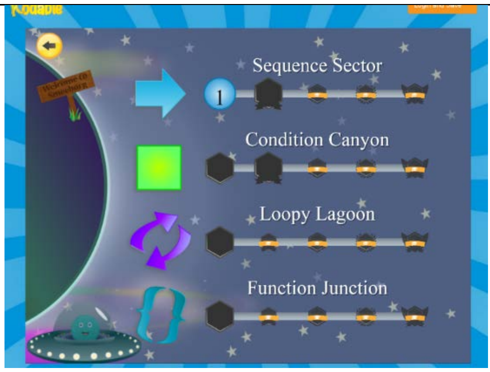
Student Journals:

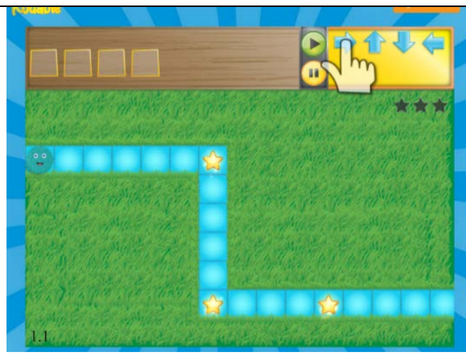
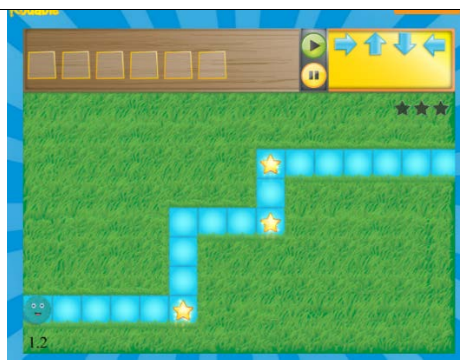
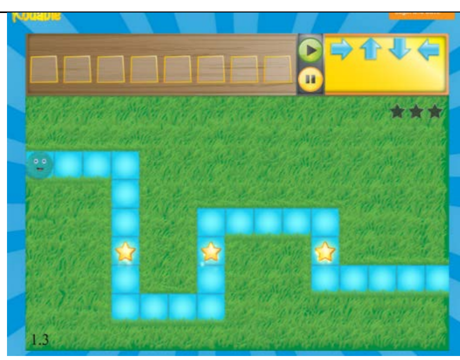
Students are expected to record in their journals the ease of completion and any challenges they encounter. They are also expected to record any ideas they may have on how this item can be included in their lessons should they choose these activities for their final thematic unit.

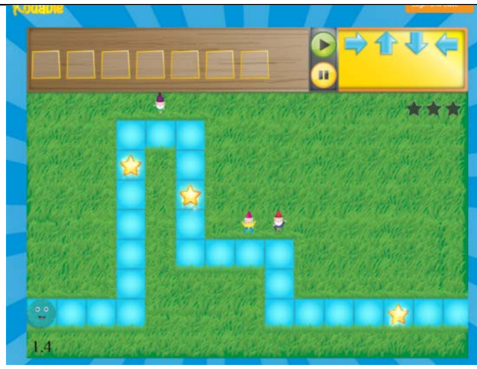
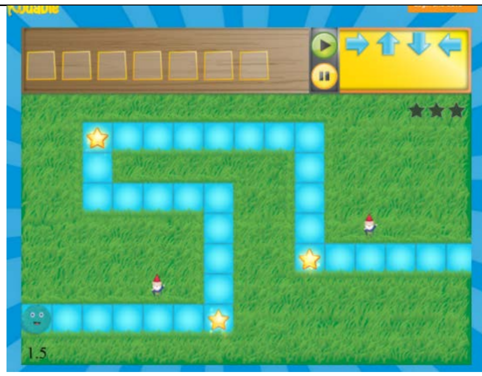
Coding Activities

Students will log unto www.code.org and search for Kodable and complete each activity on each of the 4 sub-levels under Smeeborg: Sequence Sector, Condition Canyon, Loopy Lagoon, and Function Junction.

The activities of the first set of activities included in 1, 2, 3 Roll are pictured below, however each student is expected to complete all 39 levels to the Smeeborg – Beginner Level.

<table>
<tr><td>
</td><td>Entry Screen</td></tr>
<tr><td>
</td><td>Smeeborg Entry Screen</td></tr>
<tr><td>
</td><td>Levels of Smeeborg</td></tr>
</table>

	First Set of Games: 1, 2,3 Roll
	Level 1.1
	Level 1.2
	Level 1.3

	Level 1.4
	Level 1.5

Student Journals

Students are expected to record in their journals the ease of completion and any challenges they encounter. They are also expected to record any ideas they may have on how this item can be included in their lessons should they choose these activities for their final thematic unit.

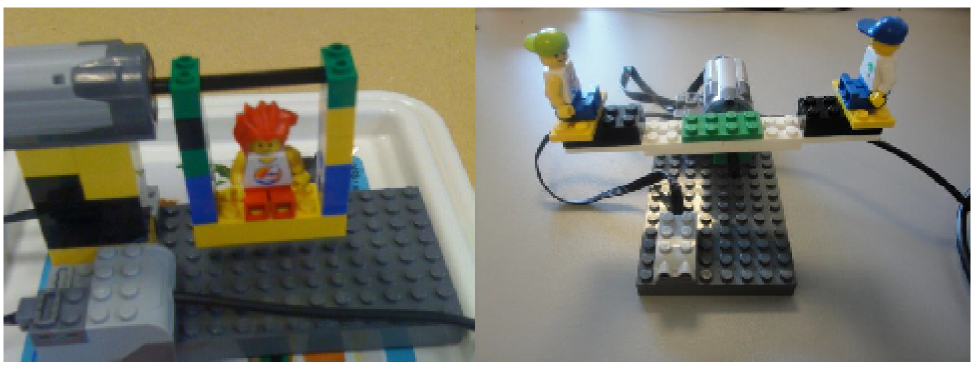
Robotics Activities

Student participants will be expected to complete all seven lessons using the LEGO WeDo™ robotics kits and Curriculum (The Playground developed by DivTech Research Group).

THE PLAYGROUND

PreK-Kindergarten

A Curriculum Unit on Programming and Robotics



DevTech Research Group[1]

Eliot Pearson Department of Child Development

Tufts University

http://ase.tufts.edu/DevTech/tangiblek/

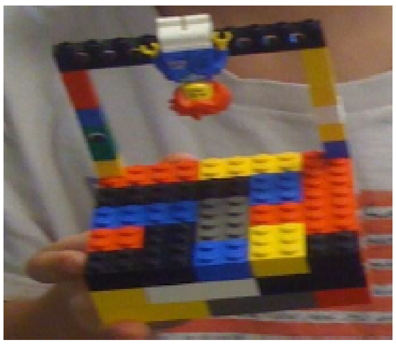
[1] This curriculum was developed by Amanda Sullivan with the help of Louise Flannery, Elizabeth Kazakoff, Adriana Flores, Ethan Peritz, and Amanda Puerto under the direction of Prof. Marina U Bers.

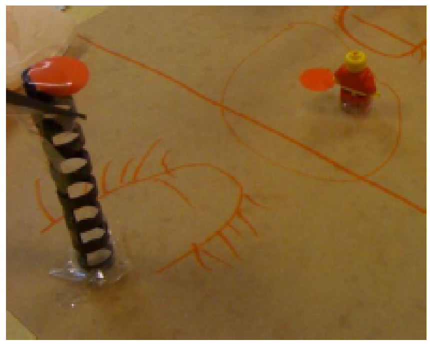
Lesson 1 | *Powerful Idea:*
What is the Engineering Design Process? | *The Engineering Design Process*

Overview:

Children use LEGO® and art materials (all non robotic materials) to build their favorite playground structure. The powerful idea in Lesson 1 (building sturdily through use of the engineering design process) will prove important to the success of the children's robots in subsequent lessons and should be rearticulated and discussed during each activity.

Examples of child projects: Monkey bars made of LEGO® and a basketball court made of art materials.





