THE IMPACT OF A SCHOOL DEVELOPED STEAM CURRICULUM ON FIRST GRADE STUDENTS' COGNITIVE DEVELOPMENT IN THE MATHEMATICS, LANGUAGE, AND LITERACY DOMAINS

by

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THESIS

Presented to the Faculty of

The University of Houston-Clear Lake

In Partial Fulfillment

Of the Requirements

For the Degree

MASTER OF SCIENCE

in Early Childhood Education

THE UNIVERSITY OF HOUSTON-CLEAR LAKE

MAY, 2020

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Dedication

For Karmyn

Acknowledgements

I am truly grateful to all the people that have supported me through this process.

First, I would like to thank my family. To my sister Nancy, your unconditional love and support has carried me through. Your belief in me is unwavering and I thank you for that. You are my touchstone and my love for you is immeasurable. To my sister Maryanne, I would not have been able to start let alone finish this journey without you by my side. You have encouraged me every step of the way and I am honored that you are my sister. To my amazing daughter Karmyn, you are the reason for all of this. If not for you I could not have made it. I love you with my whole heart. It is an honor to be your mother.

I would like to thank the faculty in the college of education. I would not have been able to write this thesis without the knowledge that I gained from each and every one of you. I would like to thank Dr. Jain and Dr. Graves for allowing me to conduct this study. To Dr. Jain, it has been a privilege working with you. You saw something in me that I did not see in myself and for that I will be eternally grateful. The knowledge you have shared and the guidance you have given to me has influenced every aspect of my life. So, thank you Dr. Jain for supporting me, encouraging me, but mostly for believing in me.

ABSTRACT

THE IMPACT OF A SCHOOL DEVELOPED STEAM CURRICULUM ON FIRST GRADE STUDENTS' COGNITIVE DEVELOPMENT IN THE MATHEMATICS, LANGUAGE, AND LITERACY DOMAINS

Tammy Lynn Spino
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STEAM education can be defined as a transdisciplinary approach to learning that intentionally integrates concepts of science, technology, engineering, and mathematics (STEM) with the arts (Gess, 2017). Students apply concepts from multiple disciplines in real-world lessons to make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy (Tsupros, Kohler, & Hallinen, 2009). STEAM education initiatives have increased exponentially in the United States. However, there is limited research on student learning outcomes as it relates to STEAM curriculum. To address this issue, this study examined the impact of a school developed STEAM curriculum on first grade students' cognitive development in the mathematics, language, and literacy domains.

The study is a quasi-experimental pretest-posttest comparison group study. The study compared two groups from English classrooms in an elementary school located in an urban school district in southeast Texas. The first group included three classrooms consisting of 39 first grade students where a school developed STEAM curriculum was implemented. The second group consisted of three classrooms with 33 first grade students following the traditional district curriculum. The purpose of this study was to provide empirical data and add to the limited research information on the impact of a school developed STEAM curriculum on first grade students' cognitive development in the mathematics, language, and literacy domains. The Brigance Inventory of Early Development (IED) III, The STAR Math, and district benchmark assessments were used measure the mathematics domain. Language and literacy domains were measured with the Achievement Improvement Monitoring System (AIMSweb) Test of Early Literacy (TEL) 2012 in reading and The Brigance Inventory of Early Development (IED) III. The results of the study indicate that there was no significant difference across all measures between the STEAM and non-STEAM groups on the gains made in each of the cognitive domains. A discussion of implications and potential rationales for the results is discussed.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF GRAPHS

CHAPTER I:

INTRODUCTION

In 2019, The National Science Board released their Science and Engineering Indicators which reported that the United States ranked 19th among world economies for producing high-achieving STEM Students (Rotermund & White, 2019). Preparing a STEM literate workforce is essential to the United States global economic success. This includes providing students with the skills necessary to solve real world problems through innovative creative thinking. STEM education focuses on improving student outcomes in the fields of science, technology, engineering, and mathematics (STEM). Over the past decades, the United States has implemented educational policies to increase STEM literacy among K-12 students. Such policies included national common core standards for mathematics and literacy, science education standards and benchmarks, as well as the development of professional organizations that support STEM education (LibGuides: STEM Education: Standards and Benchmarks, 2020). Despite the application of such policies, the United States has yet to evolve as a global leader in the STEM workforce. In an effort to advance the global standing of the United States, educators, policymakers, advocates for art education, and industry leaders support a transdisciplinary educational model that integrates STEM disciplines with the arts, STEAM education (Allina, 2018). Implementing a transdisciplinary educational approach provides for the "application of theories, concepts, or methods across disciplines with the intent of developing an overarching synthesis" (Lattuca, 2001, as cited in Constantino, 2018, p.102). When students engage in a transdisciplinary approach to learning they gain multiple perspectives in the context of real-world problems (Constanino, 2018). Integrating the arts such as visual arts, dance, music, and drama in STEM disciplines creates opportunities for students to engage in hands-on activities where they can design and produce artifacts through innovate thinking and problem-solving (Katz-Buonincontro, 2018). Developing STEAM skills in early childhood is an economic imperative in the United States (Fischer, 2019). Findings from a recent study suggest integrating musical activities in an early childhood curriculum can significantly increase young children's development of executive function specifically, inhibition which contributes to abilities in all learning domains (Bugos & DeMarie, 2017). Research has shown that when students engage in hands-on, inquiry-based, STEAM activities it supports creativity, autonomous motivation, and increases cognitive development (Thuneberg, Salmi, & Bogner, 2018). STEAM education has been found to positively influence children's language and literacy development. Findings from current research indicate that when young children engage in engineering STEAM related guided play activities such as block play, their use of spatial language is increased (Ferrara, Hirsh-Pasek, Newcombe, Golinkoff, & Lam, 2011). Other findings revealed that participation of English Language Learners (ELL) was increased when they engaged in STEAM related activities that focus on engineering through a literacy-enriched curriculum (Aguirre-Muñoz & Pantoya, 2016). An additional study found that integrating literacy and STEAM disciplines such as science improves students' abilities in both science and literacy content areas (Cohen & Johnson, 2012). Different approaches to pedagogy such as guided play, teacher-led, and play-based that are implemented in STEAM curriculum have been found to differentially influence children's mathematical learning outcomes. For example, research indicates that children in the play-based approach curriculum had a higher learning gain then those in a teacher-led approach curriculum (Vogt, Hauser, Stebler, Rechsteiner, & Urech, 2018). An educator's beliefs regarding approaches to pedagogy and STEAM may impact STEAM implementation. The Vogt et al. (2018) study found that after implementing a STEAM related play-based curriculum, educators believed that children benefited from the play-based approach and were more likely to implement that approach the following year. Another study found that an educator's beliefs in regard to STEAM education effected the importance they place on implementing a STEAM curriculum in their classrooms (Jamil, Linder, & Stegelin, 2018). Additional research indicates that the support educators receive regarding STEAM curriculum impacts their self-efficacy and their disposition (DeJarnette, 2018). Several studies have examined how STEAM education influences or increases cognitive development in mathematics, language, and literacy domains through classroom observations, teacher surveys, interviews as well as approaches to pedagogy. However, very few studies specifically compare child outcomes in mathematics, language, and literacy domains as it relates to the implementation of a school developed STEAM curriculum.

The purpose of this study was to examine the impact of a school developed STEAM curriculum on first grade students' cognitive development in the mathematics, language, and literacy domains. This study will address the following research questions:

- What impact does a school developed STEAM curriculum have on first grade students' cognitive development in mathematics?
- What impact does a school developed STEAM curriculum have on first grade students' cognitive development in language and literacy?

CHAPTER II:

LITERATURE REVIEW

Introduction

The purpose of this study is to investigate the impact of a school developed STEAM curriculum on first grade students' cognitive development in the mathematics, language, and literacy domains. This section will discuss literature that relates to STEAM education, what STEAM education is, why STEAM education, the impact of STEAM curriculum on young children's mathematical development, the impact of STEAM curriculum on language and literacy development, and factors related to STEAM education implementation.

What is STEAM Education

STEAM education can be defined as a transdisciplinary approach to learning that intentionally integrates concepts of science, technology, engineering, and mathematics with the arts (Gess, 2017). STEM education is designed to allow students to develop critical thinking and problem-solving skills, collaborate with peers and educators, and become innovators (Gess, 2017; Jolly, 2014; Eberle, 2010). The integration of the Arts disciplines such as visual art, dance, and design in the instruction and curriculum of STEM education in the primary difference between STEAM and STEM (Katz-Buonincontro, 2018). The arts and STEM disciplines are not mutually exclusive. In a transdisciplinary approach, STEAM education utilizes instructors from various disciplines such as librarians, science, math, art, and music teachers to collaborate on instructional activities and experiences for students that consist of instructional content that is problem based through multiple disciplines as well as is relevant to real world issues (Quigley, Herro, & Jamil, 2017). For example, when engaging in engineering projects, students implement artistic design to construct artifacts. Visual arts are a natural process in engineering. Technology also incorporates art through graphic design. Drama in the form of public speaking such as speech is prevalent in all the STEM disciplines and specifically in the art of debating. In addition, the process by which STEM disciplines and the arts utilize problem solving procedures is similar. For example, the scientific method includes seven steps: observing, asking questions, generating hypotheses and predictions, experimentation or testing, summarizing or analyzing to draw a conclusion, reporting the process and discovery, and identifying a new question (Gerde, Schachter, & Wasik, 2013). In the field of engineering, engineers adhere to the design loop which includes the five steps of questioning, imagining solutions, planning, creating, testing, and improving (Jackson, Heil, Chadde, & Hutzler, 2011 as cited in DeJarnette, 2018). Likewise, the creative process adopts similar procedures such as immersion, reflection, research, inspiration, apparition, trials, assembly, new ideas, selection, materials, realization, specification, finalization, examination, presentation, and settling (Botella, Zenasni, & Lubart, 2018). Throughout the design process, students create, reflect, persist, and communicate new ideas. Gess (2017) explains that "many educators are calling for STEA(arts)M education to be the approach of choice through which teachers may facilitate growth in habits of the mind and practices that [are] characteristic of a globally literate citizen" (p. 2). STEAM education is intentionally implemented and includes standards from all subjects, with embedded assessments, and promotes child directed learning (Allina, 2018).

