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Connecting STEM Curriculum with Social Emotional Learning in Early Childhood

Aaron Peterson

ABSTRACT

The purpose of this study was to explore how STEM based curriculum integrated with the Social Emotional Learning (SEL) framework can enhance learning and overall development in early childhood learners. Participants were preschoolers (N=24) between the ages of 3-5 enrolled in the Child Development Center during summer at a Midwestern mid-sized university. This study collected both quantitative (rubric scores) and qualitative data (interviews and observations) and used control and experimental groups. The control group followed the standard curriculum procedures already in place and the experimental group included STEM curriculum without SEL instructions. Data was analyzed using descriptive statistics. Using the variables of Directions, Observe, and Comparison, there were no significant difference between the groups with p-values ranging from .167 and .485. This result was largely due to the sample size. However, charts using percentage analysis showed the experimental group was more effective. Study limitations and future directions are discussed

INTRODUCTION

Science, Technology, Engineering, and Mathematics (STEM) has been a growing topic of discussion among multiple disciplines for the past decade but is most notably recognized for its connection to education. The goal of STEM education among many global initiatives is to provide greater opportunities for success and prosperity of people, therefore increasing the economic success of their respective countries. STEM education focuses on the integration of science, technology, engineering and mathematics, rather than teaching them individually and is often associated with problem based learning (PBL) or project oriented problem based learning (POPBL). PBL is the practice of teaching students through the solving of practical problems rather than lecture based instruction. This practice emphasizes the interdependence of these subjects in real world situations, such as a structural engineer's dependence on mathematics and technology to create an effective and safe bridge.

However, some concerns exist related to current status of education in the U.S. For example, Schmidt (2011) indicated U.S. students are underperforming in the areas of Math and Science, a fact that could lead to political implication to the U.S. at the global level. An additional concern relates to the long known achievement gap among different groups of students based on their educational opportunities. The perceived achievement gap is believed to keep job opportunities out of the reach of minorities or underrepresented groups. STEM education has the potential to address the achievement gap related to 21st century skills and the workforce (Stotts, 2011; Young et al., 2011). In today's ever changing world, STEM education is widely accepted as vital not only to the success of individual students, but also to the success of entire nations and the world. In President Obama’s 2011 State of the Union Address, the President voiced his desire to improve the United States’ STEM instruction by stating, “We know what it takes to compete for the jobs and industries of our time. We need to out-innovate, out-educate, and out-build the rest of the world. We have to make America the best place on Earth to do business” (Obama, 2011). Later in this speech President Obama outlines his plan for “out-educating” the rest of the world, which includes increasing spending on education and a reinvention of nationally accepted standards. Five years later STEM for All (2016) published that one billion dollars of private funds were raised to support the President's Educate to Innovate campaign to support student involvement in STEM programs.

Malaysia's National Council for Scientific Research and Development, for example, estimates that Malaysia will need 493,830 scientists and engineers by 2020. The extensive need Malaysia faces in order to compete in a global economy led the country to include additional goals for their 2013-2025 education blueprint including (1) “Prepare students with the skills to meet the science and technology challenges” and (2) “To ensure that Malaysia has a sufficient number of qualified STEM graduates” (Malaysia Education Blueprint 2013-2025, 2017). These examples of two economically and culturally contrasting nations give evidence of the depth and breadth of the world’s need for further improvement in STEM education. Although the importance of STEM curriculum in K-12 settings is well documented, fewer efforts have been made to incorporate STEM in early childhood and early elementary years. According to Swift and Watkins (2004) math and science should be exposed in early grades for long term success in these subjects. Additionally, a report by the National Science Board published in 2010 strongly supports early exposure to STEM as a way to keep students interested in pursuing additional math and science learning opportunities in subsequent years.

