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STEM Academic Engagement in Young Children with Autism: A Single Case Design Study

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STEM ACADEMIC ENGAGEMENT IN YOUNG CHILDREN WITH AUTISM: A SINGLE CASE DESIGN STUDY

by

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ABSTRACT

The researcher examined the academic engagement in Circle Time activities and STEM (science, technology, engineering, and mathematics) activities for three young children with autism spectrum disorders (ASD) who attended a large Orange County Public School, enrolled in an ASD preschool classroom. Given the increasing number of children diagnosed with ASD each year and many STEM job opportunities for individuals with ASD, it is becoming important to know how young children with ASD learn and engage in STEM activities. Strengths of individuals with ASD in the STEM field have been reported in several research studies (Chen & Weko, 2009; Kirchner, Ruch & Dziobek, 2016; Samson & Antonelli, 2013). Although this study focuses on academic engagement of young children with ASD, there has been limited research investigating the learning in academic activities for this population. Moreover, there is a distinct gap in the literature specific to young children with ASD and the academic engagement in STEM learning. A single case study with an alternating treatment design and three participants was used to investigate the difference in academic engagement of children with ASD in STEM activities compared to Circle Time activities. Data were collected using observations and a social validity questionnaire. Data were analyzed and then presented using a Time Series Line Graph. The results of this study indicated all three young children with ASD had more engaged time during STEM activities than during Circle Time activities. Furthermore, the teacher's social validity questionnaire revealed she strongly agreed that STEM activities were beneficial for children with ASD. Overall, findings from this study gave direction for future studies and intervention programs focusing on improving academic engagement and learning in STEM activities for children with ASD that may support better learning outcomes. Implications and recommendations for teachers of students with ASD were discussed.

This dissertation is dedicated to my loving parents.

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CHAPTER ONE: INTRODUCTION

Background of the Study

Autism spectrum disorder (ASD) is a developmental disability caused by deficits in brain development and characterized by outstanding difficulties in behavior, social interaction, communication, and sensory sensitivities including unusual responses to touch, smell, sounds, sights, tastes, and feel (Centers for Disease Control and Prevention [CDC], 2015). The numbers of children diagnosed with ASD are increasing each year. An estimated prevalence rate of children with ASD is 1 in 68 children (CDC, 2015). In general, this developmental disorder ha affected 1% of the population worldwide (Christensen et al., 2016).

People with ASD tend to have communication difficulties, and they highly rely on routines, are very sensitive to environmental changes, or inappropriately concentrate on unrelated items (Diagnostic and Statistical Manual of Mental Disorders [DSM-5], 2017). Samson and Antonelli (2013) found people with ASD aged between 21 and 48 months scored lower on emotional and interpersonal ability than the control group, but both groups scored highly on intellectual ability as well as restraint strength. In the last decades, the focus of many studies has been on the symptoms and deficits of people with ASD. In contrast, an increasing number of studies have revealed an interest in studying the strengths of people with ASD and their potential in increasing future independence and quality of life (Harzer & Ruch, 2014; Kirchner et al., 2016; Samson & Antonelli, 2013). Strength-focused studies are crucial because they provide valuable information that can inform intervention programs to improve the outcomes in people with ASD (Kirchner et al., 2016).

In 2016, Kirchner et al. conducted a study, and the results were similar to Samson and Antonelli's (2013) study results. Specifically, people with ASD appeared to have high skills in particular areas and their high logical skills were helpful in making decisions where emotions may have been a factor. Moreover, according to the cognitive development theories, people with ASD have better ability to systemize, and this ability is crucial in STEM fields. In accordance with this finding, Chen and Weko (2009) indicated that people with ASD are discovered to have skills that may lead them to success in STEM-related careers.

In recent years, the use of the STEM acronym has become quite popular among many U.S. educators, based upon the demand for high school and college graduates who are better prepared in these areas in order to compete globally (Breiner, Harkness, Johnson & Koehler, 2012). According to a report from National Mobility Equipment Dealers Association (NMEDA) (2015), there will be more than 1.2 million job opportunities in STEM fields by the end of 2018. Furthermore, major software companies, such as Microsoft and SAP, are actively seeking to employ individuals with ASD (NMEDA, 2015). Individuals with ASD share common strengths in attention to details and repetitive work. They also have outstanding logical and analytical skills, which make them suitable for the software testing jobs (NMEDA, 2015).

There is evidence that individuals on the spectrum have a high level of skills to be successful in STEM careers. Several researchers have also indicated that the unique strengths that individuals with ASD have would make them be more likely to gravitate toward STEM fields (Baron-Cohen, Wheelwright, Burtenshaw, & Hobson, 2007; Wei, Lenz, & Blackorby, 2013). For example, they have the ability to hyper focus on a specific analytic task and think systematically and solve problems objectively without any social bias (Baron-Cohen et al., 2007). In addition, they can conceptualize innovative solutions to solve complex problems. Some researchers even indicated that people with ASD were more likely to succeed in those STEM-related fields than the general population (Moore, 2007; Morton, 2001).

Children want to know about the world they live in and eager to make sense of it by their experiments (Keen, 2009). STEM education in early childhood settings has increased rapidly over the past decade (Haden, Jant, Hoffman, Marcus, Geddes, & Gaskins, 2014; Kazakoff, Sullivan, & Bers, 2013). Researchers such as Eshach and Fred (2005) have found a positive relationship between knowledge gained through hands-on experiments and students' further academic performance. In addition, students' scientific skills and scientific attitudes are influenced positively through first-hand experience (Eshach & Fred, 2005). Children are likely to achieve these learning goals when they are provided with hands on experiences and engaged in in-depth exploration of the environment around them (Linderman, Jabot, & Berkley, 2013). Thus, children's natural interests and abilities in science are nurtured by STEM education in early years, and in addition, their academic performance in science and math are improved by their technology and engineering competencies (Soylu, 2016).

Academic engagement can best indicate positive learning outcomes, students' learning motivation, and academic performance (Logan Bakeman, & Keefe, 1997; Mahoney & Cairns, 1997). Further, academic engagement is regarded as an important component in learning and academic achievement for children with or without developmental disabilities (McWilliam & Bailey, 1995; Greenwood, Carta, & Dawson, 2000). Currently, there seems to be agreement based on the previous studies that children with ASD have difficulties in academic engagement with their learning materials and peers (Keen, 2009). After a systematic search for previous literature, the researcher found that limited research investigating the academic engagement of children with ASD in the learning process has been published. Academic engagement plays an crucial part in the quality of education and students' academic achievements, and understanding and measuring young children's academic engagement is a crucial step in providing high quality, effective intervention for this population. To date, no other studies have been designed to investigate the academic engagement of young children with ASD in STEM and Circle Time activities.

Theoretical Framework

This study relied on sociocultural theory and cognitive development theory. Vygotsky's sociocultural theory was directly related to this dissertation research because it stresses both cognitive development and social learning theories. According to Charlesworth and Lind (1999), Vygotsky thought that both environmental and developmental factors contributed to children's cognitive development; and he suggested that the interaction of inside and outside forces worked together to produce new thoughts. Vygotsky's theory had many meaningful implications on children's cognitive and social development through play activity (Morrison, 2004). Morrison believed that children's mental, social, and language development were enhanced in the surroundings through interaction. In this study, the STEM activity was regarded as a learning environment, allowing children with ASD to learn STEM knowledge and interact with peers.

In addition, Vygotsky (1978) indicated that children could learn and develop only through their interaction and work with other people in the same environment. Once this procedure was complete, knowledge could be internalized as children's independent developmental achievement (Vygotsky, 1978). According to Vygotsky (1978), when a child is learning scientific knowledge and concepts, the reflection between his conceptual system and real world objects may occur. For example, if they are learning about counting, simply talking about numbers and math is too abstract for children with ASD; instead, children may learn better by directly counting stones or other real objects to acquire the knowledge.

According to Vygotsky (1978), “The weakness of the scientific concept lies in its verbalism; in other words, an insufficient saturation with the concrete” (p. 169). The STEM activity environment aligns with Vygotsky’s philosophy of linking scientific concepts to their authentic context, and this permits children to form relationships about the scientific concepts to their environment. Moreover, Vygotsky (1978) emphasized his concept of the zone of proximal development (ZPD), which differentiates the area of mental development that can be independently achieved on the child’s own from the area that the child might achieve with the help of an adult or more mature child. Such help is defined as scaffolding. According to Vygotsky’s theory, children learn more in collaboration (Vygotsky, l962). The STEM activity is an optimal environment in which children can learn because they could learn many concepts through cooperation.

The second theory that related to this study is Piaget’s cognitive development theory. The cognitive development of children has four stages, according to Piaget. Those children in the current study are in the second stage of Piaget’s theory of development, which is the preoperational period (roughly 2-7 years old) (Piaget, Gruber, & Vonèche, 1995). During this period of time, based on Piaget’s cognitive theory, children can use symbols to represent objects and can think imaginatively (Piaget et al., 1995). However, children with ASD have deficits in cognition and theory of mind, which means it is difficult for them to imagine things without visual assistance such as pictures and videos. Therefore, showing them the real objects can be of great help for their understanding. According to Piaget et al. (1995), children reach each stage at different pace and time, therefore, it is crucial to provide children with various hands-on activities to allow them to learn new knowledge and develop new skills at their own pace. In the current study, STEM activities with different types of materials for different levels of learning and development were implemented. Children with ASD can learn the knowledge from the teacher as well as from their interactions with peers.

According to Piaget (1973), educators should emphasis the ability of children to observe because children at the ages of four or five have incomplete and distorted perceptions of subjects from previous learning. Therefore, it is possible to suggest that children's misperceptions will be reduced when they are provided with the real natural objects. For instance, if children are learning about a flower and its structure, teachers can simply bring children to the outside garden and allow them to see what a flower looks like. This idea, supported by Piaget, is that the natural environment can nurture, stimulate, and challenge children in various ways (Piaget, 1973). Children themselves are the essential components to learn and construct the cognitive system based on their observations. In conclusion, the idea of this current study draws from sociocultural theory, cognitive theory, and the theory of mind. Figure 1 provides a concept map showing each of the elements of interest and their relationship to the study.

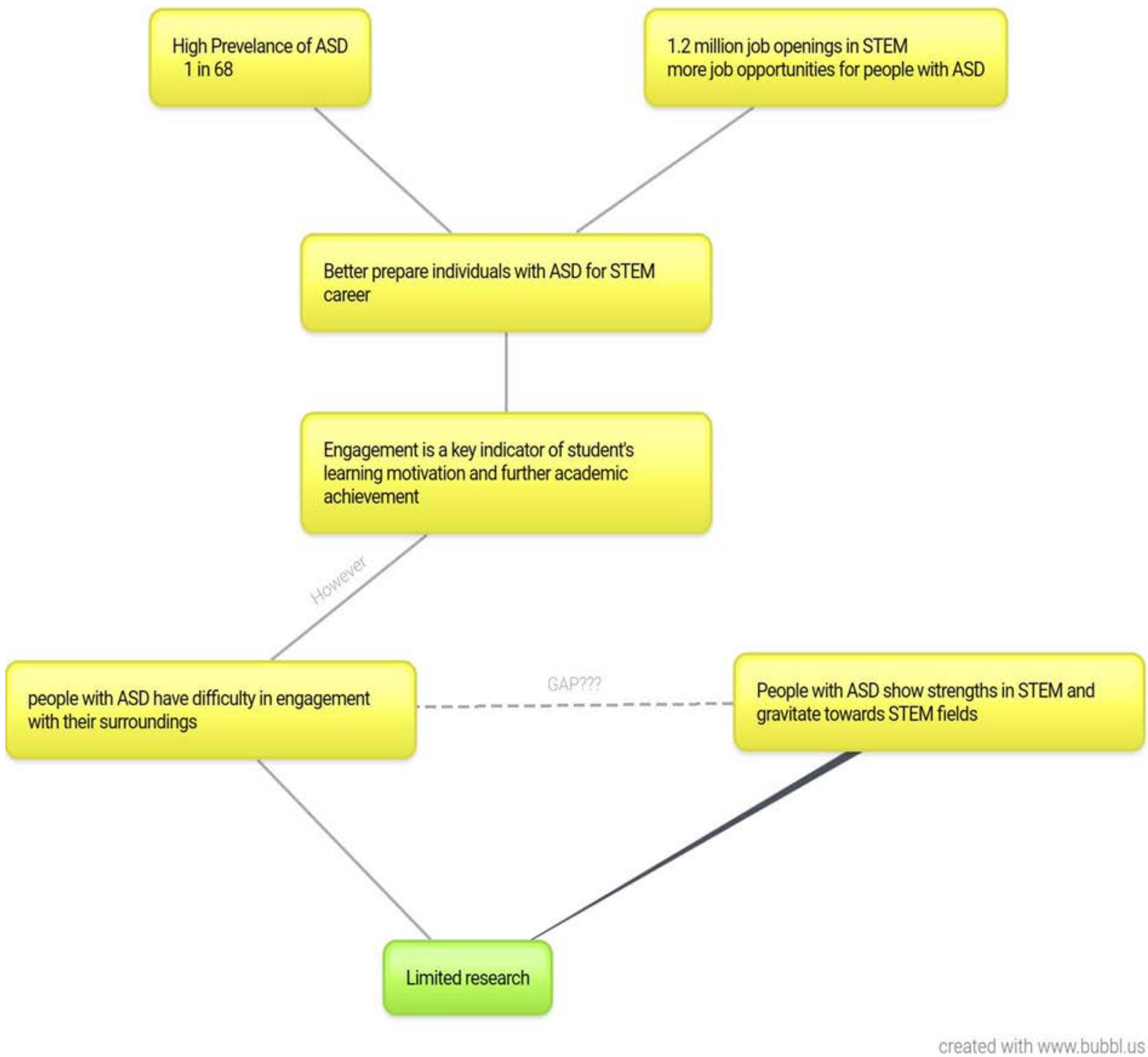

Figure 1. The concept map of each elements and its relationship within this study.

Problem Statement

Currently, due to the globally competitive economy, individuals with STEM competences are in great demand; therefore, it is crucial to make an investment to ensure continuing growth in the number of workers skilled in STEM fields (Chesloff, 2013). The problem this study addressed is the STEM education of young children with ASD in school settings. Any engagement in STEM, no matter if it is at a museum or just in outside environment, has the potential to positively influence children's overall academic performance and their later interest in STEM fields (Chesloff, 2012).

STEM education in early childhood settings has increased rapidly over the past 10 years (Haden et al., 2014; Kazakoff et al., 2013). Researchers have reported and emphasized the need of using appropriate teaching techniques to foster young children's skills (e.g., creativity, collaboration, and critical thinking) in STEM subjects in early childhood programs (Brophy, Klein, Portsmore, & Rogers, 2008; Moomaw & Davis, 2010). Several researchers noted that it is more likely for people with ASD to gravitate toward STEM fields because of their unique strengths (Baron-Cohen et al., 2007; Wei, Yu, Shattuck, McCracken & Blackorby, 2013). Due to more and more people being identified as having ASD, the participation rate of people with ASD in STEM career is increasing as well (Wei et al., 2013). Therefore, investigating learning and academic engagement of children with ASD in STEM is key to their future academic development and even further success in STEM fields.

Purpose Statement

The purpose of this study was to investigate and compare the academic engagement of three young children with ASD during STEM activities and Circle Time activities. Ultimately, the researcher was seeking to increase the interest and academic engagement of children with ASD. According to Charlesworth and Lind (1999), in order to improve cognitive development for children with ASD, interactions of inside and outside forces such as environmental and developmental factors should work together to produce new thoughts. In this study, the STEM activity is regarded as a learning environment that allows children with ASD to learn STEM knowledge and to interact with peers. One significant influence on the learning outcomes of children with ASD is academic engagement (Keen, 2009). However, children with ASD often have lower levels of interest in their surroundings; therefore, a more adult-directed, interest-directed instructional model may optimize learning outcomes. The researcher was seeking to compare the academic engagement of children with ASD during STEM activities with their academic engagement during other activities (Circle Time).

Research Questions

1. Is there a difference in academic engagement of children with ASD in STEM activities and Circle Time activities?
2. What are the teacher's perceptions of the acceptability and treatment effectiveness of STEM activities for her students, as measured by the Intervention Rating Profile (IRP-15)?