Prior Knowledge	*Objectives*	
	Students will understand that…	*Students will be able to…*
• None, but prior experience building with LEGO® and crafts or recycled materials is helpful.	• LEGO® bricks and other materials can fit together to form *sturdy structures.* • The *engineering design process* is useful for planning and guiding the creation of artifacts.	• Build sturdy, non-robotic playground structures • Use the engineering design process to facilitate the creation of their structure.

Materials / resources:

- LEGO® bricks and a variety of crafts and recycled materials for building and decorating
- Poster showing the steps of the engineering design process (see Appendix C)
- Engineering Design Journals for planning (see Appendix D)

Activity description

Warm- up : *Playground Visit*

Children will take their Engineering Design Journals on a field trip to a playground (you can show pictures/videos of a playground if this is not possible) in order to connect real life playground structures to the structures students will build using LEGO® and art materials. Children will choose two structures to describe in their journals.

Math Connection: *Shapes on the Playground*

Ask children to identify different shapes they see making up the two playground structures they have chosen to describe. Back in the classroom, look at LEGO® and art materials and ask children to identify the shapes they see and make another list. Compare the two lists. What shapes do they have in common? How can we use materials in the classroom to build structures that look like the real ones? In this activity, children will work to identify and describe 2d shapes and practice comparing and contrasting.

Introduce the concepts and the task: "Today we will be building our favorite playground equipment for toy people to use, and we're going to use a tool to help us make sure our structures are sturdy and work the way they are supposed to." Discuss what an engineer is and introduce the steps of the engineering design process (see Appendix C for a poster).

What is an engineer?
An engineer is anyone who invents or improves things (for instance, just about any object you see around you) or processes (such as baking methods) to solve problems or meet needs. Any man-made object you encounter in your daily life was influenced by engineers.

Think Like an Engineer

Everyone in the class is going to start thinking like an engineer! That means looking at the purpose of objects and how they function. What are the different parts that make up the whole? What do they do? Why are they important? Let's look at pictures of some playground equipment (See Appendix F) and ask these engineer's questions.

Ex 1: Slide- What are the different parts of the slide? What function does each part have? Why is each part important?

Ex.2: Swings- How do these swings work? What function does each part have? What would happen if it had different parts?

Jump For Engineers

Look at a series of pictures of naturally occurring and manmade objects (See Appendix F). Jump if you think an engineer built it, stay seated if you don't think so. Why or why not? Discuss.

<u>Lesson 1 Vocabulary</u>
Students should become familiar with the following words:

Artifact – something important made by people
Circle – a round shape with no edges
Cycle – something that moves in a circle (i.e. the seasons, the Engineering Design Process)
Design – a plan for a building or invention
Edge – the border of a two-dimensional shape or face
Engineer – someone who invents or improves things
Material – something used to build or construct
Rectangle – a shape with four sides, two pairs of sides with equal length
Square – a shape with four equal sides
Structure – a building or object made with different parts

<u>Individual / pair work</u> : Students follow the steps of the engineering design process and use LEGO® and crafts or recycled materials to create their favorite playground or sporting equipment (e.g. slide, basketball court, monkey bars). They may use both structural and aesthetic materials. Students should demonstrate to a teacher that their structures meet the following criteria as they are ready.

The criteria for a successful structure are that:

- At least one toy person can be attached and detached to "use" the structure
- It remains intact when picked up, moved around, and handled

<u>Language Arts Connection:</u> *Postcard Home*

Children will recall their trip to the playground. They will try to remember the structures they saw, the shapes they noticed, and what they liked the most. Children will fill out a blank postcard (in Engineering Design Journals) where they will draw pictures describing their trip for them to send home to their families. With help, they can try to label their pictures using vocabulary words (or dictate the words for the teacher to label). When postcards are complete, cut them out so that children can mail them or take them home!

Note: Working Individually vs. Working in Pairs

Whether students work in pairs versus individually throughout this lesson is left up to the teachers' discretion based on several factors. Materials may be limited, making pair work necessary. Teachers may also have goals for children's social development that an explicit focus on sharing and teamwork throughout this curriculum can support. On the other hand, teamwork can be challenging at this age, so students may benefit from having their own materials and the option rather than the requirement to collaborate with others when it makes sense.

<u>Engineering Experts:</u> Children who finish building their playground structures and master all concepts quickly get to wear a badge that says "Engineering Expert". Engineering Experts walk around and offer help to any classmates experiencing difficulties.

Collaboration Web: As children progress through the lesson, they will complete their collaboration webs. They will draw lines from their picture to the pictures of any classmates who give them help. If children say they didn't receive any help, remind them to think of their partners, class Experts, or if they got any ideas by looking at another classmate's project.

Technology Circle: After finishing, students share their creations. They may do one or more of the following:

a. explain the features of their creation
b. show how their creation moves or how the toy person could use it
c. describe the features of their final design that make it sturdy
d. talk about what they found easy and difficult, and
e. share anything they changed from their original plan.
f. share their postcards
g. share their collaboration webs

Free-play:

Provide opportunities for children to build freely with LEGO® and other arts and crafts materials.

Lesson 2 *Powerful Idea: Robotics*

What Is a Robot? *Robots have Special Parts to that let them Follow Instructions*

Overview:

Children share and learn ideas about what robots are. They are introduced to LEGO® WeDo™ robotics concepts. Children will build and test their own robotic swings.

Example of a child built robotic swing:

Prior Knowledge	*Objectives*	
	Students will understand that…	*Students will be able to…*
• LEGO® bricks and other materials can fit together to form sturdy structures. • The engineering design process is useful for planning and guiding the creation of artifacts. • Symbols (pictures, icons, words, etc) can represent ideas or things. • Some ability to recognize letters or to read is helpful, but not required.	• Robots need moving parts, such as motors, to be able to perform behaviors specified by a program. • The robotic 'brain' (in this case, the computer) has the programmed instructions that make the robot perform its behaviors. • The computer must communicate with the motors for the motors to function.	• Describe the components of a robot, including the 'brain' (computer), motors, and wires. • Upload a program to a robot • Build sturdy, robotic swings that move.

Materials / resources:

- Pictures of different robots and non-robots
- Large icons for games and reference displays
- Computers with WeDo™ software
- One set of robotic parts for each student/pair
- LEGO® bricks and a variety of crafts and recycled materials for building and decorating
- Some partially built structures (or pictures of them) to show possible attachments

Note:

It is important to establish rules or expectations for how students should treat each others' materials, programs, and robots. Find a time for students generate these group expectations. Students may be better able to imagine reasonable expectations after using the robots or programming interface once.

Activity description

Warm up activities:

1) *Jump for the robots!* Children will be shown about 10 different images of robots and non-robots. They jump up and down if they think the picture shown is of a robot. Later, make an "Is It a Robot?" chart putting these images in one of three categories: Robots, Maybe or Sort of Robots, and Not Robots.

   Yes or No? Students jump up (or make another movement) for statements they think are true and sit

Math Connection: Graphing Class Responses

Incorporate graphing into this exercise by making a chart with True and False for each question along the horizontal axis and number of students along the vertical axis. Have students place a marker (sticker, symbol, etc) with their initials in the "True" column or the "False" column. As a class, children will be able to interpret the graph in order to see whether there were more "True" or "False" responses for each question.

1. *Robots are machines (YES).* _____
2. *All robots are made of the same materials (NO).* _____
3. *Robots must have moving parts (YES).* _____
4. *Robots can think by themselves (NO).* _____
5. *All robots look like alike (NO).* _____
6. *Robots must be able to move around the room (NO).* _____
7. *Robots are operated using remote controls (NO).* _____
8. *People tell robots how to behave with a list of instructions called a program (YES).* _____
9. *Some robots can tell what is going on around them (YES).* _____
   (Examples: sensing light, temperature, sound, or a touch.)
10. *Robots are alive (NO).* _____

2) *Discussion: What is a robot?* As a class, children discuss what they think a robot is and examples of robots they know of. Children and teachers can bring in pictures of these objects later and put them on the "Is It a Robot?" chart. The teacher shows a pre-built WeDo™ playground structure and a non-robotic playground structure. The class identifies that you have to push the non-robot to make it move. You can also push the robot, but (as the teacher shows) you can give it instructions and push a button to make it follow them. Why can the robot do this? It has special parts, which the teacher overviews now.