Social Emotional Learning (SEL)

Social emotional learning (SEL) is instruction focused on students' development of socially acceptable behavior as well as understanding and regulation of emotions. Similar to the rising popularity of STEM in all levels of education, the use of SEL curriculums in early childhood education has grown significantly as evidenced by research in the past decade. The impact of SEL is well documented and widely accepted in the field of early childhood. According to Durlak et al. (2011) it is with good reason SEL has grown at the rate it has. Another study on the effects of social emotional interventions on academic classroom instruction time reported,

> our results suggest that children in FOL [Foundations of Learning, a prominent social emotional intervention] classrooms scored lower on conflictual interactions with both teachers and peers based on observations by trained coders. Moreover, there was some suggestion, at the trend level, of higher levels of self-control, greater levels of focus, and higher levels of participation in classroom activities for children in FOL classrooms. *brackets added* (Morris, 2013, p. 1039).

Improved student to teacher and student to peer relationships as well as increased positive student behavior found in studies like this are encouraging to researchers and educators alike, especially because of its implications for students later in life. Jones and Doolittle (2017) begin their review of SEL research by pointing out, “Research increasingly suggests that social and emotional learning (SEL) matters a great deal for important life outcomes like success in school, college entry and completion, and later earnings” (p. 3).

The positive learning environment and longitudinal success determined by previous research in SEL and STEM education is the foundation of and inspiration for this study.

LITERATURE REVIEW

Several scholars have documented American students’ lack of proficiency in science and mathematics. (Schmidt, 2011; Stotts 2011) which has become a common issue among educators, policy makers, and the American community as a whole. As STEM education has grown over the years to meet the rising demand for technically trained professionals and a better educated public, research on various methods of STEM education has grown as well. Important to note is that the fluidity of the term STEM which is not a unified term and can be interpreted differently by various groups of people. In some cases, STEM education refers to exclusive programs focused on developing the talents of gifted students.

Some studies state student aptitude can be a key factor in determining later academic success and achievement, such as (Colangelo, Assouline, Gross, 2004) who cite talent searches examining the results of SAT, SAT-M, and SAT-V test scores of seventh and eighth grade participants that found, “Across both sexes, young adolescents with general, quantitative, and verbal abilities in the top 1 in 100 secure doctorates at 25 times base rate expectations (25%), while those scoring among the top 1 in 10,000 secure doctorates at 50 times base rate expectations (50%); moreover, the caliber of the universities attended and the creative products generated by this latter (profoundly-gifted) group reveal a much steeper, much more impressive developmental trajectory” (p. 24). To clarify, students were selected to participate in a range of accelerated programs such as grade skipping, advanced subject matter placement, college courses while in high school, special courses, or early entrance into college, and were later found to have the greater academic achievement listed above. Proponents of accelerated education programs point to this data as support for expansion of these types of advanced programs for gifted students. The rarest of these advanced education options are specialty STEM schools (Olszewski-Kubilius, 2010, p.1). Olszewski-Kubilius (2010), later states, “over 106 schools are currently listed as members of the National Consortium for Specialized Secondary Schools of Mathematics, Science and Technology [NCSSSMST]” (p.67). Which is a significantly small number of programs in relationship both to the number of students who might benefit from them, and the increasing mass of unfilled STEM jobs in the country. In summary, STEM education, from this exclusive perspective, is directed at developing the skills and abilities of gifted individuals through a range of accelerated programs for the purpose of increasing the rate of academic achievement and development of highly educated STEM professionals such as doctors, researchers, and engineers.

Still other institutions hold alternate views of STEM's definition, objectives, and application. Many K-12 programs and researchers refer to STEM as an Inclusive initiative intended for all students. Isha DeCoito (2014), identifies STEM as "the intersection of science, technology, engineering and mathematics. It is an approach to solving problems in a holistic way; seeing how the components of STEM interact with and inform each other" (p. 34). This integrated method is often cited by programs addressing this lack of STEM professionals by seeking to better educate all members of the public. Those who hold to this view believe emphasising STEM to all students is beneficial because of the skills included in this method of learning such as collaboration, critical thinking and creativity. Decoito (2014) continues in his journal article, "Focusing on Science, Technology, Engineering, and Technology in the 21st Century," by stating "STEM facts, principles and techniques are highly transferable skills that enhance an individual's ability to succeed in school and beyond, across a wide array of disciplines" (p. 23). An inclusive philosophy of STEM believes these transferable skills are useful for everyone and that a society educated in this way is therefore more successful because of these skills. This idea greatly inspires the motivation behind the goals and practices of Inclusive STEM education programs.