Why STEAM Education

The evolution of STEM to STEAM education is rooted in American history. The issue first came to light after the launching of the Russian satellite Sputnik in 1957 which was the catalyst that forced America to focus on becoming a leader in science, technology, engineering, and mathematics (STEM) (Jolly, 2009). As a result, President

Eisenhower created the National Aeronautics and Space Administration (NASA) and in 1958 congress passed the National Defense Education Act (Jolly, 2009). President Kennedy continued the push for innovation in the STEM areas which eventually led to the moon landing in 1969. The 1970s and 1980s brought forth several science and technology accomplishments such as the cell phone and the launching of the Space Shuttle. In 2001, the National Science Foundation (NSF) introduced the STEM acronym formally known as SMET. However, the push for national STEM implementation came after the report *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (2007) was published by the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The report found that after "having reviewed trends in the United States and abroad, the committee is deeply concerned that the scientific and technological building blocks critical to our economic leadership are eroding at a time when many other nations are gathering strength" (p.3). In the following years, the STEAM educational policy developed by the Rhode Island School of Design led to the formation of the STEAM Caucus in the United States House of Representatives in 2013 (Allina, 2018). In 2015, President Obama signed the STEM Education of 2015 which provides "[expanded] research and training opportunities for math and science teachers" and "explicitly incorporates computer science into the definition of STEM" (Henry, 2015, p.1). The Building STEAM Education Act and STEM to STEAM Act were introduced in the House of Representatives in March of 2019 (Bonamici, Langevin, Stefanik Introduce Bills to Promote Art, Design in STEM Education, 2019). These bills will incorporate art and design into certain STEM education programs. The push for STEAM education arises from research that has demonstrated the benefits of STEAM education.

For example, research indicates that integrating musical learning in early childhood curriculum can facilitate executive function development. Bugos and DeMarie (2017) conducted a study that examined that effects of a short-term preschool music program on preschool children's inhibition which is a key factor in the development of executive function in children ages three to five years old. Inhibition is the cognitive ability to control impulsive responses. This executive function contributes to one's capacity to plan and problem-solve which are important developmental skills. The study included 36 children who were randomly assigned to an experimental musical training intervention or a comparable attention-related control task Lego construction intervention. During the six-week training, each group received two 45-minute weekly classes. Three assessment tools were administered for pre and post testing: The Primary Measures of Music Aptitude, the Day/Night Stroop tool, and the Matching Familiar Figures Test instrument. The musical intervention combined gross motor lessons with electronic and acoustic instruments as well as vocal exercises and creative activities that fostered critical thinking. In the Lego intervention, the participants engaged in group-based activities that focused on problem-solving skills. The participants received training on how to build shapes, form patterns, sort, and creative exploration. The results of the study indicate that for both groups visually based aspects of inhibition improved. However, factors of inhibition that were visually based and involved motor control improved only for the music group. This suggests that musical activities can increase young children's development of executive function which contributes to the abilities in all learning domains.

Research has also indicated that hands-on, inquiry-based, STEAM activities support creativity and autonomous motivation. A pretest-posttest study conducted by Thuneberg, Salmi, and Bogner (2018), sought to determine how creativity, autonomy, and visual reasoning contribute to cognitive learning in a STEAM hands-on inquiry-based math module. The sample of 392 students between 12-13 years old from 11 schools in Helsinki participated in math and art workshops. The first creative math and art workshop enriched traditional STEM into STEAM education. Prior to the beginning of the workshop, the students received a 10-minute introduction to the concrete materials. In an open learning environment, groups of six to eight students were able to create their own structures using small plastic pipes and circles within a 3x45 minute time period. Two tutors were available to the students to facilitate participation and provide information on demand. The students were encouraged to test their structures in a wind tunnel and revise their designs based on evidence that they encountered during testing. At the end of the workshop, the students' products were presented to their peers and documented through photographs and videos. The second math and art workshop that the students attended was based on a STEAM- approach that incorporated art, engineering, technology, and creative mathematics. During this workshop, groups of three students were provided with a commercial hands-on construction kit which consisted of hundreds of 2-30 cm long tubes or straws and various types of connectors to build structures such as mobile animals. After completing both workshops, the students were assessed with several measures. A pretest questionnaire was completed two weeks prior to the intervention and post-test questionnaire 10 days after the intervention. A creativity measure consisting of 10 items originating from Miller and Dumford (2012) and a science motivation measure that covered intrinsic motivation and self-determination were administered. Autonomous motivation was measured based on an assessment created by Deci and Ryan (2002) consisting of 32 items on self-regulation styles and self-determination. The results of the study indicated that the STEAM based workshop interventions increased creativity and autonomy. Within the cognitive domains, several studies indicate that STEAM curriculum can also have an impact on children's language and literacy development.

Impact of STEAM Curriculum on Language and Literacy

Studies have found that engaging in engineering STEAM related guided play activities facilitates children's language learning. During block play children utilize expressive and receptive language, mathematical skills such as geometric properties, engineering concepts that include the relationships between objects, and the design process by creating visual artifacts. Spatial skills and language are key components of learning in science, technology, engineering, and mathematics (Ferrara et al, 2011). A two-part study by Ferrara et al. (2011) examined young children's use of spatial language during block play. In both studies, the parent and child interactions were videotaped, transcribed, and then coded into spatial categories using the University of Chicago spatial language coding system (Cannon, Levine, & Huttenlocher, 2007 as cited in Ferrara et al, 2011). In the first part of the study, children and their parents were assigned to three different conditions for 10 minutes: free play with blocks, guided play with blocks, and play with preassembled structures. In the free play with blocks condition, children and their parents were given a 114-piece set of MegaBloks with various size blocks, vehicles, and figures and told to play with the blocks as they would at home. In the guided play condition, children and their parents were provided instructions on how to build a helipad or a garage. In the preassembled condition, children and their parents were asked to play with a garage or a helipad that was preassembled. The results of the first study indicated that children in the guided play and play with preassembled structures condition produced considerably more spatial language than those children in the free play intervention. The second part of the study examined the use of spatial language between children and their parents when engaged in activities that did not include spatial materials such as blocks or preassembled structures. Observed activities included play with puppets, eating lunch, drawing, playing house, playing store, dressing up, playing zoo, and throwing a ball. When compared to the results from the first study where spatial materials were included, the results of the second study indicated that the use of spatial language between parents and their children was much more significant during block play than in other types of play. The findings of these studies demonstrate the engaging children in guided-play STEAM activities such as block play increases their use of spatial language as well as strengthens language abilities, specifically spatial language.

Research suggests that integrating literacy and STEAM disciplines such as science improves students' abilities in both content areas. During learning activities, children use academic English to engage with their peers and teachers. Academic English differs from informal language that is used every day because it is more precise and uses technical vocabulary, has specific grammatical features, and is found in specific texts such as educational material and textbooks (Otto, 2015). The field of science is a discipline that consists of complex ideas therefore understanding terms and concepts is essential. In a study conducted by Cohen and Johnson (2012), the researchers examined the effect of imagery interventions of novel science vocabulary. Fifth grade students were randomly assigned to four groups that presented different instructional methods. The first instructional method was a Picture Presentation where students were shown a word paired with an image. In the second instructional method, Image Creation with no picture, students were asked to generate an image and draw it. Image Creation with a picture was the third instructional method where students were shown a picture and asked to draw it. Finally, the fourth Word Only instructional method required students to verbalize scientific terms and concepts with no picture. A biology vocabulary pretest taken by the students was used to select words that were unfamiliar to the students and were considered to easily facilitate imagery. The students' retention and acquisition of the science vocabulary were assessed with two measures: a word fill-in task and a definition word match task. An immediate recall assessment was administered 24 hours after the interventions. The delayed recall assessment was administered two-weeks after the initial interventions. The results of the study determined that students in the imagery groups scored higher in the word learning at immediate and delayed recall than those students in the word only interventions. The findings from this study suggest that children's vocabulary and comprehension were increased when literacy is integrated with science learning.

Research also found that STEAM related activities that focus on engineering through a literacy-enriched curriculum can increase the participation of English Language Learners (ELL). Aguirre-Muñoz and Pantoya (2016) conducted a withdrawal single-case study with multiple probes to investigate the impact of the implementation of a literacy-enriched engineering centered science activity on linguistically diverse kindergarten students' engagement in engineering content. The participants included two mainstream teachers from two different schools in west Texas and six female kindergarten students who were English Language Learners (ELL) and represented three ability levels: high, average, and low. Prior to the intervention, the teachers participated in a two-day training session the focused on the integration of an engineering story into a lesson planning sequence, the use of an agricultural engineering unit, and how to model and guide academic conversations with students. Pre and post-tests were administered to the teachers to determine the effectiveness of the training which indicated that the intervention increased fidelity to the instructional approach. The initial phase of the student study was a five-day baseline period. During this time, the teachers taught the regular district curriculum that consisted of teacher-directed whole group discussions with no opportunities for the students to engage in experimentation or manipulation of concrete objects. In the second phase of the study, students engaged in intervention activities for five days. During the first three days, students engaged in academic conversations with their teachers in a read-aloud with an engineering-centered picture book, participated in a hands-on design sketch activity, previewed key vocabulary with picture cards, and viewed a video about agricultural engineering. On the fourth day of the intervention, the participants manipulated concrete objects to conduct controlled experiments that simulated the steps in the pollination process, observed and compared effectiveness of the materials that were used, and engaged in an academic conversation with their teacher regarding their understanding of the materials and the results of their experiments. On the fifth day, the participants utilized their understanding of pollination, the design process, and materials to design a hand pollinator for a specified flower as well as engaged in an academic conversation that encouraged them make connections between science, engineering, and technology in reference to their design. The intervention phase was followed by a second five-day baseline period where all interventions were withdrawn. The withdrawal phase tested the degree to which the interventions affects participants' behaviors. Classroom observations took place throughout all three phases to collect data on the participants' behavioral, affective, and cognitive engagement. The results of the study revealed that in the intervention phase, participant engagement increased at all ability levels during the engineering book read aloud as well as during hands-on engineering activities. However, participant engagement decreased during the withdrawal phase. These findings suggest that integrating hands-on, literacy enriched STEAM based activities increases the engagement of English Language Learners.