Definitions

Academic Engagement

Academic engagement is defined as students participating in class activities actively or passively (Shapiro, 2004). The definition of academic engagement presented here has been modified from Engagement Profile and Scale [SSAT], (Special Schools and Academies Trust ,2010) and the Behavioral Observation of Students in Schools [BOSS] (Shapiro, 2004). Therefore, the academic engagement in this study was defined as follows:

- The child shows response to the teacher (i.e., listening to the teacher, answering questions, raising one's hand)
- The child stays in the area during the activity (i.e., in seat, following directions)
- The child has his eyes on the activity (i.e., writing, reading, looking at the teacher, looking at materials)
- The child appears curious about the activity (i.e., asking questions about activities, showing response to previous knowledge, talking about the activities with teacher/peers, showing desire to learn or make connection)

STEM Activity

STEM is a popular topic in early childhood programs. Educators came to the agreement that STEM advocacy can help students improve mathematical and scientific skills that are necessary in a career, and STEM education should start early--in preschool classrooms (Tippett, 2017). STEM activity varies in different places, with different age groups, and different children. In the current study, the STEM activity has the following characteristics that make the activity unique from other activities. The first characteristic is the STEM activity focuses on real world issues. Young children with ASD are capable to learn and make sense of the world by learning STEM knowledge. Second, the STEM activity exposes children to hands-on experiences and open-ended exploration. Third, the tasks are flexible enough to allow children at different skill levels to acquire STEM knowledge. Moreover, the STEM activity allows children to interact and cooperate with each other to deal with real-world problems. These characteristics of a STEM activity make it unique and beneficial for young children with or without special needs.

Circle Time Activity

Circle Time is a popular activity in preschool classrooms and is a time for students to get together to listen to stories and participate in group activities. In this study, every day there are circle time activities which last for 30 minutes. During Circle Time activities, young children learn numbers, alphabet, weather, colors, five senses, and calendar. This type of activity is more teacher-directed group activity, and students have to follow the rules to interact with others. The teacher, as the leading person, has a great impact on the activity. The teacher dominates the pace of the circle and frequently asks children questions. In the current study, children first reviewed previous knowledge and then learned new knowledge during Circle Time activities. Overall, it is a more traditional, teacher-directed type of teaching.

Significance

This study investigated the academic engagement of young children diagnosed with ASD in STEM activities and Circle Time activities. Children's learning and academic engagement were observed and served as data to answer the research questions. It is known that students with ASD have deficits in academic engagement that could lead to later negative learning outcomes (McWilliam & Bailey, 1995; Wimpory, Hobson, Williams, & Nash, 2000). Moreover, the understanding of academic engagement and its measurement has been limited (Keen, 2009). With many job opportunities in STEM fields for this population, students with ASD need STEM knowledge to support their future STEM careers (National Mobility Equipment Dealers Association [NMEDA], 2015).

The researcher was committed to filling, in part, an existing gap in the literature. The information from this current study illustrated and supported previous literature on the learning and academic engagement of young children with ASD by examining their academic engagement in STEM activities and Circle Time activities. Because previously conducted research to investigate academic engagement of young children with ASD in school settings was limited, the findings from the present study were able to provide suggestions for further study and professionals in special education programs.

CHAPTER TWO: LITERATURE REVIEW

Introduction

This chapter presents a literature review that addresses the purpose and questions of the current study on children with ASD related to STEM potential in early childhood education, early intervention for children with ASD, and strengths of children with ASD that support success in STEM careers. This literature review consists of a review of the broad aspects of ASD and STEM potentials.

First, the prevalence of ASD is reviewed, and the characteristics of individuals with ASD are discussed. Second, the importance of STEM is discussed with support from some previous researchers. A review of potential STEM-related careers for people with ASD, strengths and challenges that individuals with ASD may possess in STEM majors follows. Next, the importance and necessity of early intervention and the need to enhance STEM education at an early stage is discussed. Both state and federal standards related to science education in early childhood are reviewed. Lastly, a discussion on previous interventions is presented, highlighting the evidence to support activity-based curricula for students with ASD. The need to improve academic engagement for young children with ASD, specific to STEM education, is stressed.

During the phase of database searching, the following key words were used to find relevant articles: prevalence of autism, STEM and autism, strength of autism, challenges of autism, activity-based curriculum and ASD, and academic engagement of people with ASD. The academic database ERIC, PsycInfo, and Education Source were searched.

Prevalence of ASD

Over the past decade, more and more individuals have been diagnosed with autism spectrum disorder [ASD] (Christensen et al., 2016). In order to oversee and estimate the population of children with ASD, the Centers for Disease Control (CDC) funded The Autism and Developmental Disabilities Monitoring Network (ADDM) to evaluate prevalence of ASD among individuals living in different areas of the United States (CDC, 2016). In 2016, the ADDM Network reported a continued increasing number of children identified with ASD. Overall, according to the latest prevalence report, 1.5% of children aged 8 year old were identified with ASD (Christensen et al., 2016).

CDC reporting of ASD prevalence revealed statistics have changed dramatically during the past ten years. According to CDC's ADDM Network's 2007 report on 2002 data from 14 communities, 1 in 150 children had ASD. Later, based on CDC's 2009 ADDM Network's report of data from 11 communities, prevalence was 1 in 110 children. In 2012, CDC's ADDM Network reported prevalence at 1 in 88 children, based on 2008 data from 14 communities. Most recently, in 2018, based on 2014 data from 11 communities, CDC's ADDM Network reported 1 in 59 children had ASD (CDC, 2018). ADDM data indicates prevalence of children with ASD has increased rapidly with a 123% increase from 2002 to 2012 (Christensen et al., 2016). In general, late in the second decade of the 21st century, this developmental disorder was affecting 1% of the population worldwide (Christensen et al., 2016).

Characteristics of ASD

ASD is a developmental disability caused by differences in the brain and characterized by outstanding difficulties in behavior, social interaction, communication, and sensory sensitivities including unusual responses to touch, smell, sounds, sights, and tastes (CDC, 2015).

The Diagnostic and Statistical Manual of Mental Disorders (DSM-5) is to assort mental disease by professionals all over the U.S. (American Psychiatric Association [APA], 2013).

DSM-5 (APA, 2013) identified the following symptoms of ASD:

> People with ASD tend to have communication deficits, such as responding inappropriately in conversations, misreading nonverbal interactions, or having difficulty building friendships appropriate to their age. In addition, people with ASD may be overly dependent on routines, highly sensitive to changes in their environment, or intensely focused on inappropriate items. (p. 25).

It is crucial to recognize the symptoms of ASD as they may fall on the spectrum (APA, 2013). Some people demonstrate mild symptoms while others have more severe symptoms (APA, 2013). Severity levels for ASD are indicated in the DSM-5. Level one applies to individuals who require support; people may appear to show decreased interest in social communications and they have difficulty in switching between activities (APA, 2013). Level two includes individuals who require substantial support; within this level, people show limited initiation of social communications or abnormal reactions to social offers from others, and they also show restricted and repetitive behaviors that interfere with functioning in many situations (APA, 2013). Level three is assigned to those who require very substantial support, specifically individuals with ASD who have severe deficits in social commutation skills and extreme difficulty coping with change, which includes severe deficits in communication, and extreme difficulty dealing with change or changing focus (APA, 2013).

Although ASD cannot be cured, early intervention is recommended by the CDC and the National Institute of Mental Health (NIMH) to assist the development of children with ASD (CDC, 2015; NIMH, 2013). In the last decade, the focus of many studies has been on the symptoms and deficits of people with ASD. An increasing number of researchers have revealed an interest in studying the strengths of people with ASD and their potential and in increasing future independence and quality of life (Kirchner et al., 2016; Samson & Antonelli, 2013; Harzer & Ruch, 2014). Strength-focused studies are crucial because they provide valuable information that can inform intervention programs to improve the outcomes in people with ASD (Kirchner et al., 2016).

Samson and Antonelli (2013) found people in the experimental group with ASD, aged 21 to 48 months, scored lower on emotional and interpersonal character than the control group, but both of the groups scored highly on intellectual as well as restraint strength. Kirchner et al. (2016) conducted a study corroborating the study results of Samson and Antonelli's (2013) study, reporting that people with ASD were as intellectually curious, responsible, and hardworking as those in the control group. Kirchner et al. indicated other strengths that people with ASD possessed. Specifically, they found individuals with ASD were fair, as they treated all people the same; and they were creative. In addition, they reported people with ASD appeared to have high skills in particular areas; and they tended to be logical, a characteristic, which may be helpful in making decisions where emotions may play a role (Annual Report, Autism Speaks, 2010).

Importance of Early Intervention and Structured Play Groups

Early interventions are important for young people with ASD who are now in higher education and becoming more independent people (Fein et al., 2013). A short-term intervention was conducted on a group of infants who had already been diagnosed with ASD. After 36 months, the intervention group showed lower level of autism symptomatology and intellectual delay (Volkmar, 2014). This finding suggested that earlier detection and developmentally reformed intervention could have a significant impact on the progress of children with ASD (Volkmar, 2014). Similarly, Voos et al. (2012) supported the finding by asserting early interventions have a significantly positive impact on developmental gains, decrease of autistic symptoms, and social communication activities.

Over the past few years, Structured Play Groups (SPG) have become an intervention to assist young children, age 3 to 5, who were struggling with social interactions and learning in their classrooms (Stone & Stark, 2013). They are designed to promote social ability and to stimulate the "successful resolution of age-appropriate concerns" (Stone & Stark, 2013, p. 28). SPG increased the development of children's social skills and their ability to effectively participate in a classroom environment (Stone & Stark, 2013). Also, structured play groups have the potential to help the young children emerge from those small groups and be able to enjoy being a valued part of a group (Stone & Stark, 2013).

SPG provided various structured activities which were designed to improve the struggling children with both "conformity to group norms and freedom of self-expression" (Stone & Stark, 2013, p. 26). The combination of the two was a lifelong learning and development task (Stone & Stark, 2013). According to Stone and Stark (2013), young children from 3 to 5 years of age were excellent candidates for play groups when there was structure provided for those groups, although children were not fully engaged in the whole process.

Activity Based Curriculum for Students with ASD

From the constructivist point of view, learning is an active process, and students should be active when they learn (Mayer, 2004). Moreover, according to Mayer (2004), active teaching methods such as interactive activities, hands-on experiments, and group discussions were requirements for constructivist learning. Learning should be like an active sense-making process (Agyei & Voogt, 2016), which was different from traditional teaching. The activity-based curriculum was a teaching method that increased student academic engagement in constructing knowledge, and the core concepts included the requirement that learning should occur in hands-on experiments and activities (Agyei & Voogt, 2016). Active interaction with an object helped students construct knowledge and further enabled them to gain higher levels of competence, such as applied problem solving (Agyei & Voogt, 2016).

There were many study findings on the effectiveness of instruction using applied behavior analysis (ABA) to teach children with developmental disabilities (Alberto & Troutman, 2006; Ozen & Yasemin, 2011). Aims in ABA have been teaching new skills or increasing certain behaviors of individuals with developmental disabilities (Ozen & Yasemin, 2011). Researchers have shown that learning normally occurred during the phase of acquisition (becoming able to do), but the effectiveness of teaching skills on other phases such as fluency (perform the behavior easily), maintenance (be able to perform the behavior later on), and generalization (perform the behavior under various situation) was not good (Alberto & Troutman, 2006; Kerr & Nelson, 1998). According to Kurt and Tekin-Iftar, when the teaching methods were used in real settings, the aim of teaching could be realized to be systematic. Moreover, it was also suggested by some researchers that instructions used in natural settings, such as an interactive activity, were more appropriate for inclusive classrooms (Kurt & Tekin-Iftar, 2008; Woods, Kashinath, & Goldstein, 2004).

The report from a national and international evolution have indicated that traditional instruction in teaching mathematics was not effective, and the reason may have been that mathematics teachers often focused on rote learning and formula drilling instead of establishing a deep understanding of mathematics (Yüksel, 2014). According to Mustafa (2011), activity-based mathematics instruction (ABMI) aimed to build a meaningful relationship between mathematics and real-life experience. Yüksel (2014) examined the impact of ABMI on mathematics performance and investigated factors that may have influenced the performance of a group of children aged between 10 to 12 years old. The results suggested that students in the intervention (ABMI) group performed better than the control groups on a fifth grade mathematic achievement test (Yüksel, 2014). In addition to this finding, Yüksel (2014) suggested that the ABMI also contributed to the positive impact on students' attitudes towards mathematics.

Aligned with this finding, Lieberman & Hoody (1998) found that the activity-based curriculum improved students' interest in mathematics. Maqsud (1998) supported these findings by revealing that the activity-based teaching method not only improved students' academic performance in mathematics but also changed students' attitudes towards mathematics. Moreover, Mustafa (2011) asserted that the real-life learning experience turned students' negative attitudes towards mathematics into positive attitudes as well as improved their mathematics achievement.

Mastropieri, Scruggs, and Magnusen (1999) reported their findings after several classroom interventions in science education which included students with various disabilities. A comparison between the activity-oriented classroom and textbook-based curriculum over time was performed, and the results indicated that students reported their preference for the activities-oriented instruction rather than the traditional textbook-based instruction (Mastropieri et al., 1999). In addition, during the activities-oriented instruction, students reported trying harder to learn more knowledge and showed their willingness to choose activities-oriented curriculum over textbook-based curriculum in the future (Mastropieri et al., 1999). The activities-oriented approaches had lower level requirements for language and memory skills (Mastropieri et al., 1999). Activities-based curriculum focused on hands-on experiments and real-life experiences instead of memorizing text knowledge and vocabulary information (Dalton, Morocco, Tivnan, & Mead, 1997). Other studies further supported this finding by indicating that students with disabilities or other special needs found it was not easy to learn under textbook-based approaches because it required higher level of students’ language and memory skills (Bulgren, Deshler, & Schumaker, 1997; Lovitt & Horton, 1998; Mastropieri & Scruggs, 2000).

Activities-based science curricula provided opportunities for students with disabilities to prepare themselves to solve real-life problems and to earn credits for future college education, as well as to start preparing them for science-related careers (Mastropieri et al., 1999). The findings from Mastropieri et al. (1999) provided primary support and evidence for the implementation of activity-based method to teach science knowledge to students with disabilities.

Evidence-base for Structured Play Groups for Children with ASD

Strauss, Esposito, Polidori, Vicari, and Fava (2014) indicated young children with ASD demonstrated better engagement in peer activities under a structured child-oriented intervention condition. Children with ASD demonstrated more social communication with peers, presented more joint attention skills, and eventually were able to start social communications by themselves (Strauss, Esposito, Polidori, Vicari, & Fava, 2014). Studies indicated children with ASD have demonstrated equal number of play behaviors as typically developing peers in structured instruction or when provided with proper prompts (Jarrold, Boucher, & Smith, 1996; Lewis & Boucher, 1988). Teachers must implement proper prompts, at a level that helps guide children to conquer challenges, without limiting children's choices of peer engagement and their chances of social interaction (Strauss et al., 2014).

In their findings, Gunn, Trembath and Hudry (2014) indicated that children who have ASD or other developmental disabilities initiated and responded to typically developing peers more often than to peers with developmental disorders. Tsao, Davenport, & Schmiege (2012) also compared interactions of children with ASD with those of (a) peers with disabilities and (b) interactions with typically developing peers. They found children with ASD engaged in more positive and frequent interactions with typically developing peers and received more positive feedback from them.

In general, if the play groups were strategically structured in certain ways to provide support for preschoolers with or without disabilities, the play groups could be used as an effective tool for fostering the development of young children's ability to gain pleasure from both self-directed activities and group activities (Stone & Stark, 2013).

Engagement in Learning of Children with ASD

Engagement was considered as different concepts in various contexts such as school and work environment. According to different literature, engagement was a multidimensional concept that included cognitive, behavioral, and emotional engagement (Connell & Wellborn, 1991; Fredricks, Blumenfeld, & Paris, 2004; Fredricks, Blumenfeld, Friedel, & Paris, 2002). Emotional engagement included the child's interest in the class or activity, while behavioral engagement referred to "on-task" behavior that showed participation or involvement in a certain class or activity (Keen, 2009). According to Fredricks et al. (2004), the children's engagement in the learning could be best represented by cognitive engagement. This includes eagerness to learn knowledge, willingness to accomplish tasks, self-motivated behavior to reach goals, and self-regulated behavior in learning. In the education context, engagement was one of the best indicators of positive learning outcomes, students' learning motivation and academic performance (Logan et al., 1997; Mahoney & Cairns, 1997). Accordingly, supported by McWilliam & Bailey (1995), high quality engagement with the learning environment played a crucial part in the early years of children.

Children with developmental disabilities have been viewed as engaging less with teachers, their peers, and materials when compared with typically developing children (McWilliam & Bailey, 1995). Also, children with ASD have demonstrated lower levels of academic engagement than children with other types of developmental disabilities (Wimpory et al., 2000). According to Keen (2009), even if children with ASD were engaged, they were often engaged with the materials rather than people around them. This kind of low-level engagement has led to fewer opportunities for children with ASD to gain knowledge when they interact with materials or people around them (Keen, 2009). Consequently, the limited opportunities for children with ASD in learning have led to negative results for their development (Hart & Risley, 1995).

