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fuelingbrains

Scientific Research Behind Fueling Brains





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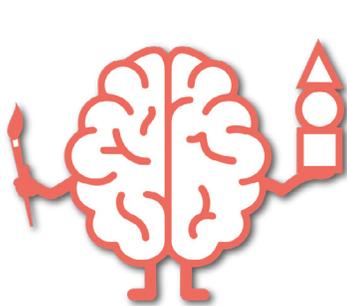
Introduction

The importance of high-quality early education on children's later cognitive and behavioral outcomes is clear (McCoy et al., 2017; Yoshikawa et al., 2013). While all children benefit from high-quality early education, children from low-income households and English Language Learners benefit the most (Blau & Currie, 2006; Brilli et al., 2013; Burger, 2010; Yoshikawa et al., 2013). In addition to academic benefits for children, economists have also shown the cost benefits of investing in high-quality early education, which generates approximately \$7 for every dollar invested (Bartik, 2014). However, the evidence is also clear that quality is crucial when it comes to early education programs. Children in lower-quality care often develop more significant cognitive delays, as well as social and behavioral issues (Belsky et al., 2007; Brilli et al., 2013; Cleveland et al., 2006; Tran & Weinraub, 2006).

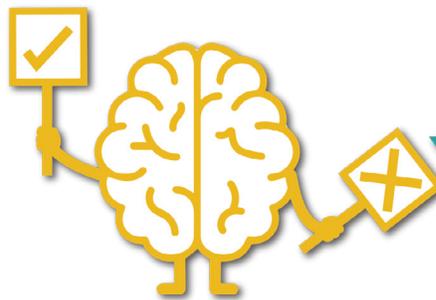
Many components contribute to the quality of early education for young children. However, the critical component is a comprehensive curriculum based on early learning standards, addresses the whole child, is developmentally appropriate, and is effectively implemented (National Association for the Education of Young Children [NAEYC], 2019; Wechsler et al., n.d.; Yoshikawa et al., 2013). In addition to domain-specific content areas (e.g., emergent literacy and numeracy skills), an early childhood curriculum that focuses on child-initiated learning (Serpell & Esposito, 2016) and domain-general skills (e.g., executive functioning, critical thinking, and problem-solving) provide the best environment for long-term development and academic learning (Center on the Developing Child at Harvard University, 2011; McClelland et al., 2007). In addition, promoting executive function skills within early education may be the key to reducing the substantial gaps in school readiness and later achievement that separates disadvantaged children from their more advantaged peers (Shonkoff & Phillips, 2000).

What Are Executive Function Skills?

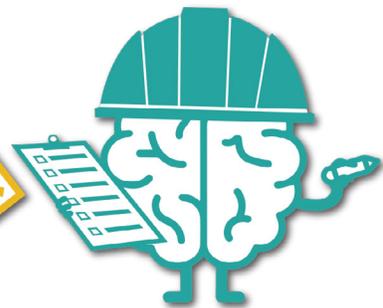
Executive function skills are a set of cognitive processes involved in conscious objective-oriented problem solving (Barkley, 2012; Garon et al., 2008; Yeager & Yeager, 2013). These include cognitive flexibility, working memory, and inhibitory control (Blair & Razza, 2007; Diamond, 2013; Zelazo & Müller, 2002). Executive functions enable children to organize their thinking and behavior with increasing intentionality and flexibility (Barkley, 2012; Hughes & Graham, 2002). Executive function development begins at infancy and develops through adolescence with the most rapid growth occurring from ages 3 – 5 years of age (Carlson, 2003; Center on the Developing Child at Harvard University, 2011). These skills develop rapidly during the preschool and early elementary years (ages 3-7) and provide a neural foundation to support school readiness, facilitating both self-regulated behavior and academic learning (Blair, 2002; McClelland et al., 2007). Executive functions enable children to stay focused for longer periods, retain and manipulate information, eliminate distractions from their environment, make better choices, and be better prepared for school and future life challenges (Diamond, 2013; Zelazo & Lyons, 2012). Executive functions also enhance the resilience of children who experience early adversity and can reduce school difficulties among maltreated children (Pears et al., 2010).