Building and Programming a WeDo™ Robot

Introducing the concepts and task: Build robotic swings that are programmed to move.

1. Introduce the robot's key parts and their functions.
2. *Communication with a robot*: Explain that we can tell a robot what to do, as long as we use a language it understands. Encourage the students to offer examples of how people communicate (speaking, writing, drawing, facial expressions, etc) and other languages they (or people they know) can speak. Discuss the idea of translating between languages, and the need to translate what we want a robot to do into the robot's language. A *program* is another word for instructions we give the robot.
3. Show how to use the programming interface on the computer. Briefly describe the icons (children will learn more about programming in the next lesson). In this lesson, children will solely concentrate on programming their motors to move in order to test their robotic creations.
4. *Individual/pair work*: Students build their own robotic swings. Allow the students to build how they see fit, but remind them that a working robot must be connected to a computer 'brain', motors, properly connected wires, and properly connected USB hub. When they think they have a working robot, they attempt to send a test program to their robot. This test is to ensure that their robot follows the instruction properly and that it is sturdy. Does the swing move? Does it move the way you want it to?

Lesson 2 Vocabulary

Students should become familiar with the following words:

Automatic – by itself, without help from a person
Axle – a pin, pole, or bar on or with which a wheel revolves
Computer – a machine that gives a robot its program or instructions
Function – the reason a machine or robot was built
Hub – the part of a robot that connects it to the computer or brain
Joint – a part of a robot that can turn
Motor – the part of a robot that makes it move
Robot – a machine that can be programmed to do different things
Wires – the long, skinny tubes that connect all the robot's parts

Programming Motors With WeDo™ (from the WeDo™ Resource Guide) :

1) Attach axle to the motor.
2) Attach the motor wire to the LEGO® Hub. It works on either port. Connect hub to computer with the hub's USB cable.
3) Drag and drop the Blocks from the Palette to the Canvas to build the following program:
Start, Motor This Way.
4) Click the Start Block.
The motor moves. The axle turns.
5)To stop the program and turn off the motor, click the Stop button.

Discussion:

What does the motor do?

Turns on and makes the axle move. *What does the Start Block do?* *The Start Block is the beginning of the program. After you click the Start Block, the program starts running. In this example, the Motor This Way Block runs.* *What does the Motor This Way Block do?* *The Motor This Way Block turns on the motor in the clockwise direction.*

Language Arts Connection: *How-To Guide* *You need to explain to someone how to build robotic swings the way you did. In your Engineering Design Journals, create a series of drawings showing all the different robotic and non-robotic parts you used. Try to use the new vocabulary words you've learned to label the different parts, or dictate to a teacher who can write the labels down for you.*

Robotics Experts: Children who finish building their robots and master all concepts quickly get to wear a badge that says "Robotics Expert". Robotics Experts walk around and offer help to any classmates experiencing difficulties building a functional robot.

Collaboration Web: As children progress through the lesson, they will complete their collaboration webs. They will draw lines from their picture to the pictures of any classmates who give them help. If children say they didn't receive any help, remind them to think of their partners, class Experts, or if they got any ideas by looking at another classmate's project.

Technology Circle: Have the students share their creations with the rest of the class (or a small group). During this time, students can share the parts and features of their robot, share what they found easy or difficult, or share what makes their robot sturdy.

What do you think will happen if you make a robot that is missing one of its pieces? Try it out!

Concluding activity: See Appendix B for examples.

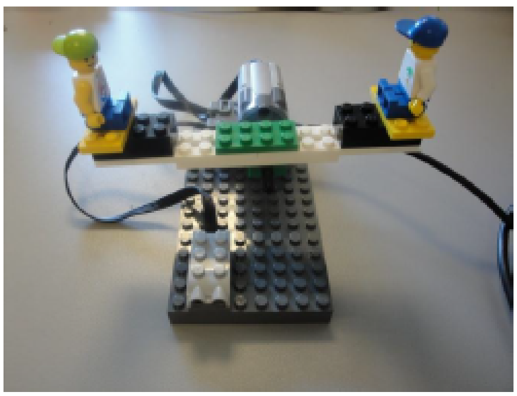
Free-play: Free exploration of building and programming with robotic materials. Children may choose to continue modifying their swings or explore the building and programming of other creations.

Lesson 3 *Powerful Idea: Programming: Control Flow by Sequencing and Instructions*
What Is a Program?

Overview: Children build and program a robotic seesaw in order to gain expertise in what a program is.

What Is a Program?
A program is a sequence of instructions that the robot acts out in order. Each instruction has a specific meaning, and the order of the instructions affects the robot's overall actions.

Example of a robotic seesaw (See Appendix F for detailed building instructions):



Prior Knowledge	*Objectives*	
	Students will understand that…	*Students will be able to…*
• A robot is a machine that can act on its own once it receives proper instructions.	• Each icon or "block" corresponds to a specific instruction • A program is a sequence of instructions that is followed by a robot • The order of the instructions dictates the order in which the robot executes the instructions	• Point out or select the appropriate block corresponding to a planned robot action • Connect a series of blocks on the computer • Transmit a program to a robot

Materials / resources:

- Large icons for games and reference displays
- Robotic and non-robotic building materials
- Computers with WeDo™ software

<u>*Activity description*</u>

<u>*Warm-Up*</u>: Play *Simon Says* or another game from Appendix B to learn/ review each of the WeDo™ programming icons and what each icon represents.

<u>*Introduce the concepts and task*</u>. Show an example robotic seesaw programmed to tilt back and forth with toy people riding on it. "Today we will build and program robotic seesaws for toy people to play on!"

<u>*Activity:*</u> Individually or in pairs, children will build their own robotic seesaws. Once built, children will experiment with programming their seesaws to tilt back and forth. Children will use cut-outs or stickers of the programming icons to put together programs in their Engineering Design Journals and work through the accompanying planning and reflecting questions.

Math Connection: *Counting and Labeling*
Students will write or draw what robotic, LEGO® , and other pieces they plan to use and:

1) *Label the pieces by shape*
2) *Count how many of each shape they used*
3) *Teacher can add individual student results to a classroom chart.*

Lesson 3 Vocabulary:

Instruction – a direction that a robot will listen to
Keyboard – the part of a computer used to type letters, numbers, symbols, and commands
Order – parts of a group arranged to make sense
Program – a set of instructions for a robot
Sequence – the order of instructions that a robot will follow exactly
Variable – something in a program that can change

Language Arts Connection: *Program Charades*

Children will pair up. One child will make up a program using the WeDo™ icons and act it out while the other partner guesses what the programming instructions are. Switch roles. Come up with a program together that you will "write" out (using stickers or cutouts of the WeDo™ instructions) to act out for the class.

<u>*Programming Experts:*</u> Children who finish programming their robots and master all concepts quickly get to wear a badge that says "Programming Expert". Programming Experts walk around and offer help troubleshooting to any classmates experiencing difficulties programming.

Collaboration Web: As children progress through the lesson, they will complete their collaboration webs. They will draw lines from their picture to the pictures of any classmates who give them help. If children say they didn't receive any help, remind them to think of their partners, class Experts, or if they got any ideas by looking at another classmate's project.

Technology circle: *At the end of class, children will share their robotic seesaws with the group and talk about their process making and programming them. As a class, they will help troubleshoot problems if any children could not get their seesaws to function properly.*

Concluding activity: Simon Says, or another game. See Appendix B for other suggestions.

Free-Play: Students continue to create and upload programs to a robot. As students are ready, prompt them to plan ahead about what they want the robot to do.

Lesson 4 *Powerful Ideas:*
What Are Repeats? *Repeats: Loops and Number Parameters*

Overview

Students will learn about a new instruction that makes the robot repeat other instructions infinitely or a given number of times. They use these new instructions to program robotic seesaws to move from left to right a particular number of times.