According to Navruz, Erdogan, Bicer, Capraro & Capraro (2014), there are three goals of inclusive STEM education, 1) to increase math and science test scores across the United States, 2) to increase representation of minorities in STEM positions, and 3) to grow a well-equipped STEM workforce to compete in a global economy. These goals are nearly identical to the purpose of exclusive programs, the difference being their definition of success and their means of achieving that success. For instance, a selective STEM program may be more concerned with the number of its students who attained professions requiring a master's degree or above, while an inclusive program places greater emphasis on technical schools and bachelor's degrees. (Navruz et. al., 2014) clarify this point in their discussion of the objectives of inclusive STEM programs, "Although there is an effort to increase the number of students who pursue advanced STEM degrees, increasing the number of students who pursue the STEM related workforce (e. g., K-12 STEM teachers, computer and medical assistance, and nursing) is equally important for the nation's economic competitiveness in the global market" (p.10). As a whole, inclusive STEM views our nation's challenges as a comprehensive societal problem, requiring better participation of all citizens in order to be successful.

Like exclusive or selective programs, inclusive STEM education can be presented in several different ways. Dedicated inclusive STEM schools do not base admission on testing and aptitude, but they are equally rare as their exclusive counterparts. Inclusive STEM more commonly presents itself as afterschool programs and integrated lessons emphasizing problem based learning (PBL) rather than traditional lecture based learning. Unlike exclusive programs that focus on developing students' existing aptitudes for science and mathematics beginning in middle school, inclusive programs seek to develop an interest throughout a student's life through exploration and discovery. While the emphasis of STEM education is still placed on secondary education, greater attention is now being paid to primary grades and early childhood.

METHODOLOGY

The Purpose of the Study

The purpose of this study is to explore how STEM based curriculum integrated with the Social Emotional Learning (SEL) framework already in place can enhance learning and overall development in early childhood learners. Participants were preschoolers between the ages of 3-5 enrolled in a summer program offered at a Midwestern mid-sized university.

The following are the central research questions:

Can social emotional instruction be integrated with STEM with the same level of success as when social emotional skills are taught independently?

Does the presence of SEL instruction integrated within STEM curricula improve the likelihood of students' achievement of STEM learning objectives?

Research Design

A mixed method approach was used for data collection. Once the child development center agreed to allow the study to be implemented, the IRB approval was obtained and the lesson plans to include STEM curriculum and state standards were developed. Parental consent forms explaining the study objectives and procedures were sent home to obtain parents or guardians approval. All consent forms sent were signed and returned. This study collected both quantitative and qualitative data. Quantitative data consisted of scores recorded on rubrics. Qualitative data was collected via classroom observations and random informal interviews with participants. The teacher was also interviewed. The study used control and experimental groups and participants were randomly assigned into the groups. The control group followed the standard curriculum procedures already in place at the center. The experimental group included Science, Technology, Engineering, and Mathematics (STEM) learning activities, such as building bridges in small groups with no SEL instructions. Researchers then compared the assessment rubric scores to determine any difference between groups. Rubric includes observational measures such as if child used senses, materials or tools to investigate and expand their knowledge.

Study Limitations

The small sample size and limited diversity, such as learning abilities, ethical and social background among participants available for the study make it difficult to generalize the findings to other populations. Additionally, future research should include a wider range of pre-and post-measures to gauge deeper insights into our participants' learning gains.

Population and Sampling

Participants in this study included twenty-five (N=25) preschoolers ranging in age from 3-5 years old and included both male and female enrolled in a summer program offered at a Child Development Center at a Midwestern mid-sized university. The inclusion of early elementary children was crucial to this study because of its focus on improving learning conditions and overall development in early childhood education as outlined in the state' guidelines. A certified teacher (N=1) with over twenty years of teaching experience ran both control and experimental groups and taught all the lessons involved in the study.