Cognitive Flexibility



Inhibitory Control



Working Memory

Components of Executive Function

Working Memory

Working memory refers to the executive functions that allow the child to carry information in the mind and connect it with new and upcoming information (Hoskyn, 2010). Working memory enables the child to be effective in social interactions in a way that the child can make decisions in random and unpredictable environments (Young et al., 2018). Working memory, also known as updating, is the capability to comprehend incoming information and knowing how to treat it (Shonkoff & Phillips, 2000). This is vital for the development of social understanding and a child's language skills (Hoskyn, 2010; Purpura & Ganley, 2014).

Cognitive Flexibility

Cognitive flexibility is the ability to shift between different tasks or goals (Carlson, 2003; Blair & Razza, 2007). This attention shifting includes both attention switching and task switching and allows the child to disengage from irrelevant information in a previous task and to focus on relevant information in a forthcoming task (Monsell, 2003). Children who have the ability to be cognitively flexible can remain goal-oriented in the face of a challenge (Carlson, 2003).

Inhibitory Control

Inhibitory control is the ability to overpower an emotion to carry out another act that is a higher priority (Miller & Cohen, 2001). Inhibitory control is the ability to ignore distractions and resist temptation (Shonkoff & Phillips, 2000). Garon et al., (2008) emphasized the importance of scaffolding and drawing attention to something else to help the development of inhibitory control. Hoskyn (2010) described inhibitory control as a key skill for the preschool age as it helps the child to regulate their emotions and refrain from acting impulsively. Self-regulation is incorporated under the heading of executive functions and inhibitory control (Hoskyn, 2010; Richland & Burchinal, 2013). Self-regulation skills allow individuals to manage and control their own emotions (Miller & Cohen, 2001; Lakes & Hoyt, 2004). Moreover, the ability to self-regulate helps a person with other tasks such as planning, organizing, and remembering details (Burchinal et al., 2002). Self-regulation in childhood affects critical developmental outcomes (Lakes & Hoyt, 2004), including mathematical and reading abilities in preschool and early grades and academic aptitude test scores in adolescence (Blair & Razza, 2007; Diaz et al., 1992; Gilmore & Cragg, 2014).

Why are Executive Function Skills Important?

Brain research in neuroscience and developmental psychology places higher importance on acquiring executive functions and self-regulation abilities than on learning basic shapes, colors, or numbers (Center on the Developing Child, 2011; Mulder et al., 2017; Nieto et al., 2016). Children who develop executive function and self-regulation abilities in the early years have a greater tendency for improved academic achievement, increased prosocial behavior, and decreased disruptive behavior (Ahmed et al., 2019; Brock et al., 2009; Diamond et al., 2007; Diamond, 2013). Executive functions give an individual the skills and ability to focus for long periods, make decisions, shift between projects, hold multiple thoughts and ideas, plan and organize, refrain from bad habits, control impulses, abstain from inappropriate behavior, have strong short-term and long-term memory, and control their emotions (Yeager & Yeager, 2013; Zelazo & Muller, 2002).

It is noteworthy that young children are not born with executive function skills; instead, they are born with the capacity to develop those (Nores & Barnett, 2010). The development of a complete series of executive function skills continues and matures through the teenage years into adulthood (Burchinal et al., 2002). However, the development of executive function skills is often delayed among children growing up in poverty (Noble et al., 2007), leading to low levels of classroom engagement and elevated teacher-rated attention problems (Allee-Herndon & Killingsworth Roberts, 2019; McClelland et al., 2007).