Prior Knowledge	*Objectives*	
	Students will understand that…	*Students will be able to…*
• Arranging instructions in a different order will result in a different program.	• An instruction or sequence of instructions may be modified to repeat. • Some programming instructions, like 'Repeat,' can be qualified with additional information.	• Recognize a situation that requires a looped program. • Make a program that loops. • Use number parameters to modify the number of times a loop runs.

Materials / resources:

- Large icons for games and reference displays
- Robotic and non robotic building materials
- Computers with WeDo™ software

Activity description: Individually or with partners, children use their already built seesaws and modify their programs to utilize Repeats.

Warm-Up: *Game or song that uses repetition.* See Appendix B for examples.

Introduce the concepts: *Repeats*

1. Discuss what it means for something to repeat. How does this relate to similar concepts like patterns?
2. Introduce the "Repeat" programming icon. Show the different ways you can program a Repeat.
3. Using a sample robot and program, demonstrate a robot acting out a pattern by repeating certain actions multiple times.

Lesson 4 Vocabulary:

Loop – something that repeats over and over again
Parameter – a limit that a robot will follow
Pattern – a design or sequence that repeats
Repeat – to do something more than once

Math Connection: *Patterns & Counting*

After showing a robot acting out a sample program that is a pattern, children will identify the repeating unit, count how many times it repeats, and (as a class) change the program so that it uses a repeat to accomplish the same outcome.

The task: Children will use repeats correctly to make their seesaws tilt from left to right 5 times (one full cycle tilting from left to right is considered "1" time or one "seesaw"). Once this is mastered, use repeats to create a more complex repeating pattern (i.e. add a repeating sound or add another repeating pattern that happens after the seesaw moves back and forth 5 times).

Language Arts Connection: *Toothbrush Exercise*

Think about the way your brush your teeth- this is a task that requires some repeating motions (like moving your toothbrush from left to right) and other motions that only happen once (like squeezing out toothpaste). Pretend YOU are a robot that needs a program to brush your teeth. Using WeDo™ programming instructions (and made-up instructions like "spit" and "rinse"). Make up a program that uses repeats and act it out for a partner. Did you have the same program or different programs?

Repeats Experts: Children who finish programming their robots and master all concepts quickly get to wear a badge that says "Repeats Expert". Repeats Experts walk around and offer help troubleshooting to any classmates experiencing difficulties programming with repeats.

Collaboration Web: As children progress through the lesson, they will complete their collaboration webs. They will draw lines from their picture to the pictures of any classmates who give them help. If children say they didn't receive any help, remind them to think of their partners, class Experts, or if they got any ideas by looking at another classmate's project.

Technology Circle: Students share their programs and discuss how Repeats work, especially how order is important.

Free-play: Students need to explore the new instructions. They should build programs that use (or don't use) them. In doing so, they will gain comfort with sequencing the blocks correctly, how the robot follows instructions depending where the repeat is placed.

Advanced Lessons 5 & 6: Sensors and Gears

Introduction

It is expected that Pre-K and Kindergarten students learning robotics for the first time will proceed slowly through the first 4 lessons and that teachers will take care to reinforce challenging concepts and give children plenty of time for free play. The following lessons (on sensors and gears) are included as an extension of the curriculum if teachers wish to continue the unit for a longer duration of time or for advanced children who speed through their understanding of the first 4 lessons. If teachers do not wish to teach sensors and gears, they may skip the next two lessons and move directly to the final project.

Lesson 5 *Powerful Idea:*
What are Sensors? *Sensors*

Overview

Children are introduced to the tilt sensor and the motion sensor and add them to their seesaws.

Prior Knowledge	*Objectives*	
	Students will understand that…	*Students will be able to…*
• Examples of human or animal sense organs and that people and animals use information provided by their senses to help make decisions.	• A robot can feel and see its surroundings with a sensor. • A robot can react to collected data by changing its behavior. • Certain instructions (like "Repeat") can be modified with sensor data.	• To use a motion sensor and tilt sensor appropriately with their robots. • Compare and contrast human sense and robot sensors

Materials / resources:

- Large icons for games and reference displays
- Robotic and non robotic building materials
- Computers with WeDo™ software
- WeDo™ tilt and motion sensors

Activity description

Warm-Up: *Game or song that uses the 5 human senses.* For example, see:

Barney Five Senses song at: http://www.youtube.com/watch?v=sipHgMvOc6Y or,

When You Use Your Five Senses at:
http://www.youtube.com/watch?v=IpbosEwpWjo&feature=bf_next&list=WL96B2F66D3C3EFB12&index=2

Introduce the concepts: Sensors and Sensor Parameters:

1. Discuss examples of human / animal senses and how these senses let us gather information about what's going on around us, so that we can make decisions based on this information.
2. Show the motion and tilt sensors and explain how they work.
3. We need programming instructions to tell the robot what to do with the information from its sensors. Show the Repeat icons, which are now familiar, and the icons for the Tilt sensor and Motion sensor.
4. Run a sample program, and have students discuss what the robot is doing.

5. Display the reference program visibly in the room.

Examples of Robots With Sensors:

Snuffles the Elephant: http://www.youtube.com/watch?v=IdqYgE8Mcqo

WeDo™ Alligator: http://www.youtube.com/watch?v=vbzcMDYyoRk

Robots Using Sensors to Locate a Ball: http://www.youtube.com/watch?v=sXKtV-_gsMo

Robot Goalie: http://www.youtube.com/watch?v=VTlW_d1XRE4

Pressure Sensor: http://www.youtube.com/watch?v=pXMtofKjJkM

Using WeDo™ Tilt Sensors with a Sample Program (From the WeDo™ Resource Guide):

1) Attach the tilt sensor wire to the LEGO® Hub. It works on either port.
2) Click the Arrow button on the Palette to see all of the Blocks.
3) Drag and drop the Blocks from the Palette to the Canvas to build the following program: Start, Display Background, Wait For, Display Background.
4) On the Wait For Block, drag and drop a Tilt Sensor Input on top of the Number Input.
The Tilt Sensor Input replaces the Number Input.
5) On the second Display Background Block, move the mouse pointer over the Number Input and type 2.
The Input changes to the number 2.
6) Click the Start Block.
The program opens the Display Tab and shows the first background. Then the program waits until you tilt the sensor upward and the Display Tab shows the second background.

Discussion
1) What does the tilt sensor do?
The tilt sensor tells the computer when it is pointed up, down or in other directions.
2) Which Blocks do you use to program the tilt sensor?
Wait For with a Tilt Sensor Input.
3) How does this program work?
The program shows a background in the Display Tab and then waits for someone to tilt the sensor upward. When the tilt sensor tilts upward, the program shows another background.
4) The tilt sensor can also be pointed in other directions. Click on the Tilt Sensor Input in your program to find out how many ways it can be tilted.
Six ways: Up, Down, This Way, That Way, No Tilt, Any Tilt.
5) Change your program to use a different Tilt Sensor Input.
Change the Tilt Sensor Input to any of these other options. Then when the program runs again, it will wait for the new tilt input direction before changing to another background.

Using WeDo™ Motion Sensors with a Sample Program (From the WeDo™ Resource Guide):

1) Attach the motion sensor wire to the LEGO® Hub. It works on either port.
3) Drag and drop the Blocks from the Palette to the Canvas to build the program shown: Start, Motor On For, Display.
4) Drag and drop a Motion Sensor Input on top of the Number Input that was automatically attached to the Wait For Block. The Motion Sensor Input replaces the Number Input.
5) Click the Start Block. Then move your hand in front of the motion sensor.
The program waits to see your hand then displays abc.

Discussion

What does a motion sensor do?
It sees objects or movement and reports to the computer.
What is the Display Block programmed to show?
The Display Block in this program shows the letters abc. It can also be programmed to show other words or numbers. See the Programming Tip.