There seemed to be an agreement, based on the previous studies, that children with ASD have deficits in academic engagement; however, the understanding of academic engagement and its measurement is still limited (Keen, 2009). If there is no common understanding on the construct of academic engagement and its measurement, the problem is whether the existing construct is helpful for teachers in their endeavor to promote the learning of children with ASD (Keen, 2009). Chalaye and Male (2014) conducted a study using the Engagement Profile and Scale (Special Schools and Academies Trust [SSAT], 2010). They suggested that academic engagement was so important that it connected students and the environment (e.g. people, materials and ideas) around them in order to make the learning and achievement happened during the process. The Engagement Profile and Scale had six areas as indicators of academic engagement (awareness, curiosity, exploration, discovery, anticipation, initiation) which was designed by SSAT to assist teachers in measuring and recording students' academic engagement in an activity (2010). According to Chalaye & Male (2014), each of the indicators had detailed definition so that practitioners can rate each indicator from 0-4 (0=not engaged, 1=low engaged, 2=partly engaged, 3=mostly engaged, 4= fully engaged) and then summed to produced a total score for each student.

One significant factor on the learning outcomes of children with ASD was their academic engagement (Keen, 2009). Engagement was regarded as an important component in learning and academic achievement for children with or without developmental disabilities (Greenwood, 2000; McWilliam & Bailey, 1995). In 2001, the National Research Council (NRC) recommended that the minimum requirement for children with ASD actively evolved in academic activities was 25 hours per week. Although the definition of academic engagement was described in different ways over the years (Marks, 2000; McWilliam & Bailey, 1995; Newmann, 1992), the shared idea of academic engagement was student participation in academic activities (Keen, 2009). McWilliam and Bailey (1995) expanded the definition of academic engagement by proposing that the total time a child spent on or interacted with the environment at different levels. This type of definition took into account the different kinds of academic engagement (such as with materials, with peers, with themselves or with teachers), and also different levels of academic engagement or "complexity of children's behavior" (Keen, 2009, p. 6).

Kim & Mahoney (2004) conducted an environmental study to find determinants of academic engagement and indicated that academic engagement was influenced by a caregiver's response (for example, directive and controlling). In order to investigate the responsiveness and academic engagement, more studies have been carried out and focused on free play in different settings (e.g., school, home). Findings from those studies showed that adults had more opportunities to be responsive to children and to give children the right to choose their own activities and to participate in the activity based on children's interest s(Kim & Hupp, 2005; Kim & Mahoney, 2004). In addition, Kishida and Kemp (2006) conducted another study by examining different levels of academic engagement of children with developmental delays across a range of activities. The results indicated that children with ASD had better academic engagement in structured activities when compared to other children (Kishida & Kemp, 2006). However, there was limited literature focusing on to what degree teachers should be responsive or directive and how their instruction may influence the level of academic engagement of children with ASD (Kishida & Kemp, 2006).

Interest played a crucial role in students' learning and achievement. Supported by Mc Gee, Morrier, & Daly (1999), early childhood programs that considered children's interest in teaching have been found to have higher levels of academic engagement of children than those programs that relied on teacher-directed instructional strategies. Although interest-directed teaching methods have been advocated in the literature, it is still recommended for intervention programs to implement a more adults-directed and structured teaching model for children with ASD (Lovaas, 1987; Smith, Groen & Wynn, 2000). In fact, children with ASD often had lower levels of interest in their surroundings; therefore, a less adults-directed, more interest-directed instructional model may fail to optimize learning outcomes (Smith, Groen & Wynn, 2000). More studies have investigated the relationship between teacher involvement and student academic engagement (Hamilton, 2005; Kishida & Kemp, 2006; Marks, 2000; McDonnell, Thorson, & McQuivey, 1998;). The results indicated that the more times a teacher interacted with students increased learning engagement, and students with disabilities demonstrated higher levels of academic engagement when they were exposed in small group instruction in contrast to larger group instruction.

A small group teaching model, more teacher involvement, and individuals' interest in materials were related to higher levels of academic engagement and led to better academic performance (Dykstra & Watson, 2015). Some strategies used in regard to instructional models were discussed by various researchers. Carnahan Musti-Rao, & Bailey (2009) conducted a single-case design research study focused on increased academic engagement of children with

ASD in small groups with the help of music and visual interactive materials. Increased academic engagement was also observed during free play under structured teaching (Mavropoulou, Papadopoulou, & Kakna, 2011) and within cooperative learning groups (Dugan et al., 1995).

Importance of STEM Education

In recent years, the use of the STEM acronym had become quite popular among many U.S. educators, based upon the demand for high school and college graduates who were better prepared in these areas in order to compete globally (Breiner et al., 2012). Although employers have been actively looking for STEM workers in recent years, students in the United States were reported as having limited interest and records of academic performance in STEM-related majors (Change the Equation, 2012). Specifically, the U.S. ranked 27th in the world in educating STEM college graduates (Change the Equation, 2012). Thus, there is an urgent call to motivate students in STEM disciplines.

Support for STEM education “is aroused based on the need of raising citizens who can contribute to nations’ economic and cultural competency, in the new information era that we are living” (Soylu, 2016, p. 3). Indeed, developing STEM skills was important at all levels of education and crucial for the future workforce. The 21st century has been driven by technology, creation, and innovation. More and more jobs in the 21st century have required students to deal with real-life problems and also asked them to answer their own questions by applying knowledge in innovative ways (Bybee, 2013).

The U.S. Department of Education’s (USDOE) 1983 national report, *A Nation at Risk*, highlighted concerns that students in the United States were falling below other countries in preparedness for the changing workforce. A *Nation Accountable* was released by the USDOE twenty-five years later. It indicated decreasing numbers of students enrolled in science, mathematics, and engineering majors; low SAT scores; and decreased literacy rates were contributing to rapidly declining competition within the world's global economy (USDOE, 2008). Thus, it was recommended that education initiatives should focus on reform in those areas in order to help students attain the necessary skills and knowledge to compete with their peers in a global economy (Martin et al., 2011). It was suggested that STEM knowledge and skills would be gradually required by most jobs in various areas over the next 20 years (Soylu, 2016). With the development of their economies, many countries all over the world have tried to reform their educational systems in order to improve economic outcomes by ensuring their students' knowledge and skills are competitive with other students in other nations (Organization for Economic Co-operation and Development, 1999). Initiatives have been underway to successfully equip students with an interdisciplinary method to solving problems in STEM as well as to gain knowledge and skills to better adapt to the changing economic environment of 21st century (Sumen & Calisici, 2016).

Standards for STEM (National and State)

National

Based on the Common Core Standards Initiative [CCSI] (2010), national standards for children before kindergarten in STEM education, children should demonstrate competence in four categories (See Appendix A for detailed standard). Under each category, there are some benchmarks. Also, there are expectations for each benchmark. For example, students should show the ability to conduct an investigation on comparing different strengths and the ability to analyze and determine how to change the direction of an object by pushing or pulling (Common Core Standards Initiative, 2010). Moreover, children should demonstrate the ability to observe the effect of sunlight on Earth and find a solution to reduce the warming effect of sunshine on an object (CCSI, 2010). Furthermore, students should demonstrate an understanding of description of plants and animals.

Under the earth and space science standard, students should demonstrate the understanding of local weather conditions and have the ability to describe the change of weather over time (See Appendix A). Students should also show an understanding of the relationship between the needs of plants or animals or humans and the places they live. Within the forth category, engineering design, students should know how to make observations and gather information to solve simple problems by developing a new tool (CCSI, 2010). In addition, students are expected to show the ability to compare two solutions to the same problem and describe the strengths and weakness of each solution (CCSI, 2010).

State

According to the CCSI (2010), Florida standard for STEM education in the VPK program, children should demonstrate mathematical thinking in five areas: number sense, numbers and patterns, geometry, spatial relations (See Appendix A for complete standard). Under each area, there are several benchmarks for each standard. For example, under number sense, children should demonstrate understanding of counting and comprising (e.g., count from 1-15 objects, compare two objects to see if they are equal or fewer or more), ordinal positions (e.g., 1^{st}, 2^{nd}, 3^{rd}), sequence of number names (e.g., count number names up through 31, know the numbers in the range of 10-15). Under the spatial relations, children should show understanding of spatial relationships (e.g., above, below, outside, inside), difference between orientation terms and position form different perspectives (e.g., the apple is on top of the table and the floor is below it). Moreover, children should demonstrate understanding in geometry with several benchmarks: for example, young children should show understanding of three-dimensional shapes (e.g., sphere, cube) and various two-dimensional shapes (e.g., circle, square). Lastly, children should know orders, compare, and describe objects by their characteristics (e.g., unit blocks).

In addition to the mathematical thinking for young children, they also should demonstrate scientific inquiry according to the Florida standards (See Appendix A). Children should show ability in five areas: “investigation and inquiry, physical science, life science, earth and space science, and environmental awareness” (CCSI, 2010, Section: FL.SC.K). Under the area of investigation and inquiry, children should demonstrate the ability to use simple tools for observe ring and investigating, to make comparisons and examine objects (CCSI, 2010). Under the area of life science, children are expected to show the ability to identify the characteristics of living things as well as the five senses; also, they should know how to explore functions of each sense. Furthermore, children also need to demonstrate understanding of outdoor environment such as weather conditions, and ongoing environmental awareness (e.g., reduce, increase) (CCSI, 2010).

STEM Curriculum

The purpose of STEM education has been to equip individuals with the competencies to conduct advanced development (Bybee, 2013). Three outcomes for STEM education have been defined by the National Research Council (2011). The first outcome was an increase in higher level of training and jobs in STEM fields’. The second outcome was an expansion of STEM-related workforce. The final outcome was an increase in scientific literacy. STEM curricula set a good example of interdisciplinary learning that provided a good foundation for 21st century education (Bybee, 2013). More specifically, STEM education has provided environment for students to become active learners who gain knowledge through creative and innovative projects (Bybee, 2013). In general, STEM education relates to real life collaboratively and includes knowledge, skills, and attitudes built at the intersection of multiple STEM–related subjects (Corlu, Capraro, & Capraro, 2014).

From an educational perspective, STEM usually takes place of traditional teaching mode by introducing with a variety of activities (Moomaw & Davis, 2010). One of the primary benefits of implementing STEM has been that it encourages meaningful learning experiences, allowing children to link content knowledge to the real world around them, which can be further strengthened if teachers implement tasks relating to children’s daily lives (Breiner et al., 2012).

STEM education has provided opportunities to transform knowledge into practice (Rodger, 2010). It has been focused on a learner centered approach in which students are encouraged to use problem solving skills and cooperation through hands-on experiments to find solutions for real life problems (Rodger, 2010). In addition to acquiring knowledge, knowing how to apply that knowledge is also crucial for students. Using Stem education, students have been able to apply their science, technology, engineering, and mathematics knowledge to find answers to real life issues (Rodger, 2010).

There is evidence that current educational approaches have failed to educate students to deal with real world problems and that there was also a disconnect among students’ knowledge across different subjects (Bybee 2013; National Governors Association [NGA], 2007). Similarly, Kelley Brenner, & Pieper (2010) indicated that although students gained advanced knowledge of mathematics, they still had difficulties dealing with real world problems. Taraban et al. (2007) reported that despite high-level thinking skill training, many engineering students were still limited to using low-level conceptual knowledge when it came to real world problem solving. The introduction of STEM education was critical if students were to gain necessary skills to figure out solutions for complex real world problems (National Academy of Engineering (NAE) and National Research Council (NRC), 2014). Furthermore, researchers have shown that applying a STEM approach to designing engineering activities and to teaching mathematics has improved student learning outcomes (Cantrell, Pekcan, Itani, & Velasquez-Bryant, 2006; Schnittka & Bell, 2011; Wendell & Rogers, 2013). In addition, the learning process for students has not only been about “what” and “how,” it has also been concerned with the “why” STEM knowledge was required (Fan & Yu, 2017). Students have been expected to implement their high-level thinking skills to turn STEM knowledge into practice (Fan & Yu, 2017).

Early Childhood and STEM

STEM education in early childhood level fits perfectly with young children’s natural learning habits (i.e., asking question, cooperating with others, and testing new ideas through play) (Corroll & Scott, 2017). Similarly, according to Van Meeteren and Zan (2010), science activities have centered on play, providing mentally and developmentally engaging ways for children to learn STEM knowledge naturally in the early-childhood years. During the early years, STEM education should focus on topics that are attractive to young children such as scientific literacy, sports, games with peers, and scientific phenomena (Corroll & Scott, 2017). Obviously, young children are interested in and eager to solve problems and to find solutions when the phenomena is related to their everyday lives. From discussing problems and solutions with teachers and peers, children gain deep understanding of the solving process and the real world around them (Van Meeteren & Zan, 2010).

STEM education has been an important component in early childhood programs because it blends nicely with students' natural interests and curiosity about the world around them; it helps build positive attitudes toward discipline and also provides a foundation for their future STEM learning and understanding (Eshach & Fred, 2005). Therefore, children's interests should be considered when planning appropriate STEM education in early childhood settings. Suggestions have been made by many researchers stating that STEM education at the early childhood level should focus on what children know about and what they are interested in learning; moreover, instructions should provide scaffolding to improve their understanding and reasoning skills (Furtak, Seidel, Iverson, & Briggs, 2012; Leuchter, Saalbach, & Hardy, 2014; Trundle & Sackes, 2012).

During the past ten years, STEM education in early childhood settings has increased dramatically (Haden et al., 2014; Kazakoff, Sullivan, & Bers 2013). Researchers have identified the need to emphasize science, mathematics, technology, and engineering in schools, especially starting in early childhood programs, to cultivate students' creativity, critical thinking, and collaboration skills by implementing a developmentally appropriate approach (Moomaw & Davis, 2010). Researchers have found a positive relationship between knowledge gained through hands-on experiments and students' further academic performance (Eshach & Fred, 2005). In addition, students' scientific thinking and their attitudes towards science could be influenced positively (Eshach & Fred, 2005).

In the past, people mistakenly thought that preschoolers lacked the foundational intellectual abilities to understand, to process, and to predict (Katz, 2010). However, children have been found to be likely to achieve these learning goals when they are provided with hands on experiences, engaging in in-depth exploration of the environment around them (Linderman et al., 2013). Similarly, children's early STEM hands-on experiences allow them to explore and experiment in various ways with everyday materials, and this experience contributes to their later academic success and social development (Katz, 2010). STEM education in early childhood programs fits perfectly with young children's interests and curiosities in science, and it improves their academic performance by implementing technology and math (Soylu, 2016).

Need to Enhance STEM Education at Early Childhood Level

Chesloff (2012) observed that any engagement in STEM, no matter if it was in school, in an outdoor classroom, or at a museum, had the potential to improve children's overall academic performance as well as enhance their later interest in STEM fields. According to a Change the Equation (2010) survey, approximately 30% of Americans had been found to be more interested in cleaning their bathroom than doing a mathematics problem. Due to the globally competitive economy, workers skilled in science, technology, engineering, and mathematics were in great demand and thus it was crucial to make an investment to ensure growing numbers of workers skilled in STEM competencies (Chesloff, 2013). The best way to ensure such investment, according to Chesloff (2013) was to start fostering these skills in early childhood programs because the core of STEM education (creativity, curiosity, and critical thinking) are naturally embedded in young children.

Chesloff also commented on the positive effect of high-quality PreK on children's performance in later studies and future employment. Specifically, he believed it had the potential to reduce the rate of children being held back a grade by 50%; increased high school attendance and college attendance by 30% and 80%, respectively; and increased employment by 23% (Chesloff, 2013). He also believed it was important and beneficial for young children to build and stimulate their inner natural curiosity to explore, to build, and to question through high quality early childhood learning environments (Chesloff, 2013). Early Education for All (2015) suggested that early mathematics and logic achievements were predictors for future development of young children aged 1-4, as children in this age group are particularly skilled in learning science and math. Furthermore, in 2009, in an effort to educate skilled workers in STEM fields, the government of Massachusetts created a state STEM plan to ensure the implementation began in early childhood programs and continued into higher education (Chesloff, 2013).