Impact of STEAM Curriculum on Mathematics

Current research indicates that mathematical, hands-on, inquiry-based, STEAM activities support cognitive learning. In a pretest-posttest study conducted by Thuneberg, Salmi, and Bogner (2018), the researchers sought to determine if an informal mathematical module that integrated the arts would increase students' cognitive knowledge. In the previously described study, participants engaged in two workshops. In the first workshops, six to eight participants worked in groups to create their own structures using small plastic pipes and circles. During the second workshop, groups of three participants were given a commercial hands-on construction kit which consisted of hundreds of 2-30 cm long tubes or straws and various types of connectors to build structures such as mobile animals. The participants were assessed with several measures. A pretest questionnaire was completed two weeks prior to the intervention and post-test questionnaire 10 days after the intervention. An ad-hoc knowledge pretest-posttest to measure cognitive learning success was administered. The measure included eight items on geometry and problem-solving. Cognition was measured using the visual reasoning Raven Standard Progressive Matrices. The measure consisted of 60 items that required the participants to identify a missing element to complete a pattern. The *Formula 1* assessment was administered to measure formal abstract operational thinking. The assessment measures the mastery of controlled variables in a modified group-version. The results of the posttest revealed that there was an increase in the participants' level of formal thinking. This suggests that students' cognitive development increases when engaged in mathematical, hands-on, inquiry based, STEAM activities.

Research indicates approaches to pedagogy in STEAM related disciplines, specifically a play-based approach directly influences children's mathematical learning outcomes. Pedagogical approaches in early childhood settings vary between educator-led, educator and child guided, play-based, and child guided. A pretest-posttest quasi-experimental study conducted by Vogt et al. (2018), examined the effects on mathematical competency of kindergarten students from a school in Switzerland in two different instructional approaches: play-based and an educator-led training program. The students were randomly assigned to three groups for an eight-week intervention. The intervention training program group included 12 kindergarten educators and 111 students. The intervention group that implemented the play-based approach consisted of 11 kindergarten educators and 91 students. The control group was comprised of 12 kindergarten educators and 137 students. The mean age of the children was six years and three months. In the training intervention, students were placed in small groups and engaged in 24 half hour teacher-led units. The lessons focused on quantity-number-competencies using specific tasks, mathematical language, and materials. In the play-based intervention, students were also placed in small groups, learning focused on quantity-number-competencies and were allotted the same amount time as the training group. However, educators were given 10 specific card and board games that were developed by the researchers or commercially available. The students were free to choose both the games and their co-players. The educator's role was to introduce the games and provide students with support. The educators in the control group implemented no changes to their daily mathematical lessons. Prior to the interventions, educators from both groups received a general introduction on the learning of mathematics in kindergarten as well as an introduction into either the play-based approach or the training program. The Zahlenstark test was utilized to collect quantitative data on child outcomes which involved tasks on ordinality, cardinality, quantity, number knowledge, and first arithmetic operations. The results revealed that participants in the play-based intervention had a higher learning gain then those in the control group. In addition, when the participants were divided into three groups based on their pretest math competency, low-level, middle-level, and high-level to determine whether the participant might benefit in different ways from the intervention, the results found that higher learning gains were made in the high-level group in the play-based intervention than in the training group. Overall, the data revealed that there were higher learning outcomes for participants in the play-based mathematics group compared to the control group. These findings suggest that approaches to pedagogy in STEAM related disciplines, specifically a play-based approach influences children's mathematical learning outcomes.

Implementation of STEAM Curriculum

Various methods and considerations have been explored in the literature regarding the implementation of STEAM curriculum. For example, current research indicates that the support educators receive regarding STEAM curriculum impacts their self-efficacy and their dispositions. A study conducted by DeJarnette (2018) investigated if providing teachers with STEAM curriculum, resources, professional development, and in-class support would positively increase their attitudes towards implementing STEAM curriculum. The researcher provided two teachers, a female librarian and a male art teacher, with a K-2 STEAM curriculum that was centered around engineering projects based on children's literature. Prior to implementing the curriculum, the teachers participated in a two-hour professional development class where the researcher discussed the background and importance of STEAM education, the engineering design process, and the STEAM lessons they would be implementing. In surveys completed prior to the implementation of the curriculum, the teachers relayed that they felt they were not knowledgeable enough to plan or implement a STEAM curriculum or to assess student learning. However, after implementing the curriculum the teacher's post-surveys revealed that they felt that they had gained the knowledge and skills needed to be successful. The results of this study suggest that professional development, resources, and a developed STEAM curriculum can positively increase the attitudes of teachers regarding STEAM curriculum.

Research has found that an educator's beliefs regarding STEAM education effect the importance they place on implementing a STEAM curriculum in their classrooms. In a mixed methods approach study, Jamil, Linder, and Stegelin (2018) examined the beliefs of early childhood educators on STEAM education for young children after they had attended a one-day conference that focused on STEAM education. The sample consisted of 41 females that were predominantly Caucasian, and most had college degrees. The conference was held at a state college of education where university faculty facilitated learning in STEAM education. During the one-day conference, educators attended a one-hour keynote session, and two different two-hour workshops that focused on STEAM teaching in four areas: mathematics, art, science, and technology. At the end of the conference, educators were asked to complete a survey that asked for feedback on the workshops they attended, information on the personal and professional demographics, and their beliefs about teaching STEAM education. The researchers then conducted follow-up interviews with four educators that filled out the surveys. In the 30-minute interviews, the themes that were discussed regarding STEAM education included focus on products, priorities for instruction, view of children, and management. The results of the study found that educators believed that STEAM lessons were engaging for students but were disconnected from standards and curriculum. In addition, results indicated that less experienced educators held beliefs about STEAM education that were less conducive to effective STEAM teaching. Finally, results found that educators believed that STEAM lessons were add-ons to the present curriculum rather than tools to be utilized within the curriculum to meet learning objectives and child outcomes. This suggests that the success of STEAM education is related to the beliefs held by educators.

Research indicates that an educator's experience with approaches to pedagogy specifically a play-based approach can influence their beliefs and teaching strategies. In a previously described pretest-posttest quasi-experimental study conducted by Vogt et al. (2018), the researchers examined educators' experiences and views of a play-based approach and a training program after implementing a kindergarten mathematical intervention. The sample included 12 kindergarten educators in an intervention training group, 11 kindergarten educators in a play-based approach intervention, and 12 educators in a control group. After the intervention was implemented data regarding educators' beliefs was collected through 30-40-minute interviews with the kindergarten educators from both intervention groups. During the interviews the educators were asked how they would explain the project to a colleague, how they implemented the intervention, how the children engaged in the intervention, and whether they would implement the play-based approach or the training program in the future. The data revealed that the 10 out of 11 educators involved in the play-based intervention would implement a similar approach the following year whereas only 5 out 12 educators from the training intervention would implement their program. The educators from the play-based intervention felt that all children benefited from the intervention. On the other hand, the educator's from the training intervention expressed it did not meet all the children's needs and more than half of the educators mentioned that they found the children to be bored during the lessons possibly because they had to sit and listen for a long time. Overall, the play-based approach was evaluated more positively than the training program. The results from this study suggest educators' experiences with a play-based approach can influences their views and teaching strategies.

Summary

The purpose of this study is to examine the impact of a first grade STEAM curriculum developed by a school on various cognitive measures. Specifically, this study will examine first grade students' cognitive development in the mathematics, language, and literacy domains. This study will compare the growth within these cognitive domains between the group that received the STEAM curriculum and those that received the traditional district curriculum. The research questions that guided this study are

- What impact does a school developed STEAM curriculum have on first grade students' cognitive development in the mathematics?
- What impact does a school developed STEAM curriculum have on first grade students' cognitive development in language and literacy?

CHAPTER III:

METHODOLOGY

Introduction

This chapter details the methods used in this study. The purpose of this study is to investigate the impact of a school developed STEAM curriculum on first grade students' cognitive development in the mathematics, language, and literacy domains. This chapter will describe the research design, the research questions, participants, instruments, data collection procedures, and data analysis procedures.

Research Design

The study is a quasi-experimental pretest-posttest comparison group study. The study utilizes archival data collected as part of a larger study conducted by Jain and Graves (2016) that examined the impact of a school developed STEAM curriculum on elementary school students' cognitive development. The university's Committee for the Protection of Human Subjects (CPHS), the participating school, and school district granted permission to conduct the original study. This current study was designed to examine the data from first grade students' cognitive development in mathematics, language, and literacy from this larger study. Permission to use the data was obtained by the principal investigators. Permission to analyze the archival data for this study was obtained from the university's CPHS.

Research Questions

This study was guided by the following research questions:

- What impact does a school developed STEAM curriculum have on first grade students' cognitive development in mathematics?
- What impact does a school developed STEAM curriculum have on first grade students' cognitive development in language and literacy?