Control Group Procedures

After students' morning recess (10:30 AM), control group students entered the classroom and sat on their group time rug. From there students were introduced to the lesson through either a story book or video as an anticipatory set. Once students covered the content of the lesson they were given specific instructions for the day's building project and were released to begin building. Students were explicitly given no social emotional direction during this time and observations were made on their peer interactions. At the conclusion of the building period, students tested their inventions each day and were asked to reflect on what they liked about their product and what they might do differently next time.

Figure 1: Sample Control Group Lesson Plan

Setting and Assessing Student Learning Outcomes/ Knowledge of Resources	
STEM Goals NE Standards or Developmental Indicators for Early Childhood	M.02 Child develops spatial sense -Uses comparison words correctly -Uses words that describe the relative position of things M.03 Child demonstrates use of measurement -Uses standard and/or non-standard measures -Recognizes that different types of measurement can be made (height, length, weight) S.01 Child develops scientific skills and methods -Makes observations, collects information, and describes objects and processes -Begins to make comparisons between objects that have been observed -Begins to look for answers to questions through active investigation Child uses sentences that include two or more ideas with descriptive details Child uses senses, materials, tools, technology, events in nature, and the environment to investigate and expand knowledge
Learning Objectives:	STEM Objectives -After reading *Stuck* by Oliver Jeffers, students will verbally describe the position of our kite using 1-2 describing words (our kite is up in the tree next to that branch). -After group instruction students will measure the distance between two points in feet using a ruler with 75% accuracy. -During group discussion students will use tools to investigate the distance between them and the kite.

This figure outlines the standards (taken from the Nebraska Early Childhood Guidelines) and objectives used in one of the control group activities.

Experimental Group Procedures

At the conclusion of the control group, experimental group students entered the classroom and sat on the rug. This group of students received the exact same lesson taught by the same teacher with the one exception of Social Emotional Learning content. During the lesson the teacher addressed common issues of working with a partner or small group and gave suggestions on how to overcome those obstacles. At the conclusion of this lesson, experimental group participants were given instructions on the day's building activity and are reminded of SEL strategies for working with partners or small groups. When the building portion of the lesson was finished students tested their inventions and were asked to reflect on the effectiveness of their invention and the possibility for improvement.

This figure outlines the standards (taken from the Nebraska Early Childhood Guidelines) and objectives used in one of the experimental group activities.

Figure 1: Sample Lesson Plan

Subject: Engineering
Unit: STEM
Lesson: Help! It's Stuck based off of "Making and Tinkering with STEM" by Cate Heroman

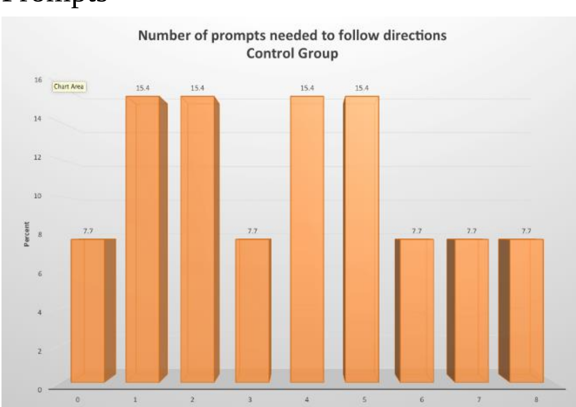
Setting and Assessing Student Learning Outcomes/ Knowledge of Resources	
STEM Goals NE Standards or Developmental Indicators for Early Childhood	M.02 Child develops spatial sense -Uses comparison words correctly -Uses words that describe the relative position of things M.03 Child demonstrates use of measurement -Uses standard and/or non-standard measures -Recognizes that different types of measurement can be made (height, length, weight) S.01 Child develops scientific skills and methods -Makes observations, collects information, and describes objects and processes -Begins to make comparisons between objects that have been observed -Begins to look for answers to questions through active investigation Child uses sentences that include two or more ideas with descriptive details Child uses senses, materials, tools, technology, events in nature, and the environment to investigate and expand knowledge
Social Emotional Goals	SE.01 Child develops independence, confidence, and competence -Likes self and shows pride in accomplishments -Joins other children in various play activities -Chooses from a range of materials and activities within the program SE.03