Language Arts Connections: *Sensor Walk*

Divide the class into two groups: Humans and Robots. Take the class for a walk around the school or neighborhood. As a class, keep a list of all the different things the humans and robots can sense and what part they used to sense it. For example, the human group may sense the sunlight with their eyes while students in the robot group would sense this with their light sensors. Children in the robot group do not need to be limited WeDo™ sensors, but can think creatively about all kinds of sensors a robot might have. Upon returning to the classroom, compare and contrast the Human and Robot lists. Are there some things humans can sense but robots cannot? What about vice versa?

The task: The students add a motion and then tilt sensors to their robot (one at a time) and program their seesaws to tilt back and forth until otherwise instructed by the sensors.

Math Connection: *Counting*

After children add motion sensors to their seesaws, they get together with partners. One partner starts the program and stops it by activating the motion sensor. Meanwhile, the other partner counts and records the number of times the seesaw goes back and forth before it stops. Partners take turns in the different roles.

Lesson 5 Vocabulary:

Direction – the way something is pointing
Motion – the state when something is moving

Power – the speed at which a motor moves *Sensor* – a machine that can tell something that is happening around it *Tilt* – how off-center something is *Vision* – the sense used by the eyes

Sensors Experts: Children who finish programming their robots and master all concepts quickly get to wear a badge that says "Sensors Expert". Sensors Experts walk around and offer help troubleshooting to any classmates experiencing difficulties attaching their sensors or programming with sensors.

Collaboration Web: As children progress through the lesson, they will complete their collaboration webs. They will draw lines from their picture to the pictures of any classmates who give them help. If children say they didn't receive any help, remind them to think of their partners, class Experts, or if they got any ideas by looking at another classmate's project.

Technology Circle: Understanding how the sensors work and how programming them can be challenging. Have students discuss their understandings of the sensors and why different programs do or do not accomplish the goal.

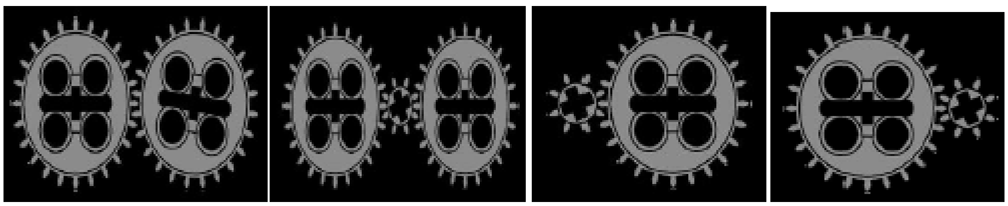
Concluding Activity: Song or game. See Appendix B for examples.

Free-play Have students explore adding sensors to robots and making programs with Repeats and Sensor Parameter instructions. Sensors use complex concepts and often work in unexpected ways. Offer support in observing the robot's behavior so students may fully understand these concepts.

Lesson 6 *Powerful Idea:*
What Are Gears? *How gears work to transmit or receive force and motion*

<u>Overview</u>: In this lesson, children will be introduced to the concept of gears. Children will build models demonstrating gears, gearing up, gearing down, and an idler gear. This lesson can be used to directly lead into an advanced final project that utilizes gears (like the WeDo™ Car, see Appendix F) or it can be used simply as an introduction to the complicated concept of gears.

Examples of gears, idler gear, gearing down, and gearing up (respectively):



Prior Knowledge	*Objectives*	
	Students will understand that…	*Students will be able to…*
• *Real world items, like bicycles, function by utilizing gears* • *Gears can be used to make something move.*	• *Gears are mechanical parts with cut teeth of such form, size, and spacing that they mesh with teeth in another part to transmit or receive force and motion.*	• *Build and explain models using gears, gearing up, gearing down, and an idler gear*

<u>Basic Properties of Gears:</u>

1) When 2 gears mesh, the driver makes follower turn in opposite direction
2) You need odd number of idler gears to make driver and follower turn in same direction.
3) When large driver turns small follower, its called *gearing up* and speeds up gear train
4) When small driver turns large follower, its called *gearing down* and increases torque (turning force)

Materials / resources:

- LEGO® WeDo™ gears found in the WeDo™ construction sets
- Pictures of real world gears kids are familiar (e.g. gears on a bicycle)
- Pictures of idler gears, gearing down, and gearing up
- Engineering Design Journals for planning and reflecting

Language Arts Connection: *Human Gears*

Get into small groups of around 5 children. You will be creating a system of gears. Children should stand shoulder to shoulder. The first child will turn in one direction gently pushing the person next to him in the opposite direction and so on down the line. Using communication skills and new vocabulary describe what you are doing as you move Once you have a whole line of gears moving, try passing an object (like a ball) down the line of "gears" (children). How did it go? Share with the class.

Individual / pair work : Individually or with groups, build and program models of gears, idler gears, gearing down, and gearing up.

Note: Teachers may wish to use or consult the Getting Started activities on gears, idler gears, gearing up and gearing down available with WeDo™ . To find these activities, open WeDo™ software, click on "Getting Started", and then click on "Gears".

Gears Experts: Children who finish building and programming all of the gear constructions assigned and master all concepts quickly get to wear a badge that says "Gears Expert". Gears Experts walk around and offer help troubleshooting to any classmates experiencing difficulties working with the different kinds of gears. Encourage experts to use the proper gear vocabulary when helping their classmates.

Collaboration Web: As children progress through the lesson, they will complete their collaboration webs. They will draw lines from their picture to the pictures of any classmates who give them help. If children say they didn't receive any help, remind them to think of their partners, class Experts, or if they got any ideas by looking at another classmate's project.

Technology Circle: After about 45 minutes of building, students share their creations and discuss the challenges they encountered building and programming with gears.

Free-play: Provide opportunities for children to build freely using gears or to begin work on a final project that utilizes gears.

Activity description

Warm- up: Real World Gears

Show videos and/or tangible examples of gears and how they work.

Videos on Gears:
Small engine animation: http://www.youtube.com/watch?v=_GVq9O9mFCs&feature=related
Watch movement animation: http://www.youtube.com/watch?v=qux3fLCf2FU&feature=related
Inside the watch and movement: http://www.youtube.com/watch?v=cn6lHIhm5Xs
Steam engine train: http://www.youtube.com/watch?v=fhvmC0Qpkk0

Introduce the concepts and the task (10 minutes): "Today we will be building models of different types of gears. We might choose to use some of the models we make today in our final projects." Show examples of the different types of WeDo™ gears and the ways you can program with them. Introduce the basic properties of gears.

What Are Gears?
Gears are a mechanical part with cut teeth of such form, size, and spacing that they mesh with teeth in another part to transmit or receive force and motion.

Math Connection: Speed and Direction
The Math Behind Gears
Complete a worksheet on gears (see Engineering Design Journal in Appendix D). What direction are the gears shown turning? Which gears are going faster? Which are going slower?

Lesson 6 Vocabulary:
Crown – a gear shaped like a crown that meshes at an angle, not in a straight line like most gears
Gear – something used to turn many parts using only one motor
Gear Down - using differently sized gears to decrease the speed of a machine
Gear Up – using differently sized gears to increase the speed of a machine
Idler – a gear that goes in between two other gears that isn't connected to the motor or a wheel
Mesh – two gears that connect
Tooth – the part of a gear that turns other gears

Lesson 7
Final Projects

<u>Overview</u>

This project should be tailored to fit with a curriculum unit, project, or event happening in the classroom so that it meets the goals of the teachers and the interests of the students and teachers. Students work together to build and program a robot to demonstrate their understandings and ideas related to the robotics and programming curriculum as well as the content of the project theme or topic. During the course of the final project, students put to use all the concepts learned during the previous lessons but transfer them to a new context. When possible, teachers should encourage the use of crafts and recycled materials.

Language Arts Connection:

-Invitations: *Write out and mail invitations to your family inviting them to come to your final project showcase. Add illustrations and information describing your project.*

-How-To Book: *Create a comprehensive How-To Book describing how to build and program the robot you made*

Math Connection:

-How Many?: *As a class, keep a chart that graphs how many of all the different types of robotic and non robotic parts you used. Make a report to display and share on the presentation day.*

Playground Final Project Ideas:

-Ferris Wheel or other ride (See Appendix F for building instructions)

-School bus or ice cream truck (See Appendix F for car building instructions)

-Soccer/basketball/baseball player

- A playground game like tag or hopscotch

<u>*Individual/pair work:*</u> Children will work individually or with a partner to plan, design, build, and program a final project from scratch. Children will be encouraged to use advanced topics such as sensors and repeats when programming their robots.