Participants

The participants were first grade students in English classrooms at an elementary school from an urban school district in southeast Texas. The sample included 32 females and 40 males. The students ranged in age from six years to seven years four months with a mean age of six years seven months. The intervention group included three classrooms consisting of 39 first grade students where a school developed STEAM curriculum was implemented. The control group consisted of three classrooms with 33 first grade students that followed the traditional district curriculum. The ethnic demographics of the elementary school include 60.5% Caucasian, 34.1% Hispanic, and 4.5% that identify as two or more races. In addition, 22% of the student population receive free or reduced lunch. There were 72 students that participated in the study. Potential participants were identified through a consent letter sent home to parents at the beginning of the 2016-2017 school year. The teachers were selected by the school principal for the intervention group based on their years of experience and willingness to accept a change in the curriculum.

Instruments

Data from several assessment measures was analyzed for this study. The specifics of each instrument are described below.

Achievement Improvement Monitoring System (AIMSweb) Test of Early Literacy (TEL) 2012 in reading.

The Achievement Improvement Monitoring System (AIMSweb) Test of Early Literacy (TEL) 2012 in reading is a benchmark and progress monitoring system based on direct, frequent, and continuous student assessment that is utilized within the school district. This assessment is required by the school district and implemented by the teachers. The data from this assessment was provided to the researchers by the school.

The STAR Math

The STAR Math is a student-based, computer adaptive assessment that measures student achievement in math. The assessment is a standard-based test that measures Texas specific learning areas and is aligned with the Texas Essential Knowledge and Skills (TEKS). The STAR Math assessment is a requirement of the school district. The assessment is conducted in the Fall and Spring of each school year and is implemented by the teachers. The school provided the data from this assessment to the researchers.

Math Benchmark Assessments

The beginning of the year benchmark assessments and the end of the year benchmark assessments were conducted by the teachers as a school district requirement to assess student's mastery in mathematics. The school provided the data from these assessments to the researchers.

Brigance Inventory of Early Development (IED) III

The researchers conducted a pretest-posttest assessment with the students using the Brigance Inventory of Early Development (IED) III. The Brigance Inventory of Early Development (IED) III is a comprehensive tool that assesses domains and skill areas that are aligned with state and national standards as well as the Individuals with Disabilities Education Act (IDEA) requirements. The tool provides both criterion-referenced and norm referenced measures. The domains that were assessed in this study include Language Development: Receptive and Expressive, Academic Skills/Cognitive Development: Literacy, Academic Skills/Cognitive Development: Mathematics.

Data Collection

For this study, data that was archived from the Jain and Graves (2016) study was analyzed. This section describes the data collection procedures that were implemented in the original Jain and Graves (2016) study. Prior to the data collection, the parents of the participants received a consent form for children under seven years old and a consent and assent form for children under seven years old as well as a demographic survey. Parents were informed that their child would be required to take developmentally appropriate standardized assessments on the school campus. In addition, district administered assessment data would be provided to the researchers. The researchers informed the parents that there was no foreseeable risk associated with their child's participation in this research study. During the first and last few weeks of the school year, the children would be pulled out of their classroom to complete an assessment that would last for approximately 30-minutes. Parents were informed that any information obtained from the study would be confidential and that their name or their child's name would not be linked to any written or verbal report on the research project. Finally, parents were informed that the data collected would be used for educational and publication purposes and presented in summary form.

Parents were given two weeks to return the consent form and the demographic survey. Any child who did not return the consent form did not participate in the study. Participation in the study was voluntary. A participant was free to drop out of the study at any time. The consent form and demographic survey were collected, and the data was entered into the database for later analysis.

Pre-assessment testing in the Brigance Inventory of Early Development (IED) III mathematics, language, and literacy was conducted on the school campus. Seven data collectors administered only the Brigance Inventory of Early Development (IED) III assessment and concurrently scored the tests. Prior to administering the assessments, all the data collectors received training on the Brigance Inventory of Early Development (IED) III.

For this assessment, testing took place on campus in a multipurpose room. Participants were taken from their classrooms by the data collector and brought to the testing area. The participant was seated across from the data collector. The data collector reviewed the participants' folder to confirm that the consent form was signed by the parent. The data collector asked the participant if they would like to participate in the study. Once verbal consent was obtained the assessment began. The Brigance Inventory of Early Development (IED) III tool was administered following specific step-by-step instructions which required that data collectors use exact phrasing, directions, and scoring to ensure the fidelity of the instrument. The participants were assessed on six items in Language Development: Receptive and Expressive (see Appendix A), nine items in Academic Skills/Cognitive Development: Literacy (see Appendix B), and 10 items in Academic Skills/Cognitive Development: Mathematics (see Appendix C). The other measures were administered by the school district and the results of those assessments were provided to the researchers.

Procedure

During the 2016-2017 academic school year, the elementary school implemented a STEAM curriculum that was developed by the school. The school had in previous years received some resources and guidance on the development of this curriculum through a partnership with a university. In order to assess the impact of this curriculum versus the traditional district curriculum, the school had some classrooms implementing this new STEAM curriculum and some continuing with the traditional district curriculum. The teachers were assigned by the school principal to the intervention group based on their years of experience and willingness to accept a change in the curriculum. The teachers in the intervention group implemented a STEAM curriculum that was developed by the school's STEAM curriculum coordinator with input from teachers and the school principal.

Teachers in the intervention group attended a Growing up Wild training session prior to the intervention. Growing up WILD is a curriculum designed for children three to seven years old (Growing Up WILD: Exploring Nature with Young Children, 2019). The curriculum develops children's understanding of nature through experiences in outdoor exploration that involve concepts of science, math, vocabulary, art, music and movement, nutrition, and health and safety (Growing Up WILD: Exploring Nature with Young Children, 2019). The Growing up WILD curriculum is aligned with the Head Start Child development and Early Learning Framework, the National Association for the Education of Young Children (NAEYC) standards, and the United States Department of Agriculture (USDA) MyPlate guidelines for child nutrition (Growing Up WILD: Exploring Nature with Young Children, 2019).

The school developed STEAM curriculum utilized lessons that were implemented using the Biological Science Curriculum Study (BSCS) 5Es Instructional Model. This is a research-based model that provides educators with a framework for lesson planning that consists of five sequenced phases: engaging learners, exploring phenomena, explaining phenomena, elaborating scientific concepts and abilities, and evaluating learners (Bybee, 2014). The curriculum was aligned with the Texas Essential Knowledge and Skills standards. The curriculum was structured to follow the scientific method with all content areas based around a daily scientific topic of investigation. Each day the students would hypothesize an answer to a science question such as "What is a new moon?" (see Appendix D). Daily activities were structured to allow students to test their hypothesis by connecting the topic to STEAM content areas. Technology was implemented to reinforce content areas either on applications on an iPad or on computer websites. For example, the students used the Lego Movie Maker app to make a movie about the phases of the moon. Weekly engineering projects were connected to the science topic such as designing a backdrop for their movie set. Students used art to make models based on their current learning and throughout the STEAM stations, they were exposed to different art mediums such as painting and sculpture. For example, the students used construction paper and playdough to design a model of the new moon. In mathematics, the students followed the scope and sequence dictated by the district but in lessons that were hands-on, student-centered, and were connect to the science topic. Art was integrated in math lessons by having the students identify shapes in specific artwork. Language and literacy connected to the science topic with read-aloud choices based on the question of the day. For instance, the students used pictures to retell important facts that they learned form an information book about the moon. The intervention group used curriculum resources and materials from Growing up WILD. The non-STEAM groups followed the traditional district curriculum and were not provided with any additional resources or materials from Growing up WILD. Both curriculums were aligned with State Standards.

Data Analysis

In order to answer the research questions, data was analyzed through descriptive and inferential statistics. The independent variable was categorical with two levels: STEAM and non-STEAM. The dependent variables were continuous and are the scores from the Brigance Inventory of Early Development (IED) III, language, literacy, and math subscales, The Achievement Improvement Monitoring System (AIMSweb) Test of Early Literacy (TEL) 2012 in reading, the STAR Math, and math benchmark assessment. Students were assessed both at the beginning of the year and at end of the school year for the Brigance Inventory of Early Development (IED) III measure, the math benchmark assessments, and the STAR Math Assessment. For this study, we focused our analysis on the comparison between the group that received the STEAM curriculum and those that received the traditional district curriculum. A Repeated Measures ANOVA was conducted for these assessments comparing between group differences on the pre-test and posts-tests. Only end of year data was provided for the Achievement Improvement Monitoring System (AIMSweb) Test of Early Literacy (TEL) 2012 in reading therefore an Independent Samples T-Test was conducted for that assessment.

CHAPTER IV:

RESULTS

Introduction

The purpose of this study is to investigate the impact of a STEAM based curriculum on first grade students' cognitive development in the mathematics, language and literacy domains. This chapter will discuss the results from the Brigance Inventory of Early Development (IED) III, language, literacy, and math subscales, and The Achievement Improvement Monitoring System (AIMSweb) Test of Early Literacy (TEL) 2012 in reading, the STAR math assessment, and the math benchmark assessment. The results from that assessment were used to answer the following research questions that guided this investigation:

- What impact does a school developed STEAM curriculum have on first grade students' cognitive development in mathematics?
- What impact does a school developed STEAM curriculum have on first grade students' cognitive development in language and literacy?

Prior to Analysis

Prior to analyzing the data, assessment results were excluded for the students who did not complete both the pre and post measures for those measures that had both, the Brigance Inventory of Early Development (IED) III, the STAR math, and the math benchmark assessments. For the reading measure, The Achievement Improvement Monitoring System (AIMSweb) Test of Early Literacy (TEL) 2012 in reading that only had end of the year results were excluded for students who did not have a numeric scaled score.