The possibilities of STEM education in early childhood education programs have not been fully explored (Tippett & Milford, 2017). One of the reasons is that teachers have not had enough knowledge and understanding of how much knowledge preschoolers have about science (Brenneman, 2011; Park Rogers, 2011). Little time has been spent on STEM subjects in early childhood programs. According to Horizon Research (2013), science only accounted for 19 minutes in a typical day in the PreK program to third grade level, but students spent 89 minutes in language arts and 54 minutes in mathematics. However, STEM experience at an early stage was crucial and regarded as starting points for supporting young children to be successful in STEM in the future (Tippett & Milford, 2017). This statement has been supported by other researchers' findings that the quality of STEM experience of a young child before six years old has a great impact on their later academic success (Campbell, Pungello, Miller-Johnson, Burchinal, & Ramey, 2007; Hadzigeorgiou, 2002).

It would be more comfortable for young children in their later lives if they were exposed to science at an early stage during their childhood (Dejonckheere, De Wit, Van de Keere, & Vervaet, 2016). In addition, according to Brenneman (2011), early positive STEM experience have been considered to be important for school readiness as well as foundational for future learning. Van Schijndel, Singer, Van der Maas and Raijmakers (2010) conducted an inquiry-based program as an intervention for STEM education, and they collected pre- and post-test data on children's exploratory play during a six-week period. The results indicated the guided exploratory play improved young children's (aged 2-3 years old) spontaneous exploratory behavior significantly (Van Schijindel et al., 2010).

In another study, French (2004) assessed the effectiveness of the ScienceStart program, which included different activities to investigate science material and scientific phenomena. French found that young children showed significant improvement in receptive knowledge of science words and the understanding of science concepts regarding weight, shade, color and air (French, 2004). French believed it was crucial to bring children into the scientific environment that provides rich experience and various language, suggesting that STEM education at the early childhood level should be in an experience-rich environment that helps young children better understand scientific language and concepts. He believed that this rich experience learning environment provided opportunities for young children to communicate with adults and to improve their acquisition of knowledge and language (French, 2004).

Dejonckheere et al. (2016) conducted research on the inquiry pedagogy in teaching science for young children four to six years of age. The intervention consisted of 15 activities so that the young children in the experience groups could explore different scientific phenomena from the control group (Dejonckheere et al., 2016). After seven consecutive weeks, the results revealed that children in the treatment group demonstrated more spontaneous exploratory science activities in general compared to the control group (Dejonckheere et al., 2016). Furthermore, children showed more occasions of investigation on target objects than did the control group, and they demonstrated more willingness to learn new information by setting up experiments (Dejonckheere et al., 2016). In addition, teachers asked questions when children were exploring and encouraged them to reflect; therefore, a deeper level of understanding and learning was encouraged by implementing a scaffolding approach. In this way, children were encouraged to predict what would happen next or what would happen if other things occurred (French, 2004). Successful learning involves making connections between different areas of knowledge and understanding subjects across contextual settings (Joshua, 2013).

Strengths of Individuals with ASD Related to STEM

Researchers have examined the general population in STEM fields; however, few studies have been focused specifically on STEM education for students with ASD (Wei et al., 2013). The cognitive development theories suggested that people with ASD have greater ability in systemizing than empathizing (Piaget, 1973). Systemizing skills were important for further success in STEM related areas (Wei et al., 2013). Indeed, many popular hypotheses revealed that people with ASD were more interested in STEM, and research findings also indicated that people with ASD were more likely to gravitate towards those STEM-related fields than the general population (Moore 2007; Morton 2001).

Several researchers further indicated that those unique strengths that individuals with ASD have would make them more likely to succeed in STEM fields (Baron-Cohen et al., 2007; Wei et al., 2013). For example, they have the ability to maintain hyper focus on a specific analytic task; and they can think systematically and solve problems objectively without any social bias. Also, they can conceptualize innovative solutions to solve complex problems (Wei et al., 2013). Furthermore, people with ASD have been recognized as high-ability learners in the areas of STEM (Wei et al., 2013).

Due to more and more people being identified as ASD, STEM participation among people with ASD has increased; also, people with ASD have responded better to STEM subjects than the general population (Wei et al., 2013). Such findings also suggest that this could be one reason for the higher participation rates of people with ASD in STEM fields (Wei et al., 2013). Studies showed that people with ASD have been successful in postsecondary education if they are provided with proper support and guidance (VanBergeijk, Klin, & Volkmar, 2008). Unfortunately, about 68% of students with ASD have not been accepted into higher education, or they dropped out after a period of time (Wei et al., 2013).

Many of those diagnosed with ASD in the early 21^{st} century have been reported to have higher readiness for higher education than those in the past (Hart, Grigal, & Weir, 2010). If the hypothesis that people with ASD have higher interests in STEM and more high-functioning ASD are identified, the population of people with ASD in the STEM-related fields is more likely to increase (Wei et al., 2013).

Challenge of Individuals with ASD Related to STEM

According to Wei et al. (2013), although people with ASD tend to choose a STEM-related major, they ranked overall lowest college enrollment rates among all disability categories. Wei et al. (2013) explained that the mental functioning skills at a very early stage play a crucial role in future postsecondary enrollment and suggested low college enrollment rates may be due to the lack of basic level of mental functioning skills in people with ASD.

Social communication difficulties in people with ASD have created the biggest problem and have had a major vocational impact (Hagner & Cooney, 2005; Hillier, Campbell, Mastriana, & Izzo, 2007; Patterson & Rafferty, 2001). Wei et al. (2013) indicated that people with ASD had strengths in systemizing and memorizing. This could be one of the reasons to explain the results that, although students with ASD may gravitate toward STEM, their college enrollment rates were lower than other 11 disability groups (such as Down syndrome, Asperger syndrome) and students in the general population (Wei et al., 2013). Therefore, although the strengths of people with ASD assist them in developing STEM-related skills, their deficits in social interactions made it difficult for them to adapt to a traditional college environment or a work environment (Wei et al., 2013).

Communication deficits in people with ASD include having difficulty in understanding directions; they often fail to recognize facial expression, emotion, tone of voice; and as noted by Hurlbutt and Chalmers (2002), they are more likely to communicate in an inappropriate way. There are many potential careers related to STEM for people with ASD; however, their deficits in social communication and cognitive abilities have hindered them from having positive relationships with their peers and building professional relationships with their colleagues (Wei et al., 2013).

Moreover, cognitive deficits of people with ASD affect their job performance (Hendricks, 2010). The impairments in executive functioning could lead to difficulties in task execution for this population (Hume & Odom, 2007; Landa & Goldberg, 2005; Lopez, Lincoln, Ozonoff, & Lai, 2005; Patterson & Rafferty, 2001). Even though the IQs of people with ASD may be at or above average, they are likely to face difficulties with both problem-solving and organization (Barnhill, 2007). Furthermore, behavioral difficulties of individuals of ASD could also lead to an employment barrier such as tantrums and aggression (Berkman & Meyer, 1988; Burt, Fuller, & Lewis, 1991; Kobayashi & Murata, 1992). Burt et al. (1991) found people with ASD might experience a higher level of anxiety due to their sensory problems in the workplace. Moreover, according to Hendricks (2010), experiencing stress and anxiety of people with ASD in working environment could interfere with their performance.

Potential of STEM Career for Individuals with ASD

Careers in STEM fields have rather quickly begun to replace many manufacturing jobs, offering a unique opportunity for many people with ASD (Kaku, 2011). People with ASD have discovered they have skills that lead them to success in STEM-related careers (Chen & Weko, 2009). According to the National Mobility Equipment Dealers Association [NMEDA] (2015), there are more than 1.2 million job opportunities in STEM fields at the time of the present study. Major software companies, such as Microsoft and SAP, have actively sought to employ individuals with ASD (NMEDA, 2015). Many individuals with ASD shared common strengths in attention to detail and repetitive work and have outstanding logical and analytical skills, which made them suitable for software testing jobs (NMEDA, 2015). Baron-Cohen et al. (2007) saw individuals with ASD who possess these common strengths as potentially excellent candidates for many STEM-related career positions.

The idea that people with ASD were inclined to choose STEM-related majors and employment has been supported by researchers (Moore, 2007; Morton, 2001). Individuals with ASD have been reported to have lower enrollment rates in college than other developmentally delayed groups (e.g., hearing impairment, learning disabilities), but the participation rate of this population has been reported as the highest among all groups (Newman, 2007). Studies have been focused on the rate of people with ASD in STEM fields among the general group and a higher prevalence of individuals with ASD in STEM fields has been found (Jarrold & Routh 1998; Wheelwright & Baron-Cohen, 2001). Moreover, in 2007, Baron-Cohen (2007) studied 792 young adults at the University of Cambridge and found that students with ASD had a greater prevalence in STEM majors than other brain disorder groups.

Researchers have also found a relationship between social skills and STEM-related skills in young people with ASD (Banda & Kubina 2010; Donaldson & Zagler 2010). However, according to Wei et al. (2013), conversational skills did not relate to the college enrollment rates or STEM-related majoring rates. They further analyzed their data and explained that young people with ASD having high level of functional skills were able to be successful at the college level, even though they demonstrated relative deficits in social skills (Wei et al., 2013).

The cognitive development theories suggested that people with ASD tended to be better at systemizing than empathizing (Wei et al., 2013). According to Baron-Cohen et al. (2007), the above average ability of systemizing of people with ASD contributes to their successful performance in many STEM-related fields and also explains why individuals with ASD gravitate toward STEM subjects than other disability groups and the general population. Chen and Weko (2009) revealed their examination of Statistics in Brief data and demonstrated that the percentage of young people with ASD in STEM disciplines was higher than 10 other disability groups, specifically 22.8% higher than the general population. They also found young people with ASD were more likely to focus on science (12.12%) than general population (8.3%) and on computer science (16.22%) than the general population (6.6%) (Chen & Weko, 2009).

Summary

High quality academic engagement was considered as an important indicator for positive learning outcomes and better academic performance (Mahoney & Cairns, 1997). However, people with ASD were reported having difficulties academically due to low levels of academic engagement (Keen, 2009). As discussed previously, individuals with ASD have strength in STEM fields and more job opportunities are open to this population. Thus, it is important to know how individuals with ASD learn and engage in STEM classes during early years. To date, no researchers have specifically investigated the academic engagement of young children with ASD in STEM activities. Further, there is a lack of literature about young children with ASD that supports increased academic engagement in class activities, specifically in the STEM area. Finally, there is a gap in the research specific to the learning and performance of young children with ASD in STEM fields.

CHAPTER THREE: METHODOLOGY

Introduction

This chapter describes the methodology for the study. The chapter is comprised of the following seven sections: (a) research design, (b) research questions, (c) sample and recruitment, (d) variables, (e) instrumentations, (f) data collection and procedures, and (g) data analysis. Prior to initiating the study, in November 2017, the researcher obtained an exempt determination letter from the Institutional Review Board (IRB) from University of Central Florida (See Appendix B).

Research Design

A single case design using alternating treatment was implemented to answer the research questions which guided the study. Single case design has commonly been used in education and psychology to test the success of a treatment on a particular group of people and to examine the treatment effectiveness using a small sample size (Kazdin, 2016). Moreover, the alternating treatment design has been used successfully in applied behavioral analysis which has been characterized by a rapid and frequency alternation of conditions (Barlow & Hayes, 1979). This design was chosen as the method in this study because it can be used to investigate and explore whether a treatment is working or failing with a certain group of people within a human service setting (Roll-Pettersson, Olsson, & Ala'i-Rosales, 2016).

This single case study using alternating treatment design was used as a method of collecting data and evidence through observations, which allowed the observer to investigate the differences in academic engagement of the three young children with ASD during STEM activities and Circle Time activities. After six weeks of observation, a social validity questionnaire was given to the teacher to obtain her perspectives and suggestions on the STEM activities and students' academic engagement. In the current study, STEM activities were provided every Tuesday and Wednesday from 10:30-11:00, and Circle Time activities were provided twice everyday: (a) in the morning from 9:30-10:00 and (b) in the afternoon from 12:15-12:45. Observations of STEM activities and Circle Time activities were alternated each session. During the first week, on Tuesday, the researcher observed the Circle Time activities at 9:30 and the STEM activities at 10:30. On Wednesday, the researcher started with STEM activities at 10:30 and observed the Circle Time activities at 12:15. During the second week of observation, on Tuesday, the researcher started with STEM activities first and then followed with Circle Time activities. On Wednesday, the observation started with Circle Time activities at 9:30 followed by the STEM activity at 10:30. During the following weeks, the researcher repeated these steps to make sure STEM activities and Circle Time activities were randomly assigned for each day. The observation lasted six weeks, and 12 data points were collected for this study.

Research Questions

1. Is there a difference in academic engagement of children with ASD in STEM activities and Circle Time activities?
2. What are the teacher's perceptions of the acceptability and treatment effectiveness of STEM activities for her students, as measured by the Intervention Rating Profile (IRP-15)?

Sample and Recruitment

The current study was carried out at a public elementary school in the southern United States. Within the elementary school, there was a PreK ASD classroom. This classroom was equipped with different materials for daily teaching activities and was used for young children with ASD. Three young children aged 3-4 diagnosed with ASD participated in this study. Participants were identified through the principal of this elementary school. The researcher contacted the principal's office to seek opportunities to conduct the study in this school and received full approval. The selection was determined based on the following criteria: (a) children should be between the ages of 3-5 years old, (b) students should possess basic verbal communication skills, (c) students should come to school every day and stay for the whole school day, and (d) students should not have any other disabilities.

In total, there were 5 male children in the PreK ASD classroom. One of the students had visual impairment and no verbal skills. Another boy barely interacted with anyone and/or anything. Therefore, these two children were not included in this study. The remaining three male children diagnosed with ASD were chosen for this study. Once the three children were identified, the IRB exempt letter was obtained (Appendix B), a consent form for parents was distributed and returned. Each child was assigned a pseudonym to maintain confidentiality. Demographic data for the three participants is provided in Table 1, and the following paragraphs briefly describe the three participants within this study.

Table 1

Participant Demographic Data

Name	Gender	Age	Race	Primary Exceptionality
Yoni	Male	3.5	Hispanic	ASD
Luke	Male	3	Asian	ASD
Andy	Male	3.5	White	ASD

Participant 1: Yoni

Yoni was a 3.5-year-old male student with Hispanic background in the PreK ASD class. He was identified with ASD before he came to the Camelot Elementary School based on the results of evaluation. He had difficulty staying focused on an activity and completing a job. Yoni was willing to interact with people but limited verbal skills hindered him from expressing himself and communicating with others. The art activity was his favorite. He was good at following directions but had difficulty in creative thinking. These behavioral issues made him difficult when participating in activities and engaging in learning.

Participant 2: Luke

Luke was a three-year-old Asian male student who was also enrolled in the PreK ASD class. He was identified as having ASD based on evaluation before he came to school. His personal characteristics were different from Yoni's as he was not willing to interact with people. Luke had difficulty making eye contact and had sensory issues. These problems potentially interfered with his learning. He did not possess language impairment, but he rarely talked using long sentences. His favorite activities were physical education classes and computer sessions. Luke was easily distracted by his peers during activities, and he was often found licking his palms due to the sensory issues. The teacher had to remind him several times to bring back his attention during the class.

Participant 3: Andy

Andy was a 3.5-year-old, male student of White background in the PreK ASD class at Camelot Elementary School. He was diagnosed with ASD based on evaluation a few months before participating in this study. He was previously diagnosed with other developmental disorders by a pediatrician at the age of two. Andy preferred to stay by himself. He refused to talk to strangers and always observed the surrounding situation before approaching other people. He shared common autistic symptoms such as repetitive behaviors, no interest in soundings, unusual habits, uncooperative behavior, and transitioning difficulty. Andy needed a lot of attention from the teacher and assistance to transit from activity to activity. He enjoyed video clips, music, and games on iPad.

Independent Variables

In this current study, independent variables were Circle Time activities and STEM activities. The classroom teacher provided both types of activities for the three young children with ASD. Two conditions are described and defined as below:

Condition 1: STEM Activities

STEM activity varies in different places, different age groups, and different children. In this study, the STEM activities were provided twice a week by the classroom teacher. It was a small teacher table instructional mode with the teacher-to-student ratio at 1:3. STEM activity in this current study has the following characteristics that make the activity unique from other activities. The first characteristic is that the STEM activity focuses on real world issues. Young children with ASD are capable to learn and make sense of the world by learning STEM knowledge. Second, the STEM activity exposes children to hands-on experiences and open-ended exploration. Third, the tasks are flexible enough to allow children at different skill levels to acquire STEM knowledge. Moreover, the STEM activity allows children to interact and cooperate with each other to deal with real-world problems. The lesson plans, an example of which is contained in Appendix C, were designed and prepared by the classroom teacher.