Presentations: Students share:

a. the robot they made,
b. why they chose the features they did for their robot,
c. the goal of their program and why they wanted it to do that / what it represents,
d. the final program they built, and
e. anything that was hard, easy, surprising, interesting, etc about the process.

Materials / resources:

- Large icons for games and reference displays
- Robotic parts for each child or pair to make a robot, plus extras
- Crafts and recycles materials for robots and for building an environment for them to run in
- Computers with WeDo™ software,
- Design journals, small icons for cutting and taping/gluing in the design journals

Student Journals

Students are expected to record in their journals the ease of completion and any challenges they encounter. They are also expected to record any ideas they may have on how this item can be included in their lessons should they choose these activities for their final thematic unit.

Appendix F

IRB APPROVAL

The University of Georgia

Phone 706-542-3199

Office of the Vice President for Research
Institutional Review Board

MODIFICATIONS REQUIRED TO SECURE APPROVAL

August 21, 2018

Dear roger hill:

On 8/21/2018, the IRB reviewed the following submission:

Type of Review:	Initial Study
Title of Study:	Impact of Robotics and STEM Instruction on Self-Efficacy of African American High School Girls
Investigator:	roger hill
Co-Investigator:	Deborah Spear
IRB ID:	STUDY00006345
Funding:	None

The IRB determined that the following modifications and/or additional information/documents are required in order to complete the review, and before approval can be granted:

- External site authorization from Jackson Public Schools Career Development Center.

Sincerely,

William Westbrook, IRB Analyst
University of Georgia

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Human Research Protection Program

EXEMPT DETERMINATION

November 27, 2018

Dear roger hill:

On 11/27/2018, the Human Subjects Office reviewed the following submission:

Type of Review:	Initial Study
Title of Study:	Impact of Robotics and STEM Instruction on Self-Efficacy of African American High School Girls
Investigator:	roger hill
Co-Investigator:	Deborah Spear
IRB ID:	STUDY00006345
Funding:	None
Review Category:	Exempt, FLEX (7)

We have approved the protocol from 11/27/2018 to 8/20/2023.

This is an exempt study, so it's not necessary to submit a modification for minor changes to study procedure. You can keep us informed of changes that don't affect the risk of the study by using "Add Comment".

Please close this study when it is complete.

In conducting this study, you are required to follow the requirements listed in the Investigator Manual (HRP-103).

Sincerely,

William Westbrook, IRB Analyst
Human Subjects Office, University of Georgia

Appendix G

JACKSON PUBLIC SCHOOLS APPROVAL TO CONDUCT RESEARCH

Jason Sargent, Ph.D.
Executive Director

Phone 601-960-8850
Facsimile 601-973-8680
Email JaSargent@jackson.k12.ms.us
www.jackson.k12.ms.us

October 25, 2018

Dear Ms. Deborah Spear:

The Research Review Committee for the Jackson Public School District has approved your request to conduct research on the title, *"Impact of Robotics and STEM on Self-Efficacy of African American High School Girls."* Please ensure that all information used in research activities pertaining to individuals' identity and facilities remain anonymous.

Before beginning your research, you are required to present a copy of this letter along with your original IRB approval letter to specified district sites. This study is limited to the Career Development Center; failure to comply with these requests will automatically nullify your research approval status. Additionally, let it be noted that your approval status is valid for the 2018 – 2019 school year.

If further assistance is needed, you may contact our office via email at shollins@jackson.k12.ms.us, and in the subject heading, please include "***research***." Best wishes with your research activities!

Sincerely,

Jason Sargent, Ph.D.
Executive Director

References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*, 179-211.

Anderson-Rowland, M., Baker, D. R., Secola, P. M., Smiley, B. A., Evans, D. L., & Middleton, J. A. (2002). “Integrating engineering concepts under current K-12 state and national standards,” in Proceedings of the 2002 ASEE Annual Conference, Montreal, PQ, Canada, June 16-19, 2002.

Asad, K., Tibi, M., & Raiyn, J. (2016). Primary School Pupils’ Attitudes toward Learning Programming through Visual Interactive Environments. *World Journal of Education, 6*(5), 20-26.

Bagiati, A., So Yoon, Y., Evangelou, D., & Ngambeki, I. (2010). Engineering curricula in early education: Describing the landscape of open resources. *Early Childhood Research & Practice (ECRP)*, *12*(2), 1.

Baker, T. R., & White, S. H. (2003). The effects of GIS on students' attitudes, self-efficacy, and achievement in middle school science classrooms. *Journal of Geography*, *102*(6), 243-254.

Bame, E. A. & Dugger, W. E. (1989). Pupils’ attitude toward technology: PATT-USA.

Bandura, A. (1997). Self-efficacy. *Harvard Mental Health Letter*, *13*(9), 4.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs, New Jersey: Prentice-Hall.

Bers, M.U., Flannery, L., Kazakoff, E.R., & Sullivan, A. (2014). Computational thinking and tinkering: Exploration of an early childhood robotics curriculum. *Computers & Education*, *72*, 145-157.

Betz, N. E., & Wolfe, J. B. (2005). Measuring Confidence for Basic Domains of Vocational Activity in High School Students. *Journal of Career Assessment*, *13*(3), 251-270.

Boston, J. S., & Cimpian, A. (2018). How do we encourage gifted girls to pursue and succeed in science and engineering? *Gifted Child Today, 41*(4), 196-207.

Brand, B. R., & Wilkins J. L. (2007). Using self-efficacy as a construct for evaluating science and mathematics methods courses. Journal of Science Teacher Education, 18(2), 297-317.

Britiner, S. L., & Pajares, F. (2001). Self-efficacy beliefs, motivation, race, and gender in middle school science. *Journal of Women and Minorities in Science and Engineering, 7*, 269-283.

Britiner, S. L., & Pajares, F. (2006). Sources of science self-efficacy beliefs of middle school students. *Journal of Research in Science Teaching, 43*, 485-499. doi: 10.1002/tea.20131

Brophy, S., Klein, S., Portsmore, M., & Rogers, C. (2008). Advancing engineering education in P-12 classrooms. *Journal of Engineering Education*, *97*(3), 369-387.

Buffer Jr, J. J. (2005). Speculations on the Insights and Perceptions of Professor William E. Warner Regarding the Status of Technology Education and its Future. *Journal of Technology Studies*, *31*(1), 13-19.

Bystydzienski, J. M., Eisenhart, M., & Bruning, M. (2015). High school is not too late: Developing girls' interest and engagement in engineering careers. *The Career Development Quarterly, 63*, 88-95

Chung, C.J.C., Cartwright, C., & Cole, M. (2014). Assessing the impact of an autonomous robotics competition for STEM education. *Journal of STEM Education Innovations & Research, 15*(2), 24-34.

Cejika, E., Rogers, C. & Portsmore, M. (2006). Kindergarten robotics: Using robotics to motivate math, science, and engineering literacy in elementary school. *The International Journal of Engineering Education, 22*(4), 711-722.

Coding with Scratch: The design of an educational setting for Elementary pre-service teachers. (2015). *2015 International Conference on Interactive Collaborative Learning (ICL), Interactive Collaborative Learning (ICL), 2015 International Conference* [serial online]. 2015;:1171. Available from IEEE Xplore Digital Library, Ipswrich, MA. Accessed May 7, 2018.

Collins, L. M., Dziak, J. J., Kugler, K. C., & Trail, J. B. (2014). Factorial experiments: Efficient tools for evaluation of intervention components. *The American Journal of Preventive Medicine, 47*(4), 498-504.

Collins, L. M., Dziak, J. J. & Li, R. (2009). Design of experiments with multiple independent variables: A resource management perspective on complete and reduced factorial designs. *Psychological Methods, 14*(2), 202-224.