Development of Executive Functions in Early Childhood

Executive functioning is central to the development of young children, especially in the pre-school years when the development of executive function skills is most rapid (Center on the Developing Child at Harvard University, 2011). Learning to control impulses, pay attention, and retain information actively in one's memory does not happen automatically as children mature, and young children who have problems with these skills will not necessarily outgrow them (Center on the Developing Child at Harvard University).

A child's experiences play a vital role in the development of executive function skills. Interventions aimed at improving executive function skills effectively support their development and benefit early reading and mathematics skills (Center on the Developing Child at Harvard University; Diamond, 2012; Wood et al., 1976). High-quality early childhood educators, quality early education programs, and a healthy family and home environment work together to support the development of executive function skills in children (Zelazo & Lyons, 2012).

Constructivism and Executive Functions

Executive function and child development are best comprehended by using the lens of constructivism. From a constructivist viewpoint, children learn and develop through their own experiences (Bolton & Hattie, 2017). Constructivists hold the view that as children experience their world, knowledge is created, and this knowledge is not acquired passively. The basic premise of constructivist theory is supported by Dewey (1963), Vygotsky (1978), and Piaget (1968), who found specific environmental factors like community and teachers best facilitate the development of child executive function when teachers show involvement in the children's lives. The constructivist theory relies on the predisposition of how children naturally learn to explain the development of executive function (Bolton & Hattie, 2017; Verenikina, 2003). According to Vygotsky (1997), the constructivist theory posits children learn through social interactions with older and more knowledgeable persons within their environment. According to Roopnarine and Johnson (2005), constructivist theory identifies learning at early ages as an active, contextualized phenomenon of constructing knowledge rather than merely acquiring it. Vygotsky (1978) also developed theories on scaffolding by more knowledgeable others and the zone of proximal development. The zone of proximal development is the difference between what a child can do without help and what they can achieve with scaffolding (guidance and encouragement) from a person who is more skilled in an area (Vygotsky, 1978). These two concepts are crucial for the development of children's executive functions. (Epstein, 1996; Peltzman, 1998; Verenikina, 2003).

Executive Function Development and Early Childhood Education

As more children are starting early learning programs as infants or toddlers, the need for curriculum models and intervention programs has increased (Hewett, 2001; Serpell & Esposito, 2016). The interventions that support self-regulation and executive function in family and classroom contexts are particularly important (Center on the Developing Child, 2017). However, only a few of such programs have been shown to enhance executive functions and self-regulation in young children (Diamond et al., 2007; Diamond & Lee, 2011; Thorell et al., 2009). Programs that include executive executive-function-promoting activities such as telling oneself out loud what one should do (“self-regulatory private speech”), dramatic play, and aids to facilitate memory and attention result in significant gains in children’s reasoning ability, control of attention, and academic achievement (Blair & Raver, 2014; Diamond et al., 2007; Diamond & Lee, 2011). Diamond’s (2012) study specifically identified activities and programs that included the development of executive function skills and abilities as part of the curriculum. Diamond concluded that Montessori and Tools of the Mind’s early childhood curriculums had the greatest change in the development of children’s executive functions. Both early childhood curriculums use Vygotsky’s (1978) theory of social and behavioral development. Diamond identified each curriculums’ approach to scaffolding as a huge contributor to the positive outcomes of executive functions in children.

Early Learning and Care Educators

Key to the effective implementation of any early childhood curriculum is the quality and training of the teacher. In fact, it is the most important school-related factor influencing student achievement (Barnett, 2003; Rice, 2003). As the ones primarily responsible for implementing any early childhood curriculum, teachers have a significant role to play in ensuring that the learning environment is conducive for the development of executive functions (Birch & Ladd, 1997; Gilmore & Cragg, 2014; Sheffler, 2009).



A well-trained and highly skilled teacher will tailor their interactions to fit the needs of the child—using responsive language, engaging all children in classroom activities, fostering independence, and creating a language-rich environment (National Center on Quality Teaching and Learning, 2013; Pianta & Stuhlman, 2004). Effective early childhood teachers play an essential role in ensuring the learning environment is suitable for the development of executive functions (Hewett, 2001; Thorell et al., 2009; Willoughby et al., 2011).