	Child increases ability to sustain relationships -Uses compromise and conflict resolution skills SE.04 Child interacts empathetically and cooperatively with adults and peers -Solves problems with other children independently -Shows awareness of and responds to the feelings of others
Learning Objectives:	STEM Objectives -After reading *Stuck* by Oliver Jeffers, students will verbally describe the position of our kite using 1-2 describing words (our kite is up in the tree next to that branch). -After group instruction students will measure the distance between two points in feet using a ruler with 75% accuracy. -During group discussion students will use tools to investigate the distance between them and the kite. SEL Objectives -While creating their simple machine, students will solve problems independently with other children using compromise and conflict resolution skills (solution cards). -After completing their simple machine students will verbally express 2-3 things they like about their invention.

Quantitative Data Analysis

Data was analyzed using descriptive statistics. Using the variables of Directions, Observe, and Comparison, there were no significant differences between the control and experimental group with p-values ranging from .167 and .485. This data means under the current conditions of this study, there is no significant difference occurred between the groups. This result can be largely explained by the study's small sample size. The charts below show, however, that this experiment is a good framework for future studies to use with larger sample size.

Table 1: Control Group Prompts Table 1.a: Experimental Group
Prompts



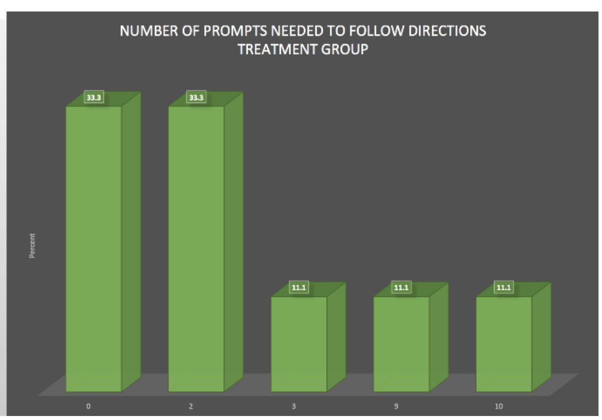


Table 2: Control Group Observations

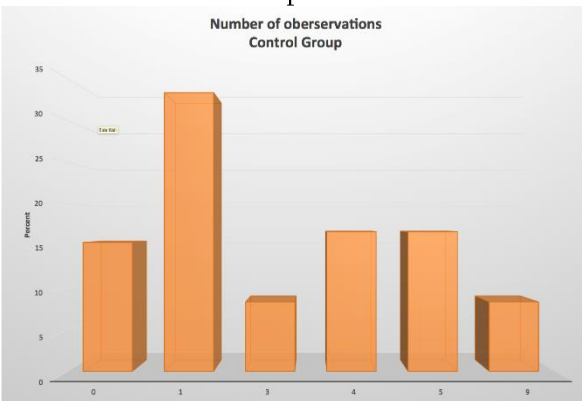


Table 2.a: Experimental Group Observations

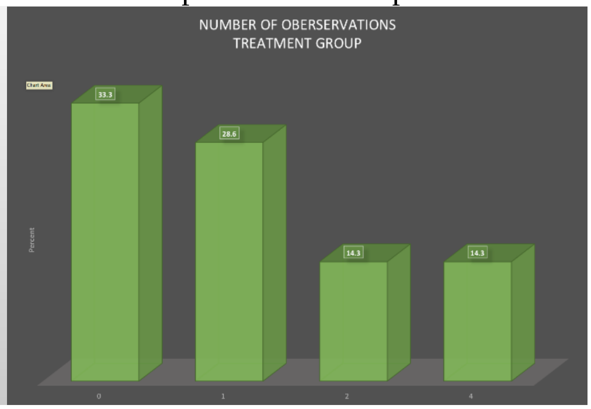


Table 3: Control Comparisons

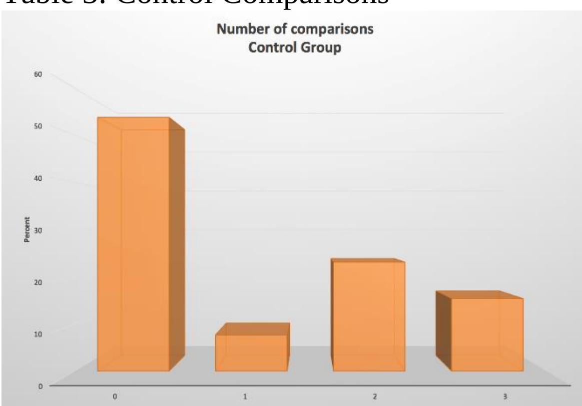
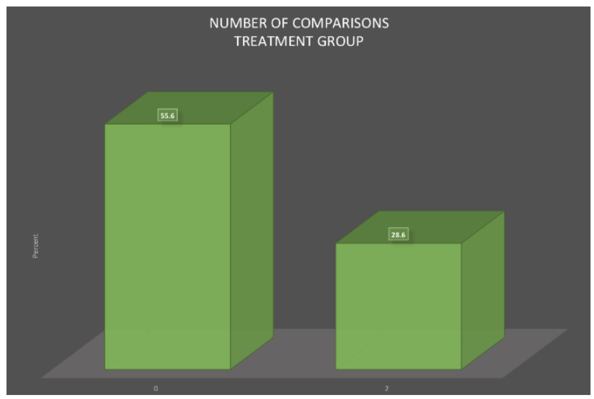


Table 3.a Experimental Group Comparisons



Qualitative Data Analysis

The data were obtained as recorded statements or responses by the study participants and were transcribed into a Microsoft Word file for analysis, which was conducted according to the general strategies proposed by Creswell (1998). The researcher reviewed participants' written responses to obtain the sense of overall data. After studying the recorded data, the researcher started the coding process. According to Stake (1995) and Creswell (1998), coding can be defined as the process of making a categorical aggregation of themes. An in vivo coding strategy was used. In vivo coding implies each code comes from the exact words of the participants. Coding implies the process of grouping the evidence and