Constan, Z., & Spicer, J. J. (2015). Maximizing future potential in physics and STEM: Evaluating a summer program through a partnership between science outreach and education research. *Journal of Higher Education Outreach and Engagement, 19*(2), 117-136.

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

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research (4th ed.).* Boston, MA: Pearson.

Denson, C. D., & Lammi, M. (2014). Building a framework for engineering design experiences in high school. *Journal of Technology Education, 26*(1), 75-87.

DeVore, P. W. (1964). *Technology: An Intellectual Discipline.* Washington, D.C.: American Industrial Arts Association.

Domenico, D. M., & Jones, K. H. (2006). Career Aspirations of Women in the 20th Century. *Journal of Career And Technical Education, 22*(2).

Eccles [Parsons], J.S., Adler, T., & Meec, J. L. (1984). Sex differences in achievement: A test of alternative theories. *Journal of Personality and Social Psychology, 46*, 26-43.

Edgerton, A.H. (1923). Impulsive tendencies satisfied by industrial studies. *Journal of Educational Psychology, 14*(8), 510-511.

Else-Quest, N. M., Mineo, C. C., & Higgins, A. (2013). Math and science attitudes and achievement at the intersection of gender and ethnicity. *Psychology of Women Quarterly, 37*(3), 293-309. doi: 10.1177/0361684313480694

Falloon, G. (2016). An analysis of young students' thinking when completing basic coding tasks using Scratch Jnr. On the iPad. *Journal of Computer Assisted Learning, 32*(6), 576-593.

Fantz, T. D., De Miranda, M. A., & Siller, T. J. (2011). Knowing what engineering and technology teachers need to know: An analysis of pre-service teachers engineering design problems. *International Journal of Technology & Design Education, 21*, 307-320.

Field, A. (2009). *Discovering statistics using SPSS*. Sage publications.

Friday Institute for Educational Innovation (2012). *Middle and High School STEM Student Survey*. Raleigh, NC: Author.

Fouad, N. A., & Santana, M. C. (2017). SCCT and Underrepresented Populations in STEM Fields: Moving the Needle. *Journal of Career Awareness, 25*(1), 24-39.

Foster, P. N. (1995). Industrial arts/technology education as a social study: The original intent?

Journal of Technology Education, 6(2), 4-18.

Foster, P. N. (1995). The founders of industrial arts in the US. *Journal of Technology Education, 7*(1), 6-21.

Foster, P. N. (1997). Lessons from history: Industrial arts/technology education as a case. *Journal of Career and Technical Education, 13*(2).

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Kwang Suk, Y. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, *38*(4), 915-945.

Grover, S. & Pea, R. (2013). Computational thinking in K-12: A Review of the state of the field. *Educational Researcher, 42*(1), 38-43. doi: 10.3102/0013189X12463051

Hall, C., Dickerson, J., Batts, D., Kauffmann, P., & Bosse, M. (2011). Are we missing opportunities to encourage interest in STEM fields? *Journal of Technology Education, 31*(1), 32-46.

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

Howes, C., Burchinal, M., Pianta, R., Bryant, D., Early, D., Clifford, R., & Barbarin, O. (2008). Ready to learn? Children’s pre-academic achievement in pre-Kindergarten program. *Early Childhood Research Quarterly, 23*(1), 27-50. doi: 10.1016/j.ecresq.2007.05.002

Husti, A. (1994). Le piège de la durée. Expérimentation de la séquence d'enseignement à durée variable au collège et au lycée. = The pitfalls of the temporal organization of instruction: Research on variable durations of instruction in high school and college. *Enfance, 4*422-426. doi:10.3406/enfan.1994.3437

Inda-Caro, M., Rodriguez-Menendez, C., & Pena-Calvo, J. (2016). Spanish high school students' interests in Technology: applying social cognitive career theory. *Journal of Career Development*, *43*(4), 291-307. doi: 10.1177/0894845315599253

Jiang, Z. & Zhang, Z. (2012). Using social cognitive career theory to predict the academic interest and goals of Chinese middle vocational-technical school students. *Public Personal Management, 41*(5), 59-68.

Johnson, R. T., & Londt, S. E. (2010). Robotics competitions: The choice is up to you!. *Tech Directions, 69*(6), 16-20.

Jonassen, D. H. (1991). Objectivism versus constructivism: do we need a new philosophical paradigm? *Educational Technology Research and Development, 39*(3), 5-14.

Jonassen, D. H., Mayes, T., & McAleese, R. (1993). Manifesto for a Constructivist Approach to Uses of Technology in Higher Education. In Duffy, T., Lowyck, J., Jonassen, D. H., & Welsh, T. M. (Eds.) *Designing Environments for Constructive Learning.* Heidelberg, Berlin: Springer.

Kalyuga, S. (2012). For whom exploratory learning may not work: Implications of the expertise reversal effect in cognitive load theory. *Technology, Instruction, Cognition and Learning, 9*, 63-80.

Karp, T. & Maloney, P. (2013). Exciting young students in grades K-8 about STEM through an afterschool robotics challenge. *American Journal of Engineering Education, 4*(1), 39-54.

Kelley, T., & Knowles, J. (2016). A conceptual framework for integrated STEM education. International Journal of STEM Education, 3(1), 1-11. doi: 10.1186/s40594-016-0046-z

Ketelhut, D. J. (2010). Assessing gaming, computer and scientific inquiry self-efficacy in a virtual environment. In L.A. Annetta and S. Bronack (Eds.), *Serious Educational Game*

Assessment: Practical Methods and Models for Educational Games, Simulations and Virtual Worlds. Amsterdam, The Netherlands, Sense Publishers. P. 1-18.

Ketelhut, Diane. Assessing scientific and technological self-efficacy: a measurement pilot. *Harvard University Graduate School of Education*. Retrieved from http://muve.gse.harvard.edu/rivercityproject/documents/setsposterpaper.pdf.

Kim, C., Kim, D., Yuan, J., Hill, R.B., Doshi, P., & Thai, C. N. (2015). Robotics to promote elementary education pre-service teachers' STEM engagement, learning, and teaching. *Computers & Education, 91*(1), 14-31.

Kimmel, H., Carpinelli, J., & Rockland, R. (2007). Bringing engineering into K-12 schools: A problem looking for solutions? *International Conference of Engineering Education – ICEE 2007*. Coimbra, Portugal.

Kinzie, M. B., Vick Whittaker, J., McGuire, P., Lee, Y., & Kilday, C. R. (2015). Research on curricular development for pre-kindergarten mathematics and science. *Teachers College Record, 117*(7), 1-40.

Kurz, M.E., Yoder, S.E., & Ling, Z. (2015). Effects of exposure attitudes towards STEM interests. *Education, 136*(2), 229-241.

Kundu, A., & Ghose, A. (2016). The relationship between attitude and self-efficacy in mathematics among higher secondary students. *IOSR Journal of Humanities and Social Science, 21*(4), 25-31.

Lauda, D. P. (2002). Conceptualizations of Jackson's Mills. *Journal of Technology Studies*, *28*(2), 93-96.

Lawanto, O., Santoso, H. B., & Liu, Y. (2012). Understanding of the relationship between interest and expectancy for success in engineering design activity in grades 9-12.

Educational Technology & Society, 15(1), 152-161.

Lent, R., Brown, S., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice and performance. *Journal of Vocational Behavior, 45*, 79-122.

Lent, R. W., & Brown, S. D. (2003). Relation of contextual supports and barriers to choice behavior in engineering majors: Test of alternative social cognitive models. *Journal of Counseling Psychology, 50*(4), 458-465.

Leonard, J., Buss, A., Gamboa, R., Mitchell, M., Fashola, O. S., Hubert, T. & Almughyirah, S. (2016). Using robotics and game design to enhance children's self-efficacy, STEM attitudes, and computational thinking skills. *Journal of Science Education Technology, 25*, 860-876.

Maccawy, M. (2017). Raising a Programmer: Teaching Saudi Children How to Code. *International Journal of Educational Technology, 4*(2), 56-65.