Research Question One

The first research question addressed in this study was, “What impact does a school developed STEAM curriculum have on first grade students’ cognitive development in mathematics?” In order to answer this question, we examined if there was any significant difference between the gains made from the beginning of the year and the end of the year between the two groups. Assessment results from the Brigance Inventory of Early Development (IED) III Math subscales, the STAR math, and the math benchmark assessments were analyzed. The independent variable was categorical and had two levels: STEAM and non-STEAM. All of the dependent variables were continuous data. Both descriptive and inferential analysis were conducted.

Descriptive Analysis

The number of students assessed, minimum and maximum scores, the means, and the standard deviations were analyzed. Table 1 provides these results by each of the measures described for this research question in each of the curriculum groups. Results indicate that both groups had strong gains between the pretest and the posttests.

Table 1

Descriptive Analysis of Math Measures

		STEAM					NONSTEAM			
Measure	n	Min	Max	*M*	*SD*	N	Min	Max	*M*	*SD*
Brigance Math – Pre-Test	38	48.51	93.07	74.31	11.63	31	71.29	92.08	81.06	5.49
Brigance Math -Post Test	38	73.27	100	90.67	6.99	31	88.12	99.01	94.73	2.88
Math Benchmark - BOY	37	30	85	55.00	15.00	31	35	90	56.94	13.83
Math benchmark- EOY	37	42	100	85.05	15.71	31	71	100	89.84	8.61
STAR Math FALL	37	119	433	245.43	73.94	31	165	410	271.52	55.98
STAR Math Spring	37	150	621	365.84	86.58	31	254	576	421.35	59.36

Inferential Analysis

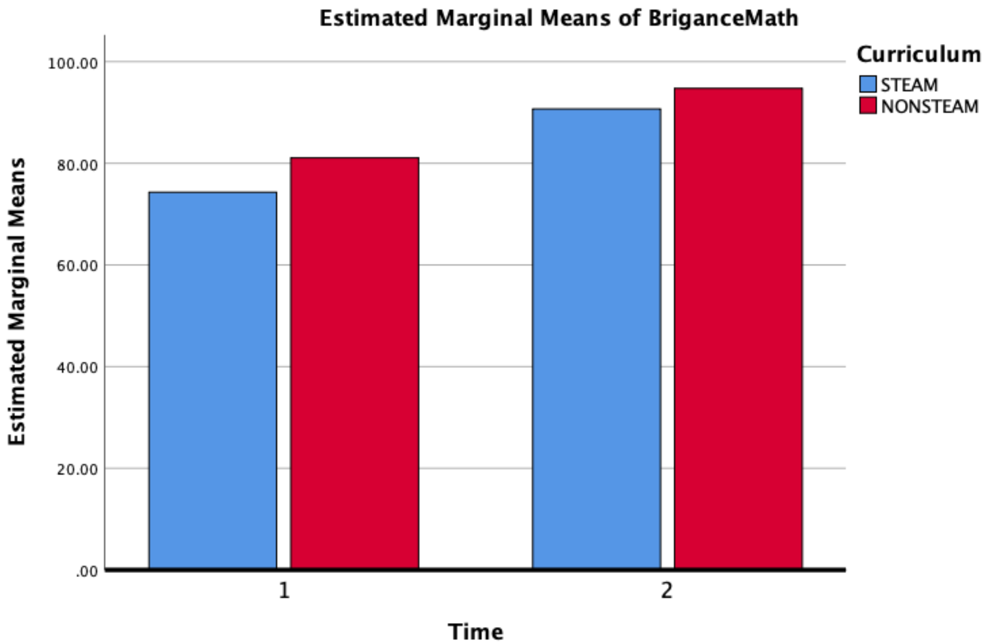
In order to compare the growth between the two groups, a Repeated Measures ANOVA was conducted on all the math assessment measures. Each math assessment had repeated assessments conducted at two different points in time. This type of analysis allows us to assess the difference in the mean scores from the first assessment and the second assessment and between the groups for any significant interaction affect. This is directly measured in the Repeated Measures ANOVA by the time group interaction analysis. In other words, did one group have significantly greater gains in scores than the other. As the focus for this study is the impact of the school developed STEAM curriculum versus the traditional curriculum, we report the results that describes any differences in the impact between the two types of curriculum. The results of each assessment are described below:

Brigance Inventory of Early Development (IED) III Math Subscale

A Repeated Measures ANOVA was conducted. Below is a graph depicting the estimated marginal means for each group.

Graph 1

Estimated Marginal Means for the Brigance Inventory of Early Development (IED) III Math Subscales



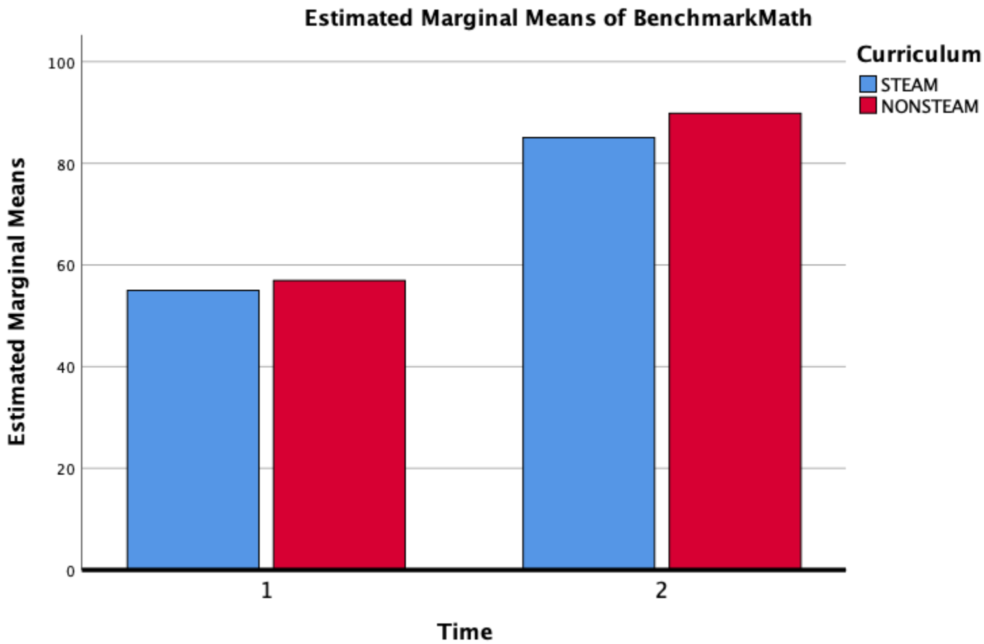
Results indicate there is no significant difference between the STEAM and non-STEAM group on the gains in the Brigance Inventory of Early Development (IED) III Math Subscale scores. $F(1, 67) = 2.29$, $p = .134$

Math Benchmark

A Repeated Measures ANOVA was conducted. Below is a graph depicting the estimated marginal means for each group

Graph 2

Estimated Marginal Means for Benchmark Math



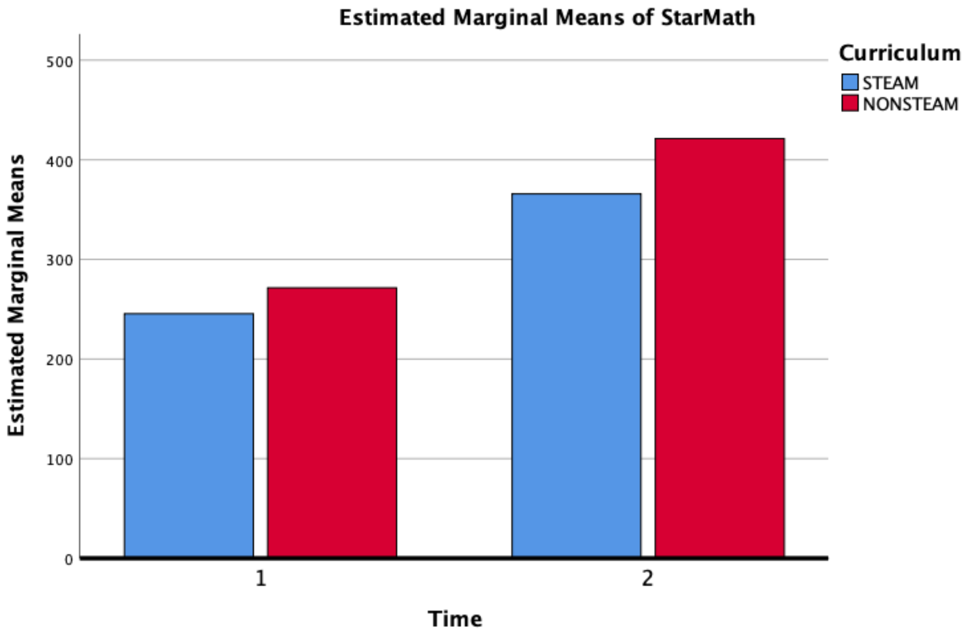
Results indicate there is no significant difference between the STEAM and non-STEAM group on the gains in the Math Benchmark scores. $F(1, 66) = .577$, $p = .450$

STAR Math

A Repeated Measures ANOVA was conducted. Below is a graph depicting the estimated marginal means for each group.

Graph 3

Estimated Marginal Means for STAR Math



Results indicate there is no significant difference between the STEAM and non-STEAM group on the gains in the STAR Math scores. $F(1, 66) = 2.26$, $p = .137$

Research Question Two

The second research question addressed in this study was "What impact does a school developed curriculum have on first grade students' cognitive development in language and literacy?" In order to answer this question, assessment results from the Brigance Inventory of Early Development (IED) III Language and Literacy subscales and the scores from the Achievement Improvement Monitoring System (AIMSweb) Test of Early Literacy (TEL) 2012 in reading were analyzed. The independent variable was categorical and had two levels: STEAM and non-STEAM. All of the dependent variables were continuous data. Both descriptive and inferential analysis were conducted.