labeling ideas. After coding was completed, the ideas were transformed into themes and sub-themes. The qualitative data are presented through visual graphs and findings were presented as an integral part of results and discussion as much as possible. After the study data were transcribed and analyzed, results are presented in the form of statements and tables. The following table summarizes the major themes that emerged from data generated by classroom observations during the implementation of the study, and informal interviews with participants.

Table 7: Themes Emerged from Qualitative Data

Excitement	Confusion	Problem Solving	Frustration
Because we think it will work and if not we'll try it again	What do we have to do?	Buy a back scratcher	She didn't help me at all
I did it!	What do I need?	Get another person to scratch your back	I don't like this story
This will be the best ever!	What do I do with this tape?	A solution is where you draw a picture and then make something	No one will help me
I made a drum!	I can't do it!	The first step is to ask a question	Why didn't you help me?
Mine is perfect!	I don't remember	A prediction is saying yes or no to something. If it will go up or down before you test it	Don't take others' things
That's a fun video		Engineers work together to make things better	No, we didn't have any ideas
Look at mine!			I can't make it
I like how it raddles!			He can't change the boat , it's mine

RESULTS

The charts show the control group does require more Directions and performed fewer Observations and Comparisons than the experiment group. The charts are based on percentages instead of frequency to provide a relative view of the limited quantitative data generated by the rubrics. Statistically, the data is not significant due to the small sample size. The following charts are broken down by group (control v. experimental). The control group does have a higher numbers percentage wise for the three variables (Directions, Observe, and Comparison) than the experimental group. This means that visually, it appears the control group required more efforts on the three variables than the experimental group. This chart is a visual representation of the data and statistically, there is no significant difference.

Results from the informal interviews and observations with students were recorded in the form of quotes and organized topically, for example see Table 7. After analyzing qualitative data generated by interviews and observations, four major themes emerged: excitement, confusion, problem solving, and frustration. These four categories provide a useful framework for understanding what the students were experiencing during these lessons, and, therefore, how we might better use this information in the future.