Condition 2: Circle Time

Circle Time activity is commonly seen every day in preschool classrooms. In this current study, the Circle Time lasted for 30 minutes every morning. During Circle Time activities, young children have opportunities to learn numbers, alphabet, weather, colors, five senses, and calendar. This type of activity is a more teacher-directed group activity, and students have to follow the rules to interact with others. The teacher, as the leading person, dominates the pace of circle and affects the activity. Overall, it is a more traditional, teacher-directed type of teaching. Appendix D contains a sample lesson plan. Usually, there was one leading teacher, one assistant, and seven students participating in Circle time, and the teacher-to-student ratio was 2:7.

Dependent Variable

The dependent variable for this study was academic engagement. For this study, the operational definition of academic engagement was modified from Engagement Profile and

Scale (Special Schools and Academies Trust [SSAT], 2010) and the Behavioral Observation of Students in Schools [BOSS] (Shapiro, 2004). Specific observable behaviors included:

- The child shows response to the teacher (i.e., listening to the teacher, answering questions, raising one's hand)
- The child stays in the area during the activity (i.e., in seat, following directions)
- The child has his eyes on the activity (i.e., writing, reading, looking at the teacher, looking at materials)
- The child appears curious about the activity (i.e., asking questions about activities, showing response to previous knowledge, talking about the activities with teacher/peers, showing desire to learn or make connection)

Instrumentation

For this study, the researcher developed and used the Time Sampling Data Collection Form (Appendix E) to track students' academic engagement during STEM and Circle Time activities. This form was developed and modified based on an existing one (Goodenough, 1928). The form called for a seven-minute observation period with five 10-second intervals (total of 50 seconds) for each child during each activity. Within each 10-second interval, the researcher circled "E" if the child was observed showing any of the academic engagement indicators or circled "NE" if the child was not showing any academic engagement indicators. After the 50-second observation, there was a 10-second break for the researcher to take additional notes. All the academic engagement indicators were clearly defined for the researcher. In addition, a free app from Apple Store called *SIT* was used to keep track of time. The app beeped every 10 seconds to remind the researcher that it was time to switch to the next 10-second interval.

Data Collection and Procedures

Data collection began immediately after receiving the IRB exempt letter in November 2017 and the permissions from school principal, classroom teacher, and parents. The researcher and the inter-observer started with the training and officially continued the data collection. Data collection lasted for six weeks. During each week, two STEM activities (30 minutes each) and two Circle Time activities (30 minutes each) were observed. In order to rule out the factor of possible differences of morning and afternoon performance, all the observations on STEM activities and Circle Time were alternated each session and recorded based on the definition of academic engagement by using Time Sampling Data Collection Form. As stated in the research design section, the researcher alternated the observations of these two types of activities. During the first week, on Tuesday, the researcher started observing the Circle Time activity at 9:30 and then observed the STEM activity at 10:30. On Wednesday, the researcher started with STEM activity at 10:30 and then observed the Circle Time activity at 12:15. During the second week, the researcher started with STEM activity at 10:30 and then observed the Circle Time activity at 12:15 on Tuesday. On Wednesday, the researcher started with Circle Time activity at 9:30 and then observed the STEM activity at 10:30. During the following weeks, the researcher repeated these steps to make sure these activities were randomly assigned for the observations.

Table 2
The Observation Schedule for Each Week

	Day	
Week	**Tuesdays**	**Wednesdays**
1	Circle Time STEM activity	STEM activity Circle Time
2	STEM activity Circle Time	Circle Time STEM activity
3	Circle Time STEM activity	STEM activity Circle Time
4	STEM activity Circle Time	Circle Time STEM activity
5	Circle Time STEM activity	STEM activity Circle Time
6	STEM activity Circle Time	Circle Time STEM activity

A total of 21 minutes was devoted to effective observations, resulting in seven separate observations per session per child per activity. Because only 21 minutes within the 30-minute activity was observed, the researcher and inter-observer normally started the collection five minutes after the activity began. The researcher conducted a time sampling for five 10-second intervals with 10-second breaks (one minute per child) to take notes and then switched to the next child. Similarly, the researcher collected data on the second child during five 10-second intervals with 10-second breaks and then switched to the third child. After collecting data on the third child, the researcher came back to observe the first child, repeating the same routine. During the observation of each child, the researcher coded the observation as “Engaged” if the student was engaging in the activity (e.g., The child showed response to the teacher, the child stayed in the area during the activity, the child had his eyes on the activity, the child appeared curious about the activity) and “Not Engaged” if he was not showing any of the academic engagement indicators previously mentioned.

Data Analysis

The analysis procedure in this study consisted of two parts: (a) observation of students’ academic engagement and (b) the Social Validity Questionnaire.

Analysis of Student Academic Engagement

Visual analysis is often used in single case research (Gast & Spriggs, 2010). The instrument, Time Sampling Data Collection Form, was used to report each participant’s academic engagement rate across activities over time. Data were collected and calculated. The variability in the percentage of academic engagement in STEM activities and Circle Time activities for each participant was analyzed and reported through visual graphs. A Time Series Line Graph was made to provide results of the observation. According to Kubina, Kostewicz, Brennan, & King (2017), visual representations have played an instrumental role in behavior analysis. The line graphs provide the overall trend over time that allow researchers to perceive trends and patterns easily (Wang, Han, Zhu, Deussen, & Chen, 2016). For the current study, the analysis was focused on the comparison between different time series line graphs. The changes of the line graphs were reported and analyzed and are discussed further in Chapters 4 and 5. In addition, the percentage of non-overlapping data (PND) for each participate in STEM activities and Circle Time activities was calculated to assess effect size.

Percentage of Non-Overlapping Data (PND)

According to Gast (2010), the percentage of non-overlapping data (PND) reflects the percentage of data overlap between two conditions. The percentage of non-overlapping data is useful to determine if a change in data points occurred from one condition to another (Gast, 2010). This form of data is commonly used in single subject design to present the effect size of the study. Generally speaking, the higher the percentage of non-overlapping data, the more significant difference between the two situations. The current study was a single case study with alternating treatment design; therefore, there was a difference in alternating treatment design for the calculation of percentage of non-overlapping data (Gast, 2010). In a single case study with alternating treatment design, the researcher is seeking a consistent difference of data points between two conditions (Gast, 2010). Each data point is compared. For example, the first data point in condition A and condition B are compared; then the second data point in condition A compares with the second data in condition B; and this continues until all the data points are compared accordingly.

In this study, the percentage of non-overlapping data was compared and calculated between two conditions (STEM activities and Circle Time activities) across all three participants. According to Gast (2010), the PND data below 50% can be considered as unreliable treatment. If the percentage falls between 50% and 70%, it reflects questionable effectiveness. If the percentage ranges from 70% to 90% it can be considered fairly effective. When the percentage is above 90%, the treatment can be considered high effective.

Validity and Reliability

Inter-observer Agreement (IOA)

In single case design, multiple observers can offer benefits for the researcher and the inter-observer agreement is important to present the "true picture" of the study (Gast, 2010). In the current study, the researcher provided an independent set of data and the inter-observer provided another independent set of data. According to Gast (2010), the high level of inter-observer agreement increases readers' confidence in the observational data and reported behaviors. Without the highly consistent agreement between multiple human observers, the basis for the results of certain interventions or behaviors is invalid (Gast, 2010). The most common measurement in single case design is to collect observational data point by point (Gast, 2010). This study used this point-by-point method to compute the degree of inter-observer agreement.

Two persons, one doctoral candidate and one graduate student, were involved in the data collection during the six weeks of observation. The primary researcher was a doctoral candidate who had taken many classes at graduate and doctoral level that were related to the education field. The graduate student served as the inter-observer for this study. She was a master's degree student in an early childhood development and education program at UCF and also served as a graduate assistant for the program. To prepare for the use of the Time Sampling Data Collection Form, the inter-observer was trained by the researcher for two school days before the data collection started. The inter-observer practiced the collection procedure on each child during both STEM activities and Circle Time activities. In total, the inter-observer participated in six practice sessions. According to Gast (2010) the degree of data collection by inter-observer should range from 20% to 33% of the total observation session. After practice sessions, the inter-observer came to the classroom as scheduled four times during the twelve observation sessions, which was 33.3% of the whole observation. During the four observation, the inter-observer remained for the entire sessions and collected data on each child for both activities. Table 3 displays, using circled shaded areas, the times when both the primary researcher and the inter-observer were in the classroom collecting data.

Table 3

Inter-observer's Schedule

Week	**Day**	
	Tuesdays	**Wednesdays**
1	Circle Time STEM activity	STEM activity Circle Time
2	STEM activity Circle Time	Circle Time STEM activity
3	Circle Time STEM activity	STEM activity Circle Time
4	STEM activity Circle Time	Circle Time STEM activity
5	Circle Time STEM activity	STEM activity Circle Time
6	STEM activity Circle Time	Circle Time STEM activity

The researcher calculated the total agreement after data collection. The total number of agreed data was divided by the total observed data points and multiplied by 100. The agreement was computed at 94% after the collection was complete. The inter-observer agreement of each activity across students was reported and is illustrated in Chapter 4.

Social Validity

Wolf (1978) introduced social validity to the Applied Behavior Analysis field to examine whether an intervention was effective in a program. Wolf (1978) highlighted three focus areas for the social validity questionnaire: goal, procedure, and results. In order to answer Research Question 2, the researcher administered a social validity questionnaire which was given to the classroom teacher after all the observations were complete. The social validity questionnaire, Intervention Rating Profile [IRP-15] (Appendix F) is an existing instrument (Martens, Witt, Elliott, & Darveaux, 1985). The IRP-15 is a 15-item single-factor scale that has been used to assess intervention acceptability. It is a self-report survey which consists of 15 six-point Likert Scale type questions. For the current study, no major changes were made to items in the IRP-15. However, minor wording changes were made as appropriate to the current study.

After completion of the data collection sessions, the classroom teacher was queried regarding her opinions on children's academic engagement in STEM activities. Specifically, the teacher was asked to share to what extent she either agreed or disagreed with the 15 statements. The teacher indicated her answers by circling the number that most closely reflected her opinion. Levels of agreement ranged from 1 to 6 indicating from "strongly disagree" to "strongly agree."

Based on the feedback from the IRP-15, the teachers' social validity questionnaire, the researcher was able to determine the academic engagement of children with ASD during STEM activities and Circle Time activities from the perspective of the classroom teacher. The results of the analysis of the social validity questionnaire responses are reported in Chapter 4 and discussed in Chapter 5.

CHAPTER FOUR: RESULTS

Introduction

The purpose of this single subject study was to investigate and compare the academic engagement of young children with ASD during Circle Time and STEM activities. The results are reported based on the observation from three young children with ASD and a questionnaire from the classroom teacher in an ASD PreK classroom in central Florida. This chapter is organized to answer the following research questions:

1. Is there a difference in academic engagement of children with ASD in STEM activities and Circle Time activities?
2. What are the teacher's perceptions of the acceptability and treatment effectiveness of STEM activities for her students, as measured by the Intervention Rating Profile (IRP-15)?

Research Question 1

Is there a difference in academic engagement of children with ASD in STEM activities and Circle Time activities?

In order to address this research question, the percentage of academic engagement time in two types of activities for all three young children with ASD was calculated. The percentage of academic engagement during each activity was calculated by dividing the academically engaged time by the total time of an activity, then multiplying it by 100. Overall, all three participants with ASD showed higher percentages of academic engagement during STEM activities compared to their academic engagement during Circle Time activities. Among all three participants, there was one child who had two days during which the percentage of his academic engagement in Circle Time activities was higher than the percentage in STEM activities. Other than these two days, he was better engaged in STEM activities. Time Series Line Graphs of overall academic engagement for the three participants are shown in Figures 2, 3, 4, for visual analysis of the study. A detailed report of the results for each child follows. For the consideration of confidentiality, a pseudonym was assigned to all three children.

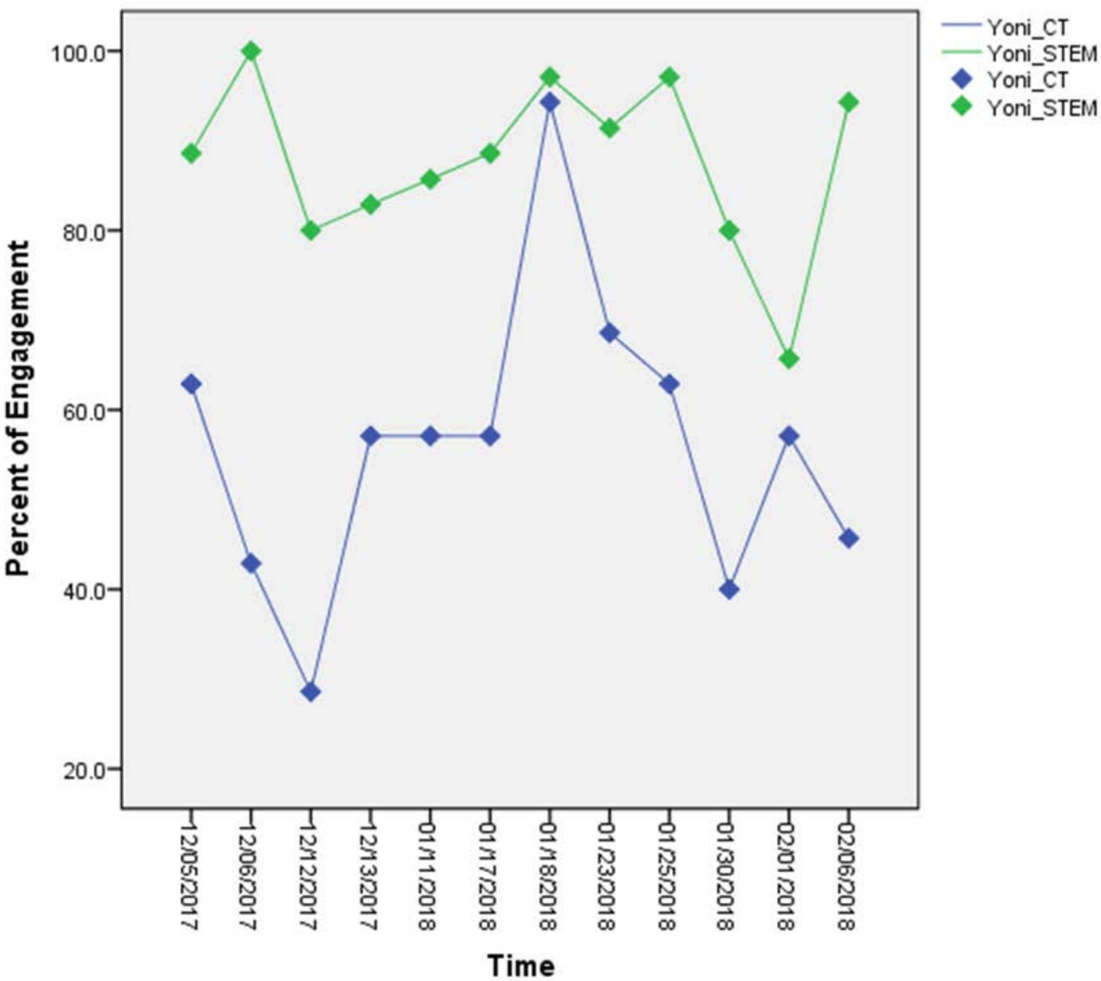

Figure 2. Yoni's percentage of academic engagement in Circle Time and Stem activities

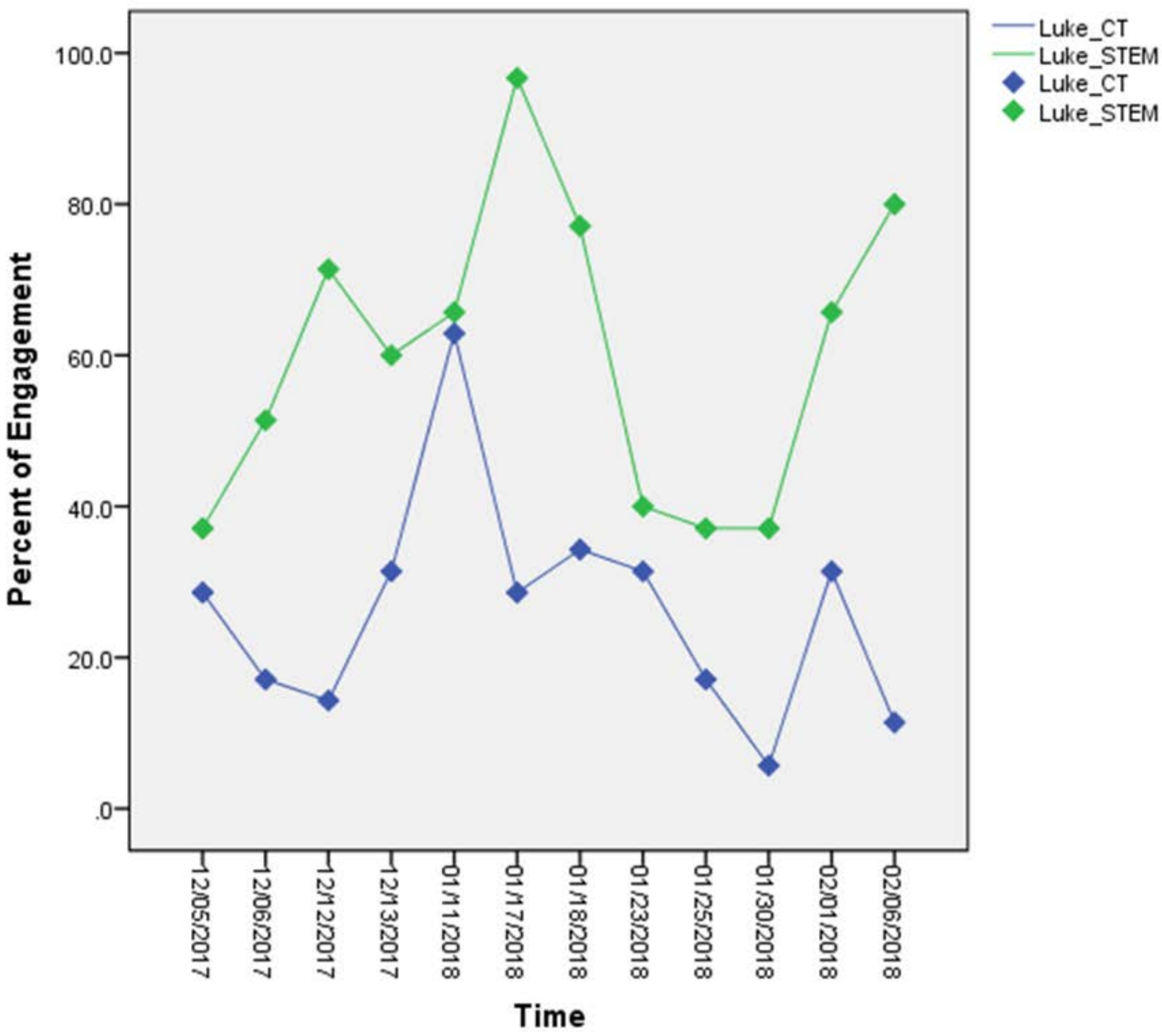

Figure 3. Luke's percentage of academic engagement in Circle Time and STEM activities.