Research Question Two Descriptive Analysis

The number of students assessed, minimum and maximum scores, means, and standard deviations were analyzed. Table 6 provides these results by each of the measures described for this research question for each curriculum group. Results indicate that both groups had some gains between the pretest and the posttests on the Brigance Language measure and strong gains between the pretest and posttest.

Table 2

Descriptive Analysis of Language and Literacy Measures

		STEAM					NONSTEAM			
Measure	N	Min	Max	*M*	*SD*	N	Min	Max	*M*	*SD*
Brigance Language – Pre-Test	38	72.45	96.94	92.21	4.70	31	81.63	94.90	90.39	3.52
Brigance Language - Post Test	38	92.86	100	96.72	1.85	31	88.78	98.98	96.38	2.07
Brigance Literacy-Pre-test	38	53.13	98.75	78.31	13.49	31	63.13	96.88	78.29	9.09
Brigance Literacy - Post Test	38	71.25	100	93.13	6.41	31	81.88	99.38	94.78	4.35
AimsWEB TEL	20	10	500	146.25	114.83	17	30	570	199.12	161.36

Inferential Analysis

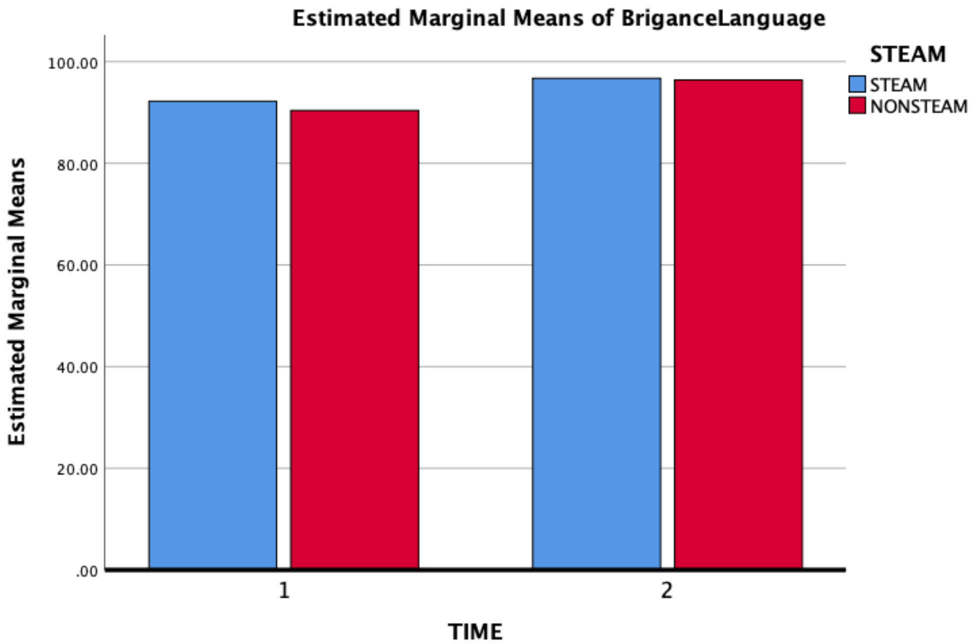
In order to assess this research question, a Repeated Measures ANOVA was conducted for the Brigance Inventory of Early Development (IED) III Language and Literacy measures and an Independent T-Test was conducted for the Achievement Improvement Monitoring System (AIMSweb) Test of Early Literacy (TEL) 2012 in reading. The Brigance Inventory of Early Development (IED) III Language and Literacy assessments had repeated measures at two different points in time. As stated earlier, the Repeated Measures ANOVA analysis allows us to assess the difference in mean scores from the first assessment and between groups for any significant interaction affects. The Achievement Improvement Monitoring System (AIMSweb) Test of Early Literacy (TEL) 2012 in reading data that was provided was only for the end of the year therefore there were no repeated measures conducted for this assessment. An Independent T-Test was conducted to obtain these results. This analysis allows us to assess if there were any significant differences in the mean scores between the groups on this measure. The results for each assessment are described below.

Brigance Inventory of Early Development (IED) III Language subscales.

A Repeated Measures ANOVA was conducted. Below is a graph depicting the estimated means for each group.

Graph 4

Estimated Marginal Means for the Brigance Inventory of Early Development (IED) III Language subscales.



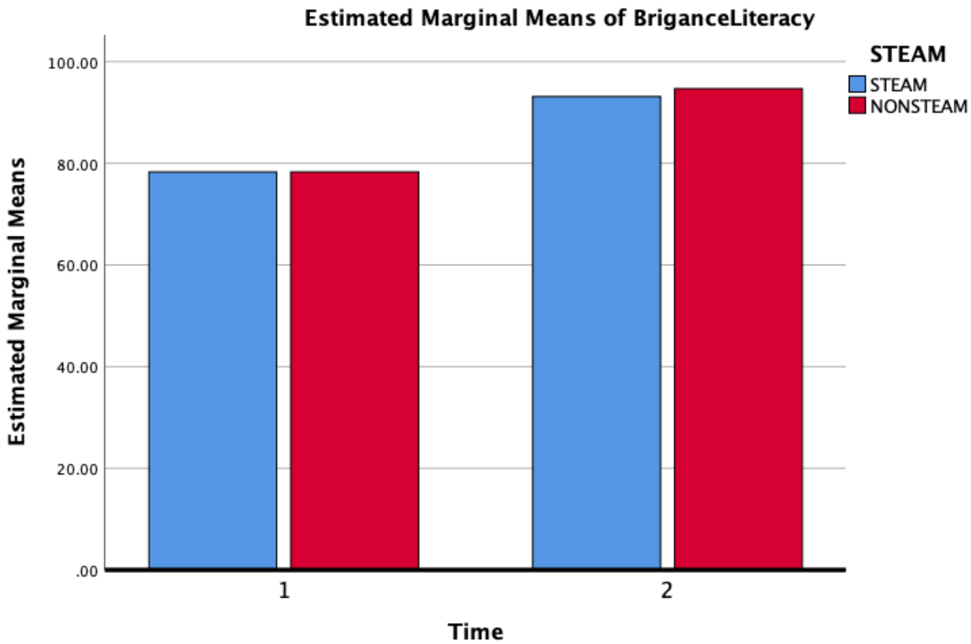
Results indicate there was no significant difference between the STEAM and non-STEAM groups on the gains Brigance Inventory of Early Development (IED) III Language subscales. $F(1, 67) = 1.95$, $p = .167$

Brigance Inventory of Early Development (IED) III Literacy subscales.

A Repeated Measures ANOVA was conducted. Below is a graph depicting the estimated means for each group.

Graph 5

Estimated Marginal Means for the Brigance Inventory of Early Development (IED) III Literacy subscales.



Results indicate that there no significant difference between the STEAM and non-STEAM groups on the gains Brigance Inventory of Early Development (IED) III Literacy subscales. $F(1, 67) = .469$, $p = .496$

The Achievement Improvement Monitoring System (AIMSweb) Test of Early Literacy (TEL) 2012 in reading.

The means and standard deviation were reported earlier in the descriptive statistics table. The 20 children who received the STEAM curriculum (*M* =146, SD = 114) compared to the 17 children who received the district curriculum (*M* = 199, SD = 161) did not demonstrate significantly different results on the Achievement Improvement Monitoring System (AIMSweb) Test of Early Literacy (TEL) 2012 in reading, $t(35) = -1.16$, $p = .254$.

Summary

The results from the Brigance Inventory of Early Development (IED) III, language, literacy, and math subscales, and The Achievement Improvement Monitoring System (AIMSweb) Test of Early Literacy (TEL) 2012 in reading were analyzed using both descriptive and inferential procedures. Although in each assessment that had repeated measures there were gains from the first assessment to the second assessment, suggesting that both curriculums positively impacted the children's math, language, and literacy development, there were no significantly different gains between the STEAM and non-STEAM groups. Similarly, there was no significant difference between the two groups on the end of the year reading assessment. This study provided empirical data on the impact of a school developed STEAM curriculum on first grade students' cognitive development in the mathematics, language, and literacy domains. The following chapter will discuss the findings for each research question, implications and interpretations of the findings, implications for further research and the limitations of the study.

CHAPTER V:

DISCUSSION

Introduction

The purpose of this study was to examine the impact of a school developed STEAM curriculum on first grade students' cognitive development in the mathematics, language and literacy domains. This chapter will discuss the findings from the analysis, the limitations of the study, and implications for further research. The decision to examine the impact of a STEAM based curriculum on first grader students' cognitive development in the mathematics, language and literacy domains derived from the fact that research indicates that the STEAM approach is considered most appropriate and effective for early childhood classrooms because of the importance and significance of the integration of the arts within the curriculum (Isbell & Raines, 2013). Although many programs across the country have begun incorporating STEM or STEAM curricula, there remains very limited empirical evidence on the effectiveness of these curriculum approaches in early childhood on measures of cognitive development, language, and literacy. In addition, there are limited studies that assessed student outcomes in the domain of mathematics, language, and literacy after the implementation of a school developed STEAM curriculum, and very few that compared outcomes between curriculum approaches.

The research questions that guided this study were:

- What impact does a school developed STEAM curriculum have on first grade students' cognitive development in mathematics?
- What impact does a school developed STEAM curriculum have on first grade students' cognitive development in language and literacy?

The study was a pretest-posttest quasi-experimental design using archival data collected by Jain and Graves (2016). The study assessed the impact of a yearlong implementation of a school developed STEAM curriculum on first grade students' cognitive development in the mathematics, language, and literacy domains.