Excitement was an obvious and prevalent theme throughout the course of these activities observable through quotes like, “This is the best ever!” This quote is in reference to a back scratcher a student made on his own during the very first lesson. This comment along with other instances where students said, “I did it!”, “Mine is perfect!”, and “I made a drum!” are all simply related to the enjoyment students found in creating and solving problems in a unique way. These reactions from students are strong indication hands on activities are fun and engaging.

The five lesson plans used in this study ranged in topic from making a musical instrument to inventing a device to get a kite out of a tree and were paired with age appropriate stories to provide a context for each problem the students were presented. While students’ enjoyment was a positive result from these lessons, it is not surprising to find lessons allowing for greater interaction and creativity resulted in more engagement. The quotes from this category that were more insightful were quotes that prompted by questioning. For example, when the teacher asked a student from the experimental group, “Why do you think your invention will help you get the kite out of the tree?” the student replied, “because we think it will work, but if not we will try again”. This student worked with another student to create a long stick made of chopsticks with a fork taped to the end as a device to retrieve the lost kite. From this situation we can tell this student could reason that a long stick could help us grasp something out of reach but is cognitively struggling to explain their thought. On the SEL side of this study, we can see a development of resilience in this quote. The category of “excitement” provides some intriguing information, but the other three categories of quotes provide more impactful information.

Confusion and frustration were two very important themes in this study, both categorized by the phrase, “I can’t do it”. Every student throughout the five lesson said this at some point. Common situations where students would use this term were either at the beginning of the lesson when they felt intimidated because they didn’t understand some element of the project which we categorized as confusion, or at the middle or end of a lesson when students didn’t have the skills or the knowledge to carry out the solution they came up with, which we labeled as frustration.

It was common for students to experience confusion or frustration throughout the course of these lessons for a handful of reasons beyond a lack of understanding. Students often expressed confusion through questions such as, “What do we have to do?”, “What do I do with this tape?", and "What do I need?" These types of questions illustrated situations where students required additional scaffolding but were not necessarily outside of their zone of proximal development.

DISCUSSION

While there was no statistically significant difference between the groups, the outcome of this study proved to be extremely beneficial. Through the process of developing and implementing lessons and rubrics, many practical lessons were learned that may benefit future research. The importance of taking time to develop students' understanding of the problem solving process became abundantly clear. From day to day it was apparent students became more open to thinking critically about the problems presented to them but struggled to do so in a consistent matter. When students were asked to reflect about an aspect of the problem solving process discussed from the day before, further time was obviously needed to help students develop an understanding of this process. Practically, this need pointed to the fact that STEM activities will require a significant amount of time to implement, especially when working with young learners.

An interesting aspect of this research was found in observing what did and did not work in respect to engaging students and managing classroom behavior. In early lessons students were given a large and diverse range of building materials to choose from for the purpose of promoting creativity. Interestingly, instead of promoting creativity, the abundant options proved to be both overwhelming and distracting, leading to less creativity and more off task and problem behaviors. In later lessons the material lists were refined to suit each individual lesson which resulted in greater student interest and creativity. Based on observations, students were able to improve their knowledge, for example, on building a bridge, materials used to build bridges and the science involved with building bridges within the lesson. Students communicating their understanding of the lesson's goal was a very positive outcome of the STEM based lessons. Their willingness and ability to communicate their understanding alone was indication that STEM brings new possibilities into the learning environment of young children.

This study has practical implications for classroom teachers interested in integrating STEM. For example, organizing material lists, extending time spent on STEM activity procedures, and implementing differentiated instruction. These critical areas will need particular attention when fully implementing STEM curriculum with early childhood learners.

While the sample size was adequate for this pilot study, a larger and more diverse group of participants is necessary to generate a more representative data set. This initial study investigated students' abilities to follow directions, demonstrate respect towards others, and compare and contrast pieces of information. In time it was found that while these topics were useful and interesting both in the context of STEM and SEL, they were difficult to quantify and largely too broad. Subsequent studies should focus on the development of more specific measures to generate robust data sets to more precisely portray student growth and learning gains overtime.

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