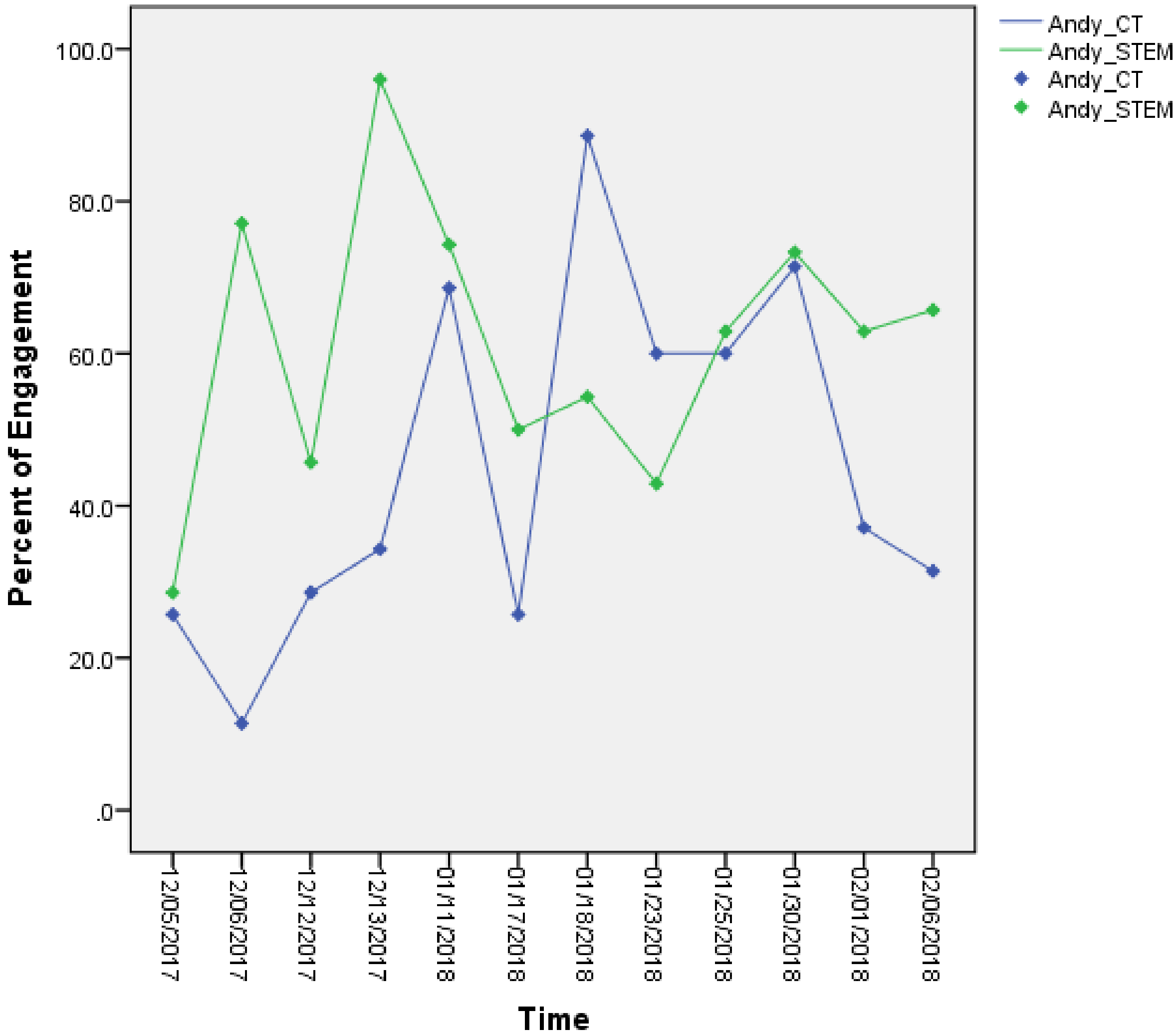

Figure 4. Andy's percentage of academic engagement in Circle Time and STEM activities.

Yoni

Figure 2 reveals results of the analysis regarding Yoni's academic engagement during STEM activities and Circle Time activities. Yoni's academic engagement in Circle Time activities was poorer than in STEM activities in general. The data points for Yoni were stable for most of the time except one day when he reached the highest percentage of academic engagement at 94.3% in Circle Time activity. His lowest percentage of academic engagement was recorded during the third time of observation, which was approximately 30% during Circle Time activity that day. Most of Yoni's values were around 60%, and they dropped to 50% for a few days. The percentage of Yoni's academic engagement during Circle Time activities ranged from 28.6% to 94.3%. Overall, the mean value for Yoni's Circle Time academic engagement was 56.2%.

In contrast, he had a higher percentage of academic engagement in STEM activities than in Circle Time activities. The data pattern looked stable during 12 observation days, indicating that all his observed academic engagement during STEM activities was better than was the time during Circle Time activities within the same school day. On one of the 12 days, Yoni showed 100% academic engagement in STEM activities. Also, most of Yoni's academic engagement percentages in STEM activities were above 80%, and there were only two days when his percentages of academic engagement dropped below 80%, but they were still above 60%. The percentages of Yoni's academic engagement during STEM activities ranged from 65.7% to 100%. Overall, the results of the analysis indicated a mean value of 87.6% for Yoni's STEM activities academic engagement.

Luke

Figure 3 shows the results of the analysis of Luke's academic engagement in STEM activities and Circle Time activities during the six weeks of observation. The overall result for Luke was similar to those of the first child, Yoni. A total of 12 data points were collected for the second child, Luke. As seen in Figure 3, all percentages of Luke's academic engagement in STEM activities were higher than the academic engagement in Circle Time activities. However, the data points were not as stable as Yoni’s. The data and results in Circle Time activities for Luke showed a low level of academic engagement, as most of his academic engagement values were close to 30%. In addition, there were five days when Luke’s academic engagement rates in Circle Time activities were below 20%, with one day when the value was even below 10%. The visual analysis of the data results indicated that the percentage of Luke’s academic engagement during Circle Time activities ranged from 5.7% to 62.9%. Overall, the mean value of Luke’s academic engagement in Circle Time activities over the six weeks of observation was computed at 26.1%.

The visual analysis of the data pattern of STEM activities revealed the percentage of academic engagement fluctuated significantly over time. The value of his academic engagement in STEM activities ranged from 37.1% to 96.7%. Most of Luke’s academic engagement rate fell between 40% and 80%, except the highest academic percentage on one day at 96.7%.

Andy

Visual analysis (see Figure 4) of Andy’s data pattern indicated that most of his academic engagement rates in STEM activities were higher than they were in Circle Time activities. By reviewing the data pattern, two days of overlapping data were noted in the middle of the observation period. The Time Series Line graph does not show stability over time on the percentage of academic engagement for either STEM activities or Circle Time activities. There was no increasing or decreasing trend detected in the academic engagement rates during Circle Time activities or STEM activities in a visual inspection. Most of the time, Andy’s academic engagement in Circle Time was stable because he engaged better when there was familiar music playing. On one of the days, Andy was engaged for 88.6% of the whole activity time. On another day, he was almost disengaged for the whole session and the percentage of academic engagement was computed at 11.4%. While watching a video for Circle Time activities on the day when he had the lowest academic engagement rate, Andy became upset and started crying due to the new songs and content in the video clips. Andy was upset easily when there were new activities presented, especially new songs in the Circle Time videos. Therefore, he had a difficult time engaging in the activities and became sad. In addition, from observer's notes, Andy's percentage of academic engagement in Circle Time activities was highly influenced by the videos played on that day. On those days when he had lower academic engagement rate, there was new content and new songs in the videos. On the days he had 88.6% academic engagement rate, he knew and he was familiar with all the songs for the Circle Time. The percentage of Andy's academic engagement during STEM activities ranged from 11.4% to 88.6%. Overall, the analysis results of the mean value on all data points demonstrated 45.2% for Andy's Circle Time activities academic engagement.

There were two overlapped data points, which means Andy had higher percentages of academic engagement in Circle Time activities than in STEM activities on those two days. In general, the data pattern of stability was not seen across time. Andy's academic engagement rate during STEM activities fell between 28.6% and 77.1% over time. On the first day of observation, he had the lowest academic engagement rate during STEM activities at 28.6%, but on the fourth day of observation, a 77.1% academic engagement rate was reported. With the exception of these two days, all his academic engagement rates in STEM activities were between 40% and 80%. Overall, the mean level of Andy's academic engagement rate in STEM activities over 12 school days was 61.1%.

Inter-observer Reliability

After the six weeks of observational data were collected, the researcher calculated the IOA using the following equation. The total number of agreed upon data divided by the total of agreements and disagreements and then multiplied by 100.

$$\frac{\text{Agreements}}{\text{Agreements} + \text{Disagreements}} \times 100\% = \text{Percentage of Agreement}$$

Figure 5. Equation for calculation of percentage of agreement for all three participants.

Inter-observer agreement was calculated across all participants four times in this study. The percentage of inter-observer agreement for Yoni was as follows: 93% during Circle Time activities, with a range from 91% to 94%; 97% during the STEM activities, with a range from 94% to 100%. The percentage of inter-observer agreement for Luke was as follows: 94% during Circle Time activities, with a range from 86% to 100%; 92% during STEM with a range from 89% to 91%. Next, the percentage of inter-observer agreement for Andy was as follows: 95% during the Circle Time activities and it ranged from 91% to 100%; 93% during STEM activities, with a range from 86% to 100%. Overall, the mean percentage of IOAacross participants was 94% for Circle Time activities and 94% for STEM activities (see Table 4). According to Gast (2010), the satisfied percentage for inter-observer agreement is 80%.

Table 4

Mean and Range of Inter-observer Agreement (IOA) Across Activities and Participants

IOA Measurement	Participant Means (Range)			Mean Across Participants
	Yoni	Luke	Andy	
Circle Time	93% (91%-94%)	94% (86%-100%)	95% (91%-100%)	94%
STEM Activity	97% (94%-100%)	92% (89%-91%)	93% (86%-100%)	94%

<u>Non-overlap Data</u>

All three young children's mean percentage of academic engagement during Circle Time activities and STEM activities were calculated, and the percentage of non-overlapping data was computed as well. As reflected in Table 5, the results of Yoni's mean value in Circle Time activities and STEM activities were 56.2% and 87.6%, and the calculation for Percentage of Non-overlapping Data was 100%. Next, the results of Luke's mean scores in both types of activities were 26.2% and 60%, and the percentage of non-overlapping data was 100%. Lastly, the mean score of Andy's academic engagement during both activities were 45.2% and 61.1%, and the percentage of non-overlapping data was 83.3%. Overall, the total percentage of non-overlapping data across all three young children was 94.4%.

Table 5

Mean Scores of Participants and PND Scores

Student	Circle Time	STEM activities	Total PND
Yoni	56.2%	87.6%	100%
Luke	26.2%	60.0%	100%
Andy	45.2%	61.1%	83.3%
Mean Across Participants	42.5%	69.6%	94.4%

Note. PND = Percentage of non-overlapping data.

Summary of Research Question 1 Results

During the six weeks of observation, all three young children with ASD were observed twice a week during Circle Time activities and STEM activities. The Circle Time in this observed classroom was a more traditional way of teaching with teacher-oriented style. In contrast, the STEM activities were conducted within small groups and contained hands-on experiences. All three participants demonstrated a relatively stable data pattern with lower percentages of academic engagement in Circle Time activities than in STEM activities. It is important to know that all three children identified with ASD may need level 2-substantial supports (APA, 2013). Based on the visual analysis, all three young children were reported to have higher percentages of academic engagement during STEM activities than during Circle Time activities. Although two participants (Yoni and Luke) showed no overlapped data points in two conditions, Andy demonstrated two days of overlapped data points that lowered his total percentage of non-overlapping data. Overall, all three participants demonstrated better academic engagement in STEM activities than in Circle Time activities.

Research Question 2

What are the teacher's perceptions of the acceptability and treatment effectiveness of STEM activities for her students, as measured by the Intervention Rating Profile (IRP-15)?

Summary of Research Question 2 Results

The results of the analysis of the teacher's opinion of the STEM activities, as measured by the Intervention Rating Profile (IRP-15) are reported in Table 6. The analysis revealed that 6 items were rated as Strongly Agree; 8 items were rated as Agree; and 1 item was rated as Slightly Agree. Therefore, the classroom teacher expressed her agreements on the positive relationship between STEM activities and children's academic engagement; also, she indicated her strong agreement as to the further implementation of STEM activities in her classroom. In summary, she thought the STEM activities were beneficial for children with ASD. Furthermore, the teacher noted that she did believe that children with ASD had strength in STEM fields, and ways used in STEM activities were appropriate to help them engage in activities. She also indicated that she would continue providing STEM activities for her students if she could. Overall, survey answers from the classroom teacher indicated positive results for the outcomes of STEM activities and students' academic engagement.

Table 6

Social Validity: Classroom Teacher Survey Results

Statement	Response
This is an acceptable intervention for Children with ASD and their academic engagement	5
Most teachers would find this intervention appropriate for behaviors as well as the one identified.	5
This intervention should prove effective in changing the child's	4
I would suggest the use of this intervention to other teachers.	5
Most teachers would find this intervention suitable for children with ASD identified.	5
I would be willing to use this intervention in the classroom setting.	6
This intervention would not result in negative side effects for the child.	6
This intervention would be appropriate for a variety of children.	6
This intervention is consistent with those I have used in classroom settings	6
The intervention is a fair way to handle the children’s academic engagement	6
This intervention is reasonable for children with ASD identified.	5
This intervention is a good way to handle a	5
The children’s autistic symptoms and academic engagement issues are severe enough to warrant the use of this intervention	5
I like the procedures used in this intervention	5
Overall, the STEM activities would be beneficial for the children with ASD	6

Note. Agree = 4; Slightly Agree = 5; Strongly Agree = 6.

CHAPTER FIVE: DISCUSSION

Introduction

This chapter contains a summary of the study, conclusions, recommendations, and implications for future studies. First, the purpose of the study, the methodology used to conduct the study and the data analysis results on each child is reviewed. Next, a discussion on previous studies and the current study is presented. Finally, limitations and recommendations for teachers and future research are discussed.