Summary of Findings

In this section, the results relative to each question are described and discussed in comparison to existing research, followed by a discussion on possible interpretations and implications, implications for future research, and limitations of findings.

Research Question One

The first research question this study addressed was, "What impact did a school developed STEAM curriculum have on first grade students' mathematical development?" In order to answer this question, scores pre/post-test scores from 10 items in the Brigance Inventory of Early Development (IED) III on Academic Skills/Cognitive Development: Mathematics were analyzed. These items assessed the participants ability to rote count, to compare different amounts, sort objects, match quantities with numerals, read numerals, solve word problems, add and subtract numbers as well as their understanding of number concepts and sequence. Data from the STAR Math and district math benchmarks was also included in the analysis. The results from this analysis yielded an interesting finding.

The analysis revealed that both groups made gains on pre and posttest measures; however, there was no significant difference between the group that received the school developed STEAM curriculum and the group that did not across all measures. This finding is not consistent with earlier research where cognitive assessments were utilized and was not expected. The school developed STEAM curriculum that was implemented in this study included mathematical lessons that were hands-on, student centered, and provided inquiry through various material such as using paper clips and cubes to measure objects and utilizing teddy bear counters to count. Additionally, the classroom environment provided children opportunities to play in a variety of learning stations such as dramatic play, art, and engineering. A study by Thuneberg, Salmi, and Bogner (2018), found that when students engaged in mathematical, hands-on, inquiry-based, STEAM activities it supported their cognitive learning. Student cognitive outcomes were assessed using the visual reasoning Raven Standard Progressive Matrices and the *Formula 1* to measure formal abstract operational thinking. Another study conducted by Vogt et al. (2018) found that participants in the play-based mathematics group had higher learning outcomes compared to the group in a teacher led approach. The Zahlenstark test was utilized to measure child outcomes related to cognition involved tasks on ordinality, cardinality, quantity, number knowledge, and first arithmetic operations.

Research Question Two

The second research question that this study addressed was "What impact did a school developed STEAM curriculum have on first grade students' language and literacy development? In order to answer this question, pretest-posttest scores from the Brigance Inventory of Early Development (IED) III as well as the scores from the Achievement Improvement Monitoring System (AIMSweb) Test of Early Literacy (TEL) 2012 in reading were analyzed. Data included scores from six items in Language Development: Receptive and Expressive and nine items in Academic Skills/Cognitive Development: Literacy in. The Language Development: Receptive and Expressive items assessed the participants ability to identify pictures, identify body parts, understand verbal concepts, follow verbal directions, know the uses of objects, repeat sentences, and the ability to use grammar and language in context. The Academic Skills/Cognitive Development: Literacy assessed the participants ability to recite the alphabet, use visual discrimination, identify uppercase letters, phonological awareness, auditory discrimination, phoneme manipulation, read common words from signs, and word recognition. The results from the analysis indicate that there were gains made by both groups on the pre and posttest measures; however, there was no significant difference between the group that received the school developed STEAM curriculum and the group that did not.

This was not expected as other studies indicated STEAM curriculums had a strong impact on language and literacy. Studies found that engaging in STEAM related guided activities facilitates spatial language learning in young children and children's vocabulary and comprehension increased when literacy was integrated with science learning. (Cohen and Johnson ,2012; Ferrara et al., 2011). A two-part study by Ferrara et al. (2011) examined young children's use of spatial language during block play as well as the use of spatial language in activities that did not include spatial materials. However, cognitive assessments were not used to measure child outcomes but rather outcomes were measured by videotaping parent and child interactions then transcribing and coding the language into spatial categories. The difference in assessments may have contributed to the inconsistent findings. In the study conducted by Cohen and Johnson (2012), the researchers examined the effect of imagery interventions of novel science vocabulary. The students in the study were assessed using to cognitive two measures: a word fill-in task and a definition word match task. Additionally, Aguirre-Muñoz & Pantoya (2016) found that student engagement increased when they were engaged in academic conversations with peers and teachers, during the engineering book read aloud as well as during hands-on engineering activities. The school developed STEAM curriculum that was implemented for this study also included daily language and literacy opportunities such as read-alouds that connected literature to the science question of the day. However, it important to note, though the researchers in the Aguirre-Muñoz & Pantoya (2016) study found increased engagement, the study did not measure cognitive outcomes as this study did.

Interpretations and Implications of the Study

Surprisingly, across all measures in each domain there was no significant differences between the groups that received the STEAM curriculum and those that did not. These findings suggest that STEAM curriculum may not necessarily in the short-term result in any difference in increased cognitive gains compared to students who received traditional curriculums. As this was not expected based on the previous STEAM research, the study highlights that there are specific components that may affect the impact of a school developed STEAM based curriculum on first grade students' cognitive development in the mathematics, language, and literacy domains that need to be considered. One consideration is training and professional development. The teachers who participated in this study received one training from Growing up WILD that was conducted by outside experts in the field of Early Childhood Education. Lack of STEAM training and professional development can influence the implementation of the curriculum which impacts student learning outcomes. Research suggests there is a lack of STEAM training or professional development for in-service early childhood and elementary educators as opposed to Middle and High school educators. (DeJarnette, 2018). Providing training and professional development is critical for early childhood educators because they often struggle with the how to implement developmentally appropriate STEAM activities due to the fact that they do not feel confident in their own understanding of STEAM subjects (DeJarnette, 2018; Fischer, 2019). Another consideration is the educator's beliefs regarding the implementation of STEAM curriculum. An educator's beliefs can play a prominent role in classroom behaviors as well as impact their effectiveness within their classrooms (Jamil, Linder, & Stegelin, 2018). Additional research findings suggest that educators believed that STEAM activities were engaging but were disconnected to standards and curriculum and believed that STEAM lessons were add-ons to the present curriculum instead of a tool that could be used within the curriculum to meet learning objectives and child outcomes (Jamil, Linder, & Stegelin, 2018). However, the current study did not assess the educator's beliefs regarding STEAM curriculum which may have contributed to the inconsistency in the findings. Another component to be considered, is that a school developed STEAM curriculum may contribute to strengths that were not measured in this study. For example, research findings indicate that musical activities can significantly increase young children's development of executive function (Bugos, & Demarie, 2017). In addition, creativity can be increased in mathematical, hands-on inquiry based, STEAM activities (Thuneberg, Salmi, & Bogner, 2018). A final consideration is intervention fidelity. The school did not provide records that the STEAM curriculum was implemented consistently in all intervention groups. Research suggests that intervention fidelity is important for replication as well as interpreting the effect of the intervention (Murphy & Gutman, 2012)

Implications for Future Research

The current study only measured cognitive development. However, research suggests that STEAM curriculum can increase executive function as well as creativity. Therefore, future research should include investigations on how STEAM curriculum impacts various aspects of learning. In addition, the current study did not compare different learning approaches, but research suggests that the play-based approach increases student learning outcomes when they engage in STEAM related activities. For this reason, it is suggested that future research should compare diverse learning approaches in STEAM curriculum implementation. Additionally, the current study did not examine the teacher's beliefs regarding STEAM curriculum which may have contributed to the results of the study. Thus, future research should investigate how teachers' beliefs about STEAM curriculum influences children's learning outcomes. In addition, the teachers in the current study attended one training from Growing up WILD. However, research suggests that ongoing training and professional development can support early childhood educator's self-efficacy and understanding of STEAM disciplines. For this reason, future research should include professional development and training programs for educators. Finally, this study did not monitor intervention fidelity. The school developed STEAM curriculum provided teachers with lesson plans and materials. However, there were no records kept that ensure that the curriculum was implemented consistently throughout all intervention groups. Therefore, future research should include measures that assess intervention fidelity.

Limitations of the Study

This study used archival data and therefore the data was limited to only those assessments that were conducted. The assessments that were conducted only measured cognitive domains. Areas such as creativity, motivation and student engagement were not measured. Additionally, observations regarding the implementation of the STEAM curriculum were not recorded therefore the fidelity of the intervention was not documented. In addition, no data existed on the individual teachers' characteristics related to the implementation of STEAM curriculums. The study was limited to one elementary school campus and therefore the generalizability of the findings is limited.

Summary

The purpose of this study was to examine the impact of a school developed STEAM curriculum on first grade students' cognitive development in the mathematics, language, and literacy domains. The findings of this study are important as they emphasize that the implementation of a school developed STEAM curriculum does not always result in stronger measurable mathematical or language cognitive development. at The developers of STEAM curriculum need to examine specific aspects of implementation and assessment that are needed to affect impact and differentiate it from traditional curriculum formats.