Family, Environment, and the Impact on Executive Functions

The child's family and home environment also have an overarching influence on the positive development of executive functions (Hosokawa & Katsura, 2018; Ladd et al., 1999). A child's early experiences are shaped by their home environment and the learning opportunities provided to the child (Bradley et al., 2001). Bernier et al. (2010) found that the attachment level of the child to their primary caregiver at 18 months to 26 months predicted outcomes in executive functions of the children at three and four years of age. Zelazo and Lyon's (2012) suggest that parental interventions at two and three years of age can impact the executive function outcomes of a child at four and five years of age. Conversely, there is a decline in children's executive functions when the children are part of socio-economically disadvantaged families that have increased violence, abuse, and limited access to quality education than those children in more favorable socio-economic and home conditions (Blau, 2003; Hosokawa & Katsura, 2018; Jednoróg et al., 2012; Nores & Barnett, 2010).

Executive Functions and Educational Outcomes

The relationship between executive function development and school readiness and academic achievement indicates that children who develop executive functions and self-regulation abilities in the early childhood years have higher academic achievement and exhibit more prosocial behavior later in life (Brock et al., 2009; Diamond, 2012; Duncan et al., 2010; Olmstead, 2000; Schweinhart & Weikart, 1998). Since executive functions, such as working memory, cognitive flexibility, and inhibitory control (Garon et al., 2008; Barkley, 2012), are used to complete various daily tasks, it makes sense that gains in their development would lead to gains in the development of other skills. Children also use these executive functions in school to complete school assignments, learn new concepts, engage appropriately with their peers and teachers, and exhibit prosocial behaviors (Barkley, 2012). For example, children who can maintain focus for longer durations of time, retain and manipulate information, exclude distractions from their environment, and make better choices are better prepared for school and future life challenges (Zelazo & Lyons, 2012).

Executive functions often predict future literacy and math achievement in children, specifically written language and reading comprehension skills (Gilmore & Cragg, 2014; Harris & Bell, 1994; Hu et al., 2017; Hughes, 1998). According to Schweinhart and Weikart (1998), when students experience delays in the development of one or more executive functions, their understanding of academic material and social interactions may suffer. This delay may prohibit children from completing academic tasks, create difficulty in grasping concepts, and create difficulty attending to instruction (Zelazo & Muller, 2002).

Brain Building Early Learning Environments

Montessori Method

The left part of our brain is the logical part that involves analytical and empirical aspects. The Montessori philosophy guides children to develop their focus and concentration. Maria Montessori developed specific educational methods and materials based on her scientific observations about how children learn. She discovered that children avidly absorb information from their environment and that if their environment provides learning opportunities, that children would readily teach themselves (American Montessori Society, n.d.). One of the key elements of the Montessori approach to learning is respecting the child's innate curiosity. This means that children are able to explore their world in a carefully planned environment that exposes them to materials and experiences that stimulate cognitive, social-emotional, and physical development (American Montessori Society).

Children are usually grouped into multi-age classrooms spanning three years. This type of classroom structure encourages younger children to learn from older ones and encourages the older children to be role models for their younger counterparts (Edwards, 2002). According to Ryniker and Shoho (2001), the Montessori approach is based on the tenet that children learn most effectively when allowed to make choices about their learning. Therefore, the philosophy gives children the ability to learn at their own pace, instilling personal independence, motivation, and self-discipline. In early childhood, Montessori students learn through sensory-motor activities, working with materials that develop their cognitive powers through direct experience: seeing, hearing, tasting, smelling, touching, and movement (American Montessori Society, n.d.).