Purpose of the Study

As stated in Chapter 1, children have been diagnosed with ASD are increasing every year. According to the CDC (2018), an estimated prevalence rate of children with ASD was 1 in 59 children at the time of the present study. Therefore, it is very important for teachers and parents to utilize evidence-based studies to improve academic performance for this population. STEM education has become quite popular among many educators in the US. The National Mobility Equipment Dealers Association [NMEDA] (2015) projected that there would be more job openings in STEM fields by the end of 2018. Furthermore, major software companies, such as Microsoft and SAP, have begun to actively seek to employ individuals with ASD (NMEDA, 2015). In addition, researchers have found individuals on the spectrum have a high level of skills needed by those in STEM careers and have suggested that people with ASD have unique strengths that would make them more likely to choose STEM fields (Baron-Cohen et al., 2007; Wei et al., 2013). Therefore, there is a need to enhance STEM education starting at a very young age.

Academic engagement is regarded as an important component in learning and academic achievements for children with or without developmental disabilities (McWilliam & Bailey, 1995; Greenwood, 2000). The majority of this ASD population have demonstrated less academic engagement and a lower level of academic engagement with their teachers, materials, and peers (Keen, 2009; Corsello, 2005; Wimpory et al., 2000). This kind of low-level academic engagement leads to fewer opportunities for this population to learn and practice when they are interacting with surroundings (Keen, 2009). Consequently, limited opportunities for individuals with ASD in learning can result in serious results in their development (Hart & Risley, 1995). To date, the understanding and measurement of academic engagement has been somewhat limited (Keen, 2009). Because there was no common understandings and measurement of academic engagement, it is questionable if the existing construct is helpful for teachers in their endeavor to help the learning of children with ASD (Keen, 2009).

Shapiro (2004) defined academic engagement as students participating in class activities actively or passively. In addition, the Engagement Profile and Scale was designed by Special Schools and Academies Trust (SSAT) to assist teachers in measuring and recording students' academic engagement in an activity (Chalaye & Male, 2014). The present study was designed to examine the academic engagement of young children identified with ASD using the modified Engagement Profile and Scale. Specifically, this study was conducted to investigate and compare the academic engagement of young children with ASD during STEM activities and Circle Time activities. This study also added to the examination of STEM education procedures and their potential impact on academic engagement of young children with ASD.

A single case design using alternating treatment was implemented to investigate and compare the academic engagement of young children with ASD during STEM activities and Circle Time activities. The participants were three young children with ASD (ages 3-4) who were enrolled in a PreK ASD classroom. The dependent variable was the percentage of academic engagement time of young children with ASD in daily academic activities. The independent variable was the Circle Time activities (teacher-oriented and large group) and STEM activities (hands-on experiment, small teacher table, and discussion-oriented).

Procedures

For this study, a package of STEM activities was developed for use by the classroom teacher in transmitting science and mathematics knowledge to her students identified with ASD. A total of 12 STEM activities were implemented in the PreK ASD classroom by the teacher. Small teacher table STEM activities were provided followed by an initial discussion of the topic. The teacher used a structured lesson plan to teach, conducting STEM activities for 30 minutes each time. Similarly, the classroom teacher provided 30 minutes' Circle Time activities by using the projector every day. All three young participants were provided with STEM activities at the same time, and all were observed for six weeks. Within this single case study using alternating treatment design across participants, alternate activity schedules were conducted on different observation days. During the six weeks of observation, each participant demonstrated a stable data pattern, and all three children showed better academic engagement in STEM activities, with the report of percentage of non-overlapping data at 94.4%.

All three young children were exposed to STEM activities and Circle Time activities equally each session, and data collection of children's academic engagement was observed for 21 minutes within each 30-minute activity. Because there was an inter-observer in this study, the inter-observer agreement (IOA) across activities and participants was calculated to illustrate the agreement among the researcher and the inter-observer. Overall, the mean values of inter-observer agreement across participants during Circle Time activities and STEM activities were both reported at 94%.

Data Analysis

A data collection form called Time Sampling Data Collection Form was developed to collect observed behaviors of academic engagement across different activities for each of the participants. The results of each child's academic engagement in STEM activities and Circle Time activities were shown in time series line graphs within the alternating treatment design format. Visual inspection was used in analyzing the data points and patterns. Changes in mean, trend, and level were reported and discussed across all participants. In addition to the visual analysis from the time series line graph of results for each child, the percentage of non-overlapping data for each student during STEM activities and Circle Time activities was calculated to evaluate effect size. The percentage of non-overlapping data was computed and reported at the average value of 94.4% across all participants.

Research Question 1

Is there a difference in academic engagement of children with ASD in STEM activities and Circle Time activities?

The purpose of the first research question was to investigate if the academic engagement of three young children with ASD had any differences in STEM activities and Circle Time activities. As stated in Chapter 4, the findings of this investigation revealed that there was a difference in the academic engagement of the participating children with ASD in STEM activities and Circle Time activities. All three young children demonstrated higher percentages of academic engagement in STEM activities than in Circle Time activities, which suggested all participants were more fully engaged during STEM activities. Therefore, the results can be interpreted as the STEM activities having had a positive impact on academic engagement for all three participants. Although one of the participants (Andy) had two days of overlapped data points, the total mean value of academic engagement rate in STEM activities was higher than the rate in Circle Time activities. All of the percentages of academic engagement in STEM activities were higher than the academic engagement percentages in Circle Time activities for the other two participants (Yoni and Luke).

Yoni

Yoni had the greatest percentage of academic engagement in Circle Time activities and STEM activities among all three participants. Yoni sustained his academic engagement rate in Circle Time activities at an average of 56.2% and in STEM activities at an average of 87.6%. Both average academic engagement rates were higher than the mean value across all participants. During the STEM activities, he was excited and curious about what was to be taught. As described earlier, the STEM activities were provided twice a week. The teacher normally started the activities with a brief discussion on previous knowledge and then introduced new content of the day. Yoni was able to answer most of teacher’s questions during discussion that were related to previous knowledge and stay focused the entire 30 minutes. Hands-on experiments were not challenging for him, and he was comfortable and willing to play the materials during experiment time. Furthermore, he performed well when the teacher asked him to work with other students on an experiment. He was also able to stay focused if he had to work on his own project. There were some moments when he was confused and could not understand what the teacher was saying, but he still paid attention and responded well. Sometimes, he lost focus on participation because the content was too difficult for him or he was tired.

During Circle Time activities, Yoni was also able to participate for about 30 minutes. The difference was that Circle Time activities were provided every day with all seven students present. Students were familiar with the videos shown, and most were able to sing along. Yoni performed well during Circle Time, but he was easily distracted by other students sitting beside him. While watching the Circle Time videos, he often became distracted, and the teacher had to remind him to watch and focus on the video. Overall, Yoni's Circle Time activities academic engagement rate (56.2%) was lower than his STEM activities academic engagement rate (87.6%); but both were higher than the mean scores of all participants. Moreover, the percentage of non-overlapping data was reported at 100%.

Luke

Luke was another participant in the current study with sensory issues. Similar to Yoni, Luke sustained his academic engagement rate in Circle Time activities at an average of 26.2% and in STEM activities at an average of 60%. Both average academic engagement rates were higher than the mean value across all participants, but Luke showed a distinct difference in the percentage of academic engagement between Circle Time activities and STEM activities. During STEM activities, Luke showed interest in what was being taught and was able to stay focused for a certain period of time. He was more interested in color sorting, shape matching, and Lego building, but he was in need of his teacher's directions or hints to complete the job. Furthermore, he had sensory issues that made touching the experiment materials difficult. Initially, he refused to grab blocks but then got used to it. While participating in a science experiment, Luke had a hard time touching water and brush, and the teacher had to assist him. These sensory issues may have influenced Luke's academic engagement in STEM activities.

It was noted that Luke was a quiet little boy, as he barely talked to anyone during the six weeks of observation. During Circle Time activities, he was easily distracted by other students or the teacher's assistants. Therefore, he was reminded by the teacher many times to watch and focus on the videos. As was stated earlier, he showed familiarity with Circle Time videos, but no obvious reaction was observed. Sometimes, he was able to point at the right location of letters and numbers, but he had difficulty in performing specific academic engagement indicators (e.g., awareness, curiosity, discovery and investigation) during the activity. Overall, Luke's STEM activities academic engagement rate (60%) was greater than his Circle Time activities academic engagement rate (26.2%); but both were lower than the mean scores across all participants. The percentage of non-overlapping data for Luke was reported at 100%.

Andy

Andy's data pattern was the least stable among all three participants. Visual analysis of his data points suggested that he had higher percentage of academic engagement in STEM activities than in Circle Time activities. Although he had two data points that overlapped, his performance of academic engagement was calculated at an average of 61.1% in STEM activities and 45.2% in Circle Time activities. Based on the visual inspection of Andy's line graph on both activities over time, it was difficult to interpret the trend of his data. Given the lack of stable data pattern from visual analysis either during Circle Time activities or STEM activities, there may have been some other factors at work. During the STEM activities, he was more engaged when there were more hands-on activities provided. Unlike the other two participants (Yoni and Luke), Andy did not show excitement or curiosity about what was being taught. Also, he was quiet and did not like to talk. However, he enjoyed sorting blocks by color and building different shapes with the blocks. Although he showed no obvious reaction during the beginning discussion, he started focusing and engaging once all materials were presented. Because the STEM activities were provided at a small teacher table, normally there were two students in the activity at the same time. The observer noticed that Andy demonstrated better academic engagement when there was one-on-one teaching mode. It is crucial to note that Andy had difficulty in changing routines. As described in Chapter 3, STEM activities were provided only two days a week instead of every day, and Andy had difficulty in transitioning from other activities to the STEM activity. This factor may have had an impact on his STEM activities academic engagement results. In contrast, however, Andy's academic engagement rate (45.2%) in Circle Time activities was above the average value (42.5%). During Circle Time activities, videos were played for most of the time. Andy liked music so he was focused and engaged when the video was played with music. The children watch the videos almost every day; thus, he was familiar with them. He was very excited each time and danced and sang along. Overall, due to the two overlapped data points, the PND was reported at 83.3% for Andy.

The change in academic engagement percentage was observed from Circle Time activities to STEM activities for three students. In summary, all three participants in this study were reported having better academic engagement rates in STEM activities than in Circle Time activities; and the mean percentage of non-overlapping data was reported as highly effective (94.4%) across participants.

Research Question 2

What are the teacher's perceptions of the acceptability and treatment effectiveness of STEM activities for her students, as measured by the Intervention Rating Profile (IRP-15)?

The second research question was designed to report the results of social validity of STEM activities implementation. The survey, the Intervention Rating Profile (IRP-15) was sent to the teacher to assess her perceptions regarding the procedures and outcomes of STEM activities and the current study. The classroom teacher reported positive social validity results. Answers from the teacher's questionnaire suggested that STEM activities were important and valuable for her students with ASD. She also strongly agreed that STEM activities were not only suitable for children with ASD but also appropriate for a variety of children. In terms of the outcomes of STEM activities, she strongly agreed that they were reasonable and acceptable for children with ASD and their academic engagement. The teacher also reported that she felt most teachers would find STEM activities suitable for children identified with ASD. It is worth noting that she only slightly agreed that STEM activities were effective in changing academic engagement of children with ASD. During conversation, she stated that she was not confident about improving academic engagement by just implementing STEM activities because of Andy's performance. Overall, however, she expressed positive attitudes toward continuing to provide STEM activities in her future classes. She indicated she liked the procedure used in STEM activities and thought those activities would be beneficial for children with ASD.

Connection to Previous Research

The findings of the study indicated a distinct difference in academic engagement of children with ASD in STEM activities and Circle Time activities. All three participants demonstrated better academic engagement in STEM activities than in Circle Time activities. This finding was consistent with previous studies in which children with ASD demonstrated gravity toward STEM and were more likely to be in STEM fields (e.g., Baron-Cohen et al., 2007; Moore, 2007; Morton, 2001; Newman, 2007). In addition, more results were reported by Jarrold and Routh (1998) and Wheelwright and Baron-Cohen (2001) that there was a higher prevalence of people with ASD in STEM related fields. The results of this current study also provided foundational background for previous researchers who reported people with ASD had greater aptitude toward systemizing ability that contributed to their successful performance in STEM careers (Baron-Cohen et al., 2007; Wei et al., 2013). According to the findings from Chen and Weko (2009), participation in STEM related fields of young people with ASD was 22.8% higher than the general population in STEM careers. In addition, young people with ASD had a higher concentration on science than general population (12.12% vs. 8.3%) (Wei et al., 2013). This finding can be supported by this study that individuals with ASD were inclined toward STEM related knowledge at an early stage, and that may lead them to choose STEM careers later in their lives.

The STEM activities provided in this current study followed an activity-based curriculum that allowed children to experiment with scientific materials on their own. The hands-on experiments by students could be counted as one of the reasons for their better academic engagement in STEM activities than in Circle Time activities. This was in line with previous studies of Mustafa (2011), Yukel (2004), Lieberman and Hoody (1998) and Maqsud (1998), who have posited that activity-based mathematics instruction (ABMI) contributed to the positive impact on student's attitudes towards mathematics and could improve student's interests and performance in this area. Aligned with this, Mastroppieri et al. (1999) suggested that students with disabilities have difficulty in learning under the traditional teaching method, and activity-based curriculum provided opportunities for this population to be prepared for future college education as well as science-related jobs.

An interesting finding from the present study revealed that children with ASD tended to be more engaged when a familiar song was played. This finding was supported and aligned with previous research findings that the use of music and songs in teaching may provide an engaging environment for children with ASD that led to positive learning outcomes (Carnahan, Basham, & Musti-Rao, 2009; Carnahan et al., 2009). There are many studies that have demonstrated that music had been used in different academic activities for typical or atypical children in order to build up various targeted behaviors, such as social interactions, attention, and proper educational behaviors (Chatzipanteli, Pollatou, Diggelidis, & Kourtesis, 2007; Derri, Tsapakidou, Zachopoulou, & Kioumourtzoglou, 2001; Kern, Wolery, & Aldridge, 2007; Kim, Wigram, & Gold, 2008). One of the participants responded when familiar songs were played by paying attention to the teacher or materials, smiling, dancing to the music and engaging with the content. It was also found in another study that the limited communication abilities of the target child with ASD hindered him from participating in group activities, but he was found to react positively to familiar music by showing a smile and turning his head to the group (Vaiouli & Ogle, 2015).

The findings from this study also indicated that when the three young participants with ASD were engaged in STEM activities, they showed fewer times of academic engagement with the teacher and their peers. These results aligned with those of Keen (2009) stating that even if children with ASD were engaged in an activity, they were more often engaged in the materials than the people around them. In this study, the teacher structured the STEM activities in this current study, and students were free to do hands-on experiment within the structured instructions. The results revealed that three participants performed better when the activity was organized well and the teacher was there to direct. This finding was similar to that of Kishida and Kemp in 2006, stating that children with ASD had better academic engagement in structured activities by examining the academic engagement of children with developmental delays across different activities. Although there were not many studies on this topic, some of the current findings can be related to previous studies. The results from this current study demonstrated that young children with ASD had better academic engagement in STEM activities than in Circle Time activities.

Conclusion

Academic engagement is a crucial indicator of students' positive learning outcomes and academic performance, but students with ASD have been reported to have lower levels of academic engagement compared to typically developing children. In this study, the researcher employed a single case study with alternating treatment design to examine the difference in academic engagement of three young children with ASD in Circle Time activities and STEM activities. Two research questions were used to guide this study. The first question was designed to collect observational data on three young children's academic engagement rate in STEM activities and Circle Time activities by utilizing a Time Sampling Data Collection Form. The second question was developed to obtain the teacher's perspectives on her students' academic engagement in both activities by utilizing a questionnaire. The findings of this study indicated that all three participants, aged 3-4, showed better academic engagement during STEM activities than during Circle Time activities. The results helped fill the knowledge gap that exists about learning and academic engagement of young children with ASD in STEM fields and supported previous literature on the higher rate of participation in STEM majors of this population. Therefore, increasing young children's academic engagement can be effective when teachers provide various teaching techniques (e.g., structured play groups, role play and video modeling, etc.), and it is important to use multiple strategies to promote the academic engagement level of young children with ASD by teachers, parents, and caregivers in the future.

Implications

The findings of this current study somewhat supported/explained the previous studies on young adults with ASD and their choices of STEM careers. Although in the current study, the researcher found all three participants showed better academic engagement in STEM activities than in Circle Time activities, more studies needed to be conducted in the area of academic engagement for children with ASD. The current study was designed to examine the difference in academic engagement of children with ASD in STEM activities and Circle Time activities. There have been many research studies that have demonstrated that students with ASD have lower levels of academic engagement in learning and that they are more likely to gravitate towards STEM majors in secondary education. The published studies investigating academic engagement of students with ASD in various academic activities, however, have been limited. Therefore, in order to fill the knowledge gap, more studies are needed on this population of students across settings, ages and subjects.