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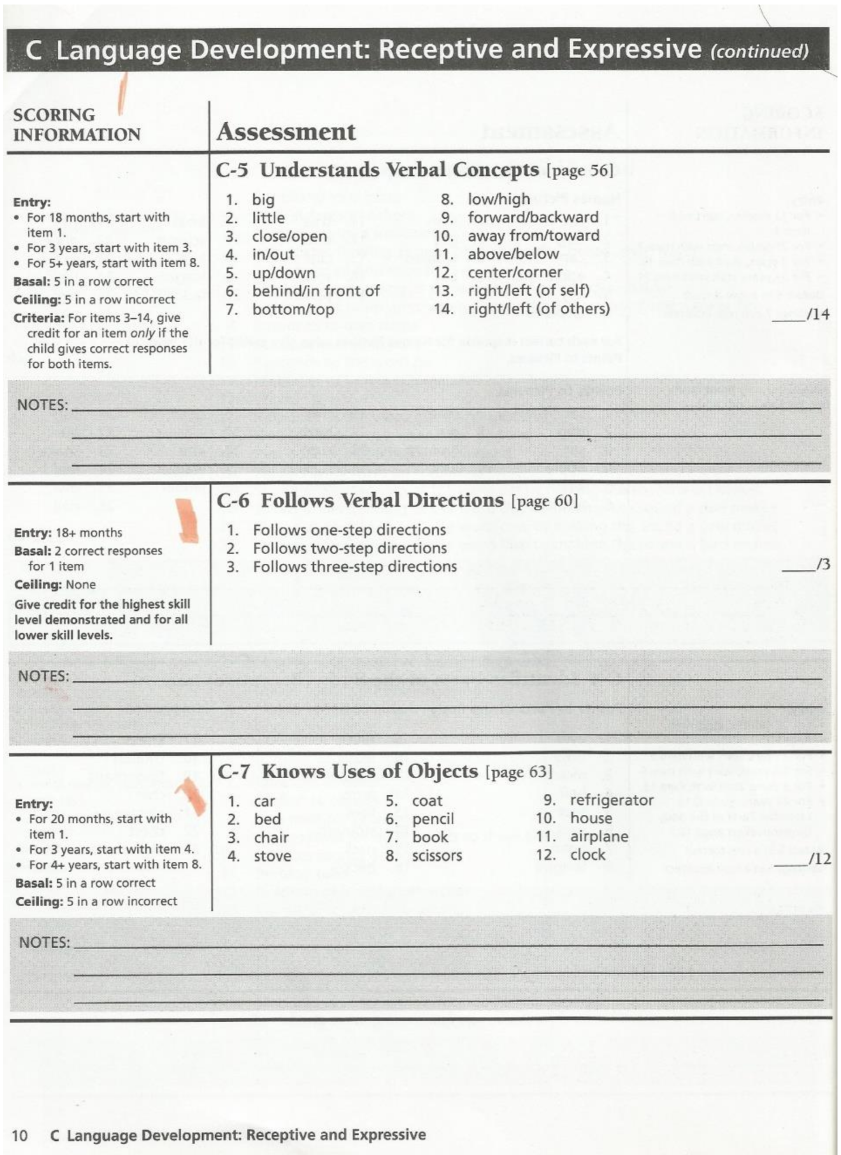
APPPENDIX A:

BRIGANCE INVENTORY OF EARLY DEVELOPMENT (IED) III SAMPLE

LANGUAGE SCORING SHEET



C Language Development: Receptive and Expressive *(continued)*

SCORING INFORMATION	Assessment
Entry: • For 18 months, start with item 1. • For 3 years, start with item 3. • For 5+ years, start with item 8. **Basal:** 5 in a row correct **Ceiling:** 5 in a row incorrect **Criteria:** For items 3–14, give credit for an item *only* if the child gives correct responses for both items.	**C-5 Understands Verbal Concepts** [page 56] 1. big 2. little 3. close/open 4. in/out 5. up/down 6. behind/in front of 7. bottom/top 8. low/high 9. forward/backward 10. away from/toward 11. above/below 12. center/corner 13. right/left (of self) 14. right/left (of others) ____/14

NOTES: ____________________

Entry: 18+ months **Basal:** 2 correct responses for 1 item **Ceiling:** None **Give credit for the highest skill level demonstrated and for all lower skill levels.**	**C-6 Follows Verbal Directions** [page 60] 1. Follows one-step directions 2. Follows two-step directions 3. Follows three-step directions ____/3

NOTES: ____________________

Entry: • For 20 months, start with item 1. • For 3 years, start with item 4. • For 4+ years, start with item 8. **Basal:** 5 in a row correct **Ceiling:** 5 in a row incorrect	**C-7 Knows Uses of Objects** [page 63] 1. car 2. bed 3. chair 4. stove 5. coat 6. pencil 7. book 8. scissors 9. refrigerator 10. house 11. airplane 12. clock ____/12

NOTES: ____________________

10 C Language Development: Receptive and Expressive

APPENDIX B:

BRIGANCE INVENTORY OF EARLY DEVELOPMENT (IED) III SAMPLE

LITERACY SCORING SHEET

D Academic Skills/Cognitive Development: Literacy *(continued)*

SCORING INFORMATION | **Assessment**

D-6 Auditory Discrimination [page 97]

Entry: 4+ years
Basal: None
Ceiling: None

Discriminates Beginning Consonant Sounds

1. go—so (*not the same*)
2. rain—rain (*the same*)
3. job—job (*the same*)
4. pig—big (*not the same*)
5. fan—van (*not the same*)

Discriminates Ending Consonant Sounds

6. sick—sit (*not the same*)
7. red—red (*the same*)
8. bus—buzz (*not the same*)
9. seed—seal (*not the same*)
10. pass—pass (*the same*)

____/10

NOTES: ____________________

D-7 Familiarity with Sounds: Phoneme Manipulation [page 100]

Entry: 5+ years
Basal: None
Ceiling: None

Identifies Blended Phonemes as Words

1. boat
2. hat
3. fish

Deletes Word Parts, Syllables, and Phonemes

4. shine
5. key
6. ame
7. bay

____/7

NOTES: ____________________

D-8 Reads Words from Common Signs [page 103]

Entry: 5+ years
Basal: None
Ceiling: None

1. STOP	2. GO	3. IN	4. OUT
5. BOYS	6. GIRLS	7. MEN	8. WOMEN
9. EXIT	10. ENTER	11. WALK	12. LADIES
13. WAIT	14. DANGER	15. CAUTION	16. POISON

____/16

NOTES: ____________________

D Academic Skills/Cognitive Development: Literacy 17

APPENDIX C:

BRIGANCE INVENTORY OF EARLY DEVELOPMENT (IED) III SAMPLE MATHEMATICS SCORING SHEET

E Academic Skills/Cognitive Development: Mathematics *(continued)*

SCORING INFORMATION	Assessment
Entry: • For 3 years, start with item 1. • For 5+ years, start with item 3. **Basal:** Correct responses for 2 complete word problems in a row **Ceiling:** Incorrect responses for 2 complete word problems in a row	**E-7 Solves Word Problems** [page 117] **4 dogs and 3 balls** 1. *(no)* 2. *(1)* **6 children and 3 caps** 3. *(no)* 4. *(3)* **3 children and 7 bikes** 5. *(yes)* 6. *(yes)* **20 rabbits and 19 carrots** 7. *(no)* 8. *(1)* **16 children and 20 cupcakes** 9. *(yes)* 10. *(4)* ____/10

NOTES: ____________________

SCORING INFORMATION	Assessment
Entry: • For 4 years, start with item 1. • For 5+ years, start with item 3. **Basal:** 3 in a row correct **Ceiling:** 3 in a row incorrect	**E-8 Knows Missing Numerals in Sequences** [page 119] 1. 4 2. 8 3. 3 4. 9 5. 13 6. 16 7. 29 8. 33 9. 44 10. 66 11. 83 12. 100 ____/12

NOTES: ____________________

SCORING INFORMATION	Assessment
Entry: 5+ years **Basal:** None **Ceiling:** None	**E-9 Adds Numbers** [page 120] 1. 6 2. 7 3. 9 4. 13 5. 12 6. 19 7. 18 8. 25 9. 29 ____/9

NOTES: ____________________

E Academic Skills/Cognitive Development: Mathematics 21

APPENDIX D:

SAMPLE LESSON PLAN

Scope and sequence 4/6-4/10 Day 1 Question of the day What is a new moon?

Subject	TEK/Steam Standards	Engage	Explore	Explain	Elaborate/Extend	Reteach	Evaluate
Science	K.8C Observe, describe, and illustrate objects in the sky such as the clouds, Moon, and stars, including the Sun.	Show all the pictures of the phases of the moon Ask students which of the pictures is the first phase of the moon	Students predict what the first phase of the moon is called and what happens between the moon, earth, and sun to make this happen	Watch you tube video on the phases of the moon (only watch the part explaining the new moon phase)	Students will use Lego Movie Maker app for a two week long project to make their own movie about the phases of the moon. Today they will make a back drop for the movie set, design the new moon phase out of playdough or construction paper, and take the first picture for the movie	Complete the new moon phase of a phases of the moon book	Students can name the first phase of the moon and explain how this happens
Math	K.2B read, write, and represent whole numbers from 0 to at least 20 with and without objects or pictures;	Review numbers 1-20	Give each student 20 "moon rocks" (cubes, counters, or pebbles) they will test each other by showing their partner a set of rocks and their partner has to say the number the set represents	Teacher reviews counting a set of objects and what is 1 or 2 more or less of the set	Teacher demonstrates how to solve practice benchmark questions through think alouds	Counting app	Students are able to count a given set of objects
Read Aloud	K10 A-D analyze, make inferences, and draw conclusions about informational text	Show an informational book about the moon	Review text features/ picture walk through book	Read book aloud to the class	Stop periodically throughout the reading to model/practice retelling important facts from the book	Students use pictures to retell important facts learned from the book	Student conversations through accountable talk
Shared Reading	K.7A respond to rhythm and rhyme in poetry	Show poem about the moon Give summary of poem	Read poem together demonstrating prosody	Invite the students to listen for how the teacher reads each sentence smoothly and have them repeat using the same fluency	Students turn/talk to partner pointing out the vocabulary from the poem	Teacher reads one line from the poem and students repeat using the same tone of prosody	Students will be able to read the poem with prosody
Social Studies	Identify jobs in the community	Show a picture/video/ book of a apace launch	Students list questions they have about the history of space travel	Teacher explains the history of space travel in our country	Watch united streaming/ brainpop video about space travel	Students act out being a part of a rocket launch	The students knows the importance of the history of space travel in our community

Social/Developmental Centers-

- **Dramatic play- students pretend to be an astronaut**
- **Art- astronaut on the moon color page**
- **Fine Motor Skills- moon sensory box http://totallytots.blogspot.com/2011/02/whats-in-tub-space-sensory-tub.html**
- **Engineering- design/build a balloon rocket http://www.sciencebob.com/experiments/balloonrocket.php**
- **Technology- math review apps**