Mann, M. J., & Golubski, C. (2013). Self-efficacy and First Year Biology Majors. NABT Biology Education Research Symposium, Atlanta, Georgia. http://www.nabt. org/websites/institution/File/docs/Four% 20Year% 20Section/2.

Mead, R. A., Thomas, S. L., & Weinburg, J. B. (2012). From Grade to Grad. In Barker, B. S., Nugent, G., Grandgenett, N., & Adamchuk, V. I. (Eds.). *Robots in K-12 education: A new technology for learning*. (pp. 302-325). Hersey: IGI Global. National Science Foundation [NSF]. (2007). *The National Standards for Technological Literacy*. Reston, Virginia: International Technology and Engineering Education Association.

Milner, A. R., Sondergeld, T.A., Demir, A., Johnson, C.C., & Czerniak, C.M. (2011). Elementary teachers' beliefs about teaching science and classroom practice: An examination of pre/post NCLB testing in science. *Journal of Science Teacher Education, 23*, 111-132. doi: 10.1007/s10972-011-9230-7

Nadelson, L.S., Callahan, J., Pyke, P., Hay, A., Dance, M. & Pfiester, J. (2013). Teacher STEM perception and preparation: Inquiry-based STEM professional development for elementary teachers. *The Journal of Educational Research, 106*(2), 157-168.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: National Academies Press.

National Research Council. (2014). *STEM integration in K-12 education: Status, prospects, and an agenda for research.* Honey, M., Pearson, G., & Schweingruber, H. (Eds). Washington, D.C., The National Academies Press.

National Science Board. (2016). *Science and Engineering Indicators 2016*. Washington, D.C.: National Academy of Sciences.

National Science Foundation [NSF]. (2007). *The National Standards for Technological Literacy*. Reston, Virginia: International Technology and Engineering Education Association.

National Research Council. (2007). *Taking science to school.* Washington, D.C.: National Academy of Sciences.

Nugent, G., Barker, B., Grandgenett, N., & Adamchuk, V. (2010). Impact of Robotics and Geospatial Technology Interventions on Youth STEM Learning and Attitudes. *Journal of Research on Technology in Education, 42*(4), 391-408.

Ortiz, A.M., Boz, B., & Smith, S. (2015). The power of educational robotics as an integrated STEM learning experience in teacher preparation programs. *Journal of College Science Teaching, 44*(5), 42-47.

Palardy, G. J., & Rumberger, R. W. (2008). Teacher effectiveness in first grade: The importance of background qualifications, attitudes, and instructional practices for student learning. *Educational Evaluation and Policy Analysis*, *30*(2), 111-140.

Prajapati, B., Dunne, M., & Armstrong, R. (2010). Sample size estimation and statistical power analysis. *Optometry today, 16*(07), 10-18.

Pryor, B. W., Pryor, C. R., & Kang, B. (2015). Teachers' thoughts on integrating STEM into social studies instruction: Beliefs, attitudes, and behavioral decisions. *The Journal of Social Studies Research (2015)*, http://dx.doi.org/10.1016/j.jssr.2015.06.005

Reynolds, R., & Caperton, I. H. (2011). Contrasts in student engagement, meaning-making, dislikes, and challenges in a discovery-based program of game design learning. *Educational Technology Research and Development*, *59*(2), 267-289.

Rittmayer, A. D., & Beier, M. E. (2008). Overview: self-efficacy in STEM. *SWE-AWE CASEE Overviews*.

Robinson, T.P., & Stewardson, G.A. (2012). Exciting students through VEX robotics competitions. *Technology and Engineering Teacher, 72*(2), 15-21.

Rockland, R., Bloom, D. S., Carpinelli, J., Burr-Alexander, L., Hirsch, L. S., & Kimmel, H. (2010). Advancing the "E" in K-12 STEM education. *The Journal of Technology Studies, 36*(1), 53-64.

Saez-Lopez, J., Roman-Gonzalez, M., & Vazquez-Cano, E. (2016). Visual programming languages integrated across the curriculum in elementary school: A two year study using "Scratch in five schools. *Computers & Education*, *97*, 129-141. doi:10.1016/j.compedu.2016.03.003

Sahin, A., Ayar, M., & Adiguzel, T. (2014). STEM related after-school program activities and associated outcomes on student learning. *Educational Sciences: Theory & Practice,* 14(1), 309-322.

Salkind, N. J. (2016). Statistics for people who (think they) hate statistics. *Sage Publications*.

Scott, J. L. & Sarkees-Wircenski, M. (2004). *Overview of Career and Technical Education, Third Edition*. Homewood, Illinois: American Technical Publishers.

Shane, P. M., & Wojnowski, B. S. (2007). Technology integration enhancing science: Things take time revisited. *Science Educator, 16*(2), 51-57.

Shein, E. (2014). Should everybody learn to code? *Communications of the ACM, 57*(2), 16. doi:10.1145/2557447

Stains, M., Pilarz, M. & Chakraverty, D. (2015). Short and long-term impacts of the Cottrell Scholars Collaborative new faculty workshop. *Journal of Chemical Education, 92*, 1466-1476.

Snyder, J. F., & Hales, J. F. (1981). *Jackson's Mill industrial arts curriculum theory*. Charleston: West Virginia Department of Education.

Sternberg, R. J. (2003). What is an "expert student?" *Educational Researcher, 32*(8), 5-9.

Strimel, G., & Grubbs, M. E. (2016). Positioning technology and engineering education as a key force in STEM education. *Journal of Technology Education, 27*(2), 21-36.

Sullivan, A. & Bers, M U. (2016). Robotics in the early childhood classroom: Learning outcomes from an 8-week robotics curriculum in pre-kindergarten through second grade. *International Journal of Technology and Design Education, 26*(1), 3-20.

Sullivan, F. R. & Moriarty, M. A. (2009). Robotics and discovery learning: Pedagogical beliefs, teacher practice, and technology integration. *Journal of Technology and Teacher Education, 17*(1), 109-142.

Sweller, J., Ayers, P., & Kalyuga, S. (2011). *Cognitive Load Theory*. New York: Springer.

Tseng, K., Chang, C., Lou, S., & Chen, W. (2011). Attitudes towards science, technology, engineering, and mathematics (STEM) in a project-based learning (PjBL) environment. *International Journal of Technology Design Education*, *23*, 87-102.

Unfried, A., Faber, M., Stanhope, D. & Wiebe, E. (2015). The development and validation of a measure of student attitudes toward science, technology, mathematics, and engineering. *Journal of Psychoeducational Assessment*, *33*(7), 622-639. doi:10.1177/0734282915571160

Valenzuela, J. (2018). Introduce coding to students with littleBits code kits. *Children's Technology & Engineering*, *22*(3), 30-32.

Walkins, C., Carnell, E., & Lodge, C. (2007). *Effective Learning in Classrooms.* Paul Chapman Educational Publishing.

Wendt, S., Isbell, J.K., Fidan, P. & Pittman, C. (2015). Female teacher candidates' attitudes and self-efficacy for teaching engineering concepts. T*he International Journal of Science in Society, 7*(3), 1-11.

Wicklein, R.C. (2006). Five good reasons for engineering as the focus for technology education. *The Technology Teacher, 65*(7), 25-29.

Wigfield, A., Tonks, S., & Klauda, S. L. (2009). Expectancy-Value Theory. In Wentzel, K., & Miele, D. (Eds.), *Handbook of Motivation at School* (pp. 55-75). New York: Routledge.

W. K. Kellogg Foundation. (2004). Using logic models to bring together planning, evaluation, and action: Logic development guide. Battle Creek, Michigan: W.K. Kellogg Foundation

Xu, X., Pasilla, A. M., & Silva, D. (2014). The time factor in Mandarin language learning: the four-week intensive versus the regular high school semester. *The Language Learning Journal*, *42*(1), 55-66.

Yoon, S.Y., Dyehouse, M., Lucicetto, A.M., Diefes-Dux, H.A., & Capubianco, B.M. (2014). The effects of integrated science, technology, and engineering education on elementary students' knowledge and identity development. *School Science and Mathematics, 114*(8), 380-391.