According to the literature, people with ASD have strengths in STEM fields but their college enrollment in such subjects has been low due to their deficits in social skills and cognitive development (Wei et al., 2013). The findings from this study indicate all three young children with ASD showed better academic engagement in STEM activities across time; therefore, more studies implementing intervention programs (e.g., video modeling, structured play group, role play and discussion) are needed for children with ASD to promote social skills of children with ASD while providing STEM classes. It is important to implement intervention package(s) in the process to provide individuals with ASD opportunities to interact with their classmates and teachers.

Recommendations for Teachers

People with ASD are different although they share common characteristics. Many researchers have identified the lower level of academic engagement of students with ASD (Logan et al., 1997; Mahoney & Cairns, 1997; Corsello, 2005). Thus, providing appropriate support in the process of learning should be important for individuals with ASD. Special education teachers should be knowledgeable about students with special needs and know how to implement effective instruction to promote positive learning outcomes (Simpson, 2005). Results from this study support young children with ASD having a higher level of academic engagement in STEM courses and imply that they are in great need of further assistance in learning.

There are several important recommendations for teachers when teaching STEM and other courses for students with ASD. First, students with ASD may benefit from structured teaching using different techniques. Some teaching techniques, such as video modeling and structured play group, may lead to better academic engagement and increased motivation during the learning process of individuals with ASD. It is crucial to note that teachers should take into consideration children's different characteristics so as to develop lesson plans that satisfy each student's needs.

Second, incorporating music into STEM curriculum could be another consideration. Rosenberg (2008) stated that children with ASD have fewer learning opportunities due to the challenging experiences in academic engagement and participation. However, music can decrease the experience of challenge in daily academic activities and increase children's academic engagement because music develops children's cognitive skills and creates an important environment to promote life skills (Humpal & Wolf, 2003; Neely, Kenney, & Wolf, 2000). Studies have reported that interactive music in daily activities for children with ASD had positive results on the level of academic engagement and learning outcomes (Carnahan et al., 2009; Lanter & Watson, 2009; Kern et al., 2007). Therefore, teaching STEM knowledge combined with music strategies by using precomposed songs could be an effective method to improve academic engagement and learning for children with ASD. Since children with ASD have limited verbal abilities, they tend to engage better when language is presented in music and songs during academic activities. Moreover, small learning groups and hands-on experiments contribute to better academic engagement and positive academic learning outcomes of young children with ASD. Teachers are encouraged to provide hands-on experiences during STEM classes and pay more attention to those students who struggle with directive instructions.

Recommendations for Future Studies

Future research studies could include typically developing children in an inclusive setting by using similar research methods to investigate the academic engagement difference between children with ASD and general population and/or other developmental delay. Therefore, the focus would be beneficial to the field and the population; also, the results could be compared to see if there are any academic engagement differences across groups and activities.

Based on the results of this current study, future studies could involve music and songs in academic activities. The modification can be made to the lesson plan, so that music with or without lyrics, could be utilized to teach science, mathematics or literacy classes by teachers. This comparison can be of interest to the field. Furthermore, additional time could be spent on the data collection procedure. With only six weeks of data collection in this current study, two to four more weeks could be added in future studies in order to see a clearer trend of data points or a more stable data pattern of participants.

Additional studies could be conducted in a modified setting. Although many researchers have demonstrated that outdoor classrooms positively affect the learning outcomes of children with or without developmental disabilities, the investigation of relationships between STEM classes in an outdoor environment and students' academic engagement has been limited. More studies utilizing outdoor environment as STEM classrooms to teach scientific concepts and mathematics knowledge are needed, and the comparison across different settings could be examined. Therefore, the results could contribute to the STEM education in early childhood programs as well as natural environment classrooms for children with ASD.

Limitations

The results of this study demonstrated that all three participants demonstrated better academic engagement in STEM activities than in Circle Time activities. However, there were some limitations. First, the small sample size limited the external validity of the current study. In terms of the characteristics of single case study, the external validity was one of the limitations to the investigation. Only three children with ASD were chosen for this study, thereby precluding the ability to generalize to all populations of children with ASD. In addition, within a single case study, some variables cannot be easily controlled despite all attempts to control extraneous variables (Borden & Abbott, 2011). When applying single case study design to humans, variables such as personality and IQ cannot be controlled by the experimental design. There was no easy way to eliminate those effects, but they can be controlled by performing additional measurements on those variables. Furthermore, the quality of this current study relied heavily on the observer's skills, and Creswell (2013) has noted that the results of such a study can be easily influenced by the researcher's personal bias (Creswell, 2013).

According to McGowan & Wong (2014), the potential problems of alternating treatment design are contrast effects and multiple variables. In the current study, three young children's academic engagement was influenced by their physical condition and teacher's style of instruction. They were not interested and engaged when they felt sleepy or tired. In addition to that, the teacher's performance and mode of instruction had an impact on the children's academic engagement as well. For instance, the children were more engaged if content was more appealing to them or if the teacher asked questions frequently in order to get them involved.

Lastly, time limit was another limitation of this study. This study, with a longer period of time to collect data on both activities, may have resulted in different findings. Additional data collection could provide more information about the three young children's academic engagement across activities over a longer period of time.

APPENDIX A: STEM STANDARDS

Scientific Inquiry - VPK

a. Investigation and Inquiry – VPK

1. Demonstrates the use of simple tools and equipment for observing and investigating

2. Examines objects and makes comparisons

b. Physical Science - VPK

1. Explores the physical properties and creative use of objects or matter

c. Life Science – VPK

1. Explores growth and change of living things

2. Identifies the characteristics of living things

3. Identifies the five senses and explores functions of each

d. Earth and Space - VPK

1. Explores the outdoor environment and begins to recognize changes (e.g., weather conditions) in the environment, with teacher support and multiple experiences over time

2. Discovers and explores objects (e.g., rocks,

3. twigs, leaves, seashells) that are naturally found in the environment

c. Environmental Awareness - VPK

1. Demonstrates ongoing environmental awareness and responsibility (e.g., reduce, reuse, recycle), with teacher support and multiple experiences over time

A. Mathematical Thinking – VPK

a. Number Sense - VPK

1. Demonstrates understanding of one-to-one correspondence

Benchmark a: Child demonstrates one-to-one correspondence when counting.

Benchmark b: Child demonstrates one-to-one correspondence to determine if two sets are equal.

2. Shows understanding of how to count and construct sets

Benchmark a: Child counts sets in the range of 10 to 15 objects.

Benchmark b: Child constructs sets in the range of 10 to 15 objects.

3. Shows understanding by participating in the comparison of quantities

Benchmark a: Child compares two sets to determine if they are equal.

Benchmark b: Child compares two sets to determine if one set has more.

Benchmark c: Child compares two sets to determine if one set has fewer.

4. Assigns and relates numerical representations among numerals (written), sets of objects, and number names (spoken) from zero to 10

5. Counts and knows the sequence of number names (spoken)

Benchmark a: Child counts and recognizes number names (spoken) in the range of 10 to 15.

Benchmark b: Child counts up through 31 by understanding the pattern of adding by one, with teacher support and multiple experiences over time.

6. Shows understanding of and uses appropriate terms to describe ordinal positions

Benchmark a: Child demonstrates the concept of ordinal position with concrete objects (e.g., children or objects).

b. Number and Operations - VPK

1. Shows understanding of how to combine sets and remove from a concrete set of objects (receptive knowledge). Benchmark a: Child indicates there are more when combining (adding) sets of objects. Benchmark b: Child indicates there are less (fewer) when removing (subtracting) objects from a set.

2. Shows understanding of addition and subtraction using a concrete set of objects (expressive knowledge) or story problems found in everyday classroom activities.

Benchmark a: Child combines sets of objects to equal a set no larger than 10.

Benchmark b: Child removes objects from a set no larger than 10.

c. Patterns and Seriation - VPK

1. Understands characteristics of patterns and non- patterns and begins to reproduce them with at least two elements (e.g., red/blue, red/blue versus a non-pattern like a rainbow). Benchmark a: Child recognizes patterns and nonpatterns. Benchmark b: Child duplicates identical patterns with at least two elements. Benchmark c: Child recognizes pattern units (e.g., red/blue is the pattern unit of a red/blue/red/blue/red/blue pattern; dog/cat/cow is the pattern unit of a dog/cat/cow/dog/cat/cow pattern).

2. Sorts, orders, compares, and describes objects according characteristic s or attribute(s) (seriation). Benchmark a: Child places objects in increasing order of size where the increasing unit is constant (e.g., unit blocks). Benchmark b: Child verbalizes why objects were placed in order (e.g., describes process of how and why), with teacher support and multiple experiences over time.

d. Geometry - VPK

1. Understands various two-dimensional shapes, including circle, triangle, square, rectangle, oval, and other less common shapes (e.g., trapezoid, rhombus}. Benchmark a: Child categorizes (sorts} examples of two- dimensional shapes. Benchmark b: Child names two-dimensional shapes. Benchmark c: Child constructs examples of two dimensional shapes.

2. Shows understanding that two-dimensional shapes are equivalent (remain the same} in different orientations. Benchmark a: Child slides shapes, with teacher support and multiple experiences over time. Benchmark b: Child flips shapes, with teacher support and multiple experiences over time. Benchmark c: Child rotates shapes, with teacher support and multiple experiences over time.

3. Understands various three-dimensional shapes, including sphere, cube, cone, and other less common shapes (e.g., cylinder, pyramid). Benchmark a: Child categorizes (sorts} examples of three- dimensional shapes. Benchmark b: Child names three-dimensional shapes.

4. Analyzes and constructs examples of simple symmetry and non-symmetry in two dimensions, using concrete objects.

e. Spatial Relations - VPK

1. Shows understanding of spatial relationships and uses position words

Benchmark a: Child shows understanding of positional words (receptive knowledge).

Benchmark b: Child uses the positional terms verbally (expressive knowledge}, with teacher support and multiple experiences over time.

2. Describes relative position from different perspectives

3. Understands and can tell the difference between orientation terms (e.g., horizontal, diagonal, vertical)

4. Uses directions to move through space and find spaces in place

f. Measurement - VPK

1. Engages in activities that explore measurement

2. Compares continuous quantities using length, weight, and height

Benchmark a: Child measures or compares the length of one or more objects using a nonstandard

Benchmark b: Child measures or compares the weight of one or more objects using non-standard

Benchmark c: Child measures or compares the height of one or more objects using non-standard

3. Represents and analyzes data.

Benchmark a: Child assists with collecting and sorting materials to be graphed. Benchmark b: Child works with teacher and small groups to represent mathematical relations in charts and graphs. Benchmark c: Child analyzes, with teacher and small groups, the relationship between items/objects represented by charts and graphs.

4. Child predicts the results of a data collection, with teacher support and multiple experiences over time.

Note. (Adapted from Common Core Standards Initiative, 2010).

APPENDIX B: IRB EXEMPT LETTER

University of Central Florida

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Determination of Exempt Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Yixuan Ji**

Date: **November 26, 2017**

Dear Researcher:

On 11/26/2017, the IRB reviewed the following activity as human participant research that is exempt from regulation:

Type of Review:	Exempt Determination – Categories 1 and 2
Project Title:	The Potential of STEM Education in Early Childhood Programs for Children with Autism Spectrum Disorders:A Single Case Design Study on STEM Activity and Children' s Academic Engagement
Investigator:	Yixuan Ji
IRB Number:	SBE-17-13530
Funding Agency:	
Grant Title:	
Research ID:	N/A

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

This letter is signed by:

Signature applied by Jennifer Neal-Jimenez on 11/26/2017 09:46:46 PM EST

Designated Reviewer

APPENDIX C: LESSON PLAN FOR STEM

Topic: growth of baby

Abstract:

It is important for young children with ASD to understand the growth of babies. They should understand there are two essentials for babies to grow: water and food. At the meantime, it is a great opportunity for young children with ASD to do hands-on experiment.

Materials:

- A balloon
- A cup of vinegar
- Baking soda powder
- A doll

How to do it:

- Talk about babies and growth of babies.
- Asking questions on how does a baby grow up?
- The teacher present the experiment to all students as an example.
- Ask one students to hold the balloon, let another student to pour baking soda into the balloon, and then have another student pour vinegar into the balloon.
- See what happens after all the above steps.
- Discussion.

APPENDIX D: LESSON PLAN FOR CIRCLE TIME

Sessions	**Circle Time Lesson Plan**
Learning Goals	• Demonstrate the ability to take turns • Demonstrate the ability to maintain focus for a period of time • Demonstrate the understanding of five senses, weather, days of the week, colors and alphabets • Demonstrate the ability to interact with peers
Objective	• To learn the knowledge and basic skills • To concentrate on the activity for a period of time
Materials	• Videos clips • Alphabet cards • Number cards
Procedures	• Calendar- days of the week, days of the month • Weather- sunny, windy, rainy • Five senses • Numbers • Alphabet

APPENDIX E: TIME SAMPLING DATA COLLECTION FORM

Data Collection Form — DAY _________

	Child #1						Child #2						Child #3					
	50 seconds					10s break	50 seconds					10s break	50 seconds					10s break
Minute 1-3	E N.E	E N.E	E N.E	E N.E	E N.E		E N.E	E N.E	E N.E	E N.E	E N.E		E N.E	E N.E	E N.E	E N.E	E N.E	
Minute 4-6	E N.E	E N.E	E N.E	E N.E	E N.E		E N.E	E N.E	E N.E	E N.E	E N.E		E N.E	E N.E	E N.E	E N.E	E N.E	
Minute 7-9	E N.E	E N.E	E N.E	E N.E	E N.E		E N.E	E N.E	E N.E	E N.E	E N.E		E N.E	E N.E	E N.E	E N.E	E N.E	
Minute 10-12	E N.E	E N.E	E N.E	E N.E	E N.E		E N.E	E N.E	E N.E	E N.E	E N.E		E N.E	E N.E	E N.E	E N.E	E N.E	
Minute 13-15	E N.E	E N.E	E N.E	E N.E	E N.E		E N.E	E N.E	E N.E	E N.E	E N.E		E N.E	E N.E	E N.E	E N.E	E N.E	
Minute 16-18	E N.E	E N.E	E N.E	E N.E	E N.E		E N.E	E N.E	E N.E	E N.E	E N.E		E N.E	E N.E	E N.E	E N.E	E N.E	
Minute 19-21	E N.E	E N.E	E N.E	E N.E	E N.E		E N.E	E N.E	E N.E	E N.E	E N.E		E N.E	E N.E	E N.E	E N.E	E N.E	

APPENDIX F: SOCIAL VALIDITY QUESTIONNAIRE FOR TEACHER

INTERVENTION RATING PROFILE-15

The purpose of this questionnaire is to obtain information about your opinion on STEM activities and children's academic engagement. Please indicate the extent to which you agree or disagree with the following statements regarding academic engagement of children with ASD by circling a number that most closely reflects your opinion.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
1	2	3	4	5	6

1. This is an acceptable intervention for the children with ASD and their academic engagement.

1 2 3 4 5 6

2. Most teachers would find this intervention appropriate for children with ASD and their academic engagement.

1 2 3 4 5 6

3. This intervention should prove effective in changing the children's academic engagement by implementing STEM activities.

1 2 3 4 5 6

4. I would suggest the use of this intervention to other teachers.

1 2 3 4 5 6

5. Most teachers would find this intervention suitable for children with ASD identified.

1 2 3 4 5 6

6. I would be willing to use this intervention in the classroom setting.

1 2 3 4 5 6

7. This intervention would not result in negative side effects for the child.

1 2 3 4 5 6

8. This intervention would be appropriate for a variety of children.

1 2 3 4 5 6

9. This intervention is consistent with those I have used in classroom settings.

1 2 3 4 5 6

10. The intervention is a fair way to handle the children's academic engagement.

1 2 3 4 5 6

11. This intervention is reasonable for children with ASD identified.

1 2 3 4 5 6

12. This intervention is a good way to handle children's academic engagement.

1 2 3 4 5 6

13. The children's autism symptoms and academic engagement issues are severe enough to warrant the use of this intervention.

1 2 3 4 5 6

14. I like the procedures used in this intervention.

1 2 3 4 5 6

15. Overall, the STEM activities would be beneficial for the children with ASD.

1 2 3 4 5 6

Note. (Adapted from Martens, B., Witt, J., Elliott, S., Darveaux, D., & Tingstom, D. H., 1990)

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