Montessori classrooms employ an open concept in which desks are arranged in "rafts" to promote individual and small-group learning rather than desks oriented in one direction for whole-group instruction (Chattin-McNichols, 1992). Instructionally, Montessori programs use didactic manipulative materials designed by Maria Montessori as an instructional methodology. Each piece or set of equipment is designed to provide the child with a clear-cut experience and then gradually lead to more complicated tasks (American Montessori Society, n.d.). Furthermore, Montessori is distinct because it does not use textbooks, worksheets, tests, grades, punishments, or rewards (Edwards, 2002)

Reggio Emilia

The right side of our brain is creative, social and imaginative. Building this side of the brain is just as important as building the left side of the brain. The Reggio Emilia Approach is a play-based educational philosophy where passion, natural curiosity, and inquiry act as the catalysts to the child's learning & brain development. Developed by Loris Malaguzzi and the parents of the villages around Reggio Emilia in Italy after World War II, Reggio Emilia is based on the principles of respect, responsibility, and community through exploration and discovery in a supportive and enriching environment based on the interests of the children through a self-guided curriculum (Malaguzzi, 1993).

The heart of the Reggio Emilia approach is that young children are individuals with rights and who are curious about their world and have the powerful potential to learn from all that surrounds them (Malaguzzi, 1993). Important to this approach is that curriculum topics are derived from talking with children and their families and things that are known to be interesting to children (Vakil et al., 2003). The Reggio Emilia approach calls for the presentation of new ideas and concepts in multiple forms, such as print, art, drama, music, puppetry, and so on. Varied presentations ensure that all children have the chance to understand and connect with the concepts being explored.

Documentation of the growth of both children and teachers is another important component of the Reggio Emilia approach. For instance, displays of photographs and examples of children's work as well as teachers' recordings and note-taking of conversations provide records of children's development (New, 2007). Keeping within this framework, projects that emphasize children's expressions in an aesthetic environment are emphasized in the curriculum (Lim, 2004). The classroom is referred to as the "third teacher" in Reggio schools. Much like the Montessori approach, great care is taken to construct an environment that allows for the easy exploration of various interests (Vakil et al., 2003).

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Movement-Based Learning

Movement-based learning is the concept that cognitive learning and physical development go hand in hand. When a child's body is involved in movement, the brain is in a higher state of arousal (Stevens-Smith, 2016). This allows children to learn best when moving because the movement actually stimulates the neurons and electrical wiring of the brain. Because of this stimulation, when movement and cognitive development is combined, it increases the number of neurons being used, and over time will allow them to become more efficient (Stevens-Smith, 2016).

A movement-based learning environment is based on promoting a healthy body and healthy mind. It enhances positive peer interaction and locomotor skills of students. It also helps students develop stability and strengthens object manipulation. In addition, opportunities for semi-structured peer play and scaffolding of inhibitory control are likely to enhance executive function-related skills (Serpell & Esposito, 2016). The movement-based environment involves play and physical activity, which makes students alert, active and prepares them to absorb the left brain and right brain learning. Through group games, sports, and fundamental movement skills, as well as plenty of outdoor exercises and nutritional guidance, students are exposed to a well-balanced and active lifestyle.

The Fueling Brains Approach to Brain Building

The Fueling Brains approach to early learning integrates the Left Brain, Right Brain, and Movement Learning to support executive function in young children with the goal of helping them realize their full learning potential. The Fueling Brains philosophy teaches children how to learn, not what to learn. Parent expectations on teaching letters, colors, numbers and shapes changes to a focus on the acquisition of working memory, cognitive flexibility and impulse control. Fueling Brains includes an integrated early learning suite that tracks a child's progress, customizes curriculum to each child's individual needs, measures positive changes, and provides quality feedback for parents. This focus on the whole child and executive function develops lifelong skills and abilities so children can grow up to be courageous, make conscious decisions, manage their impulses, and regulate their emotions (Brock et al., 2009; Center on the Developing Child, 2017; Diamond, 2012; Duncan et al., 2010; Olmstead, 2000; Schweinhart & Weikart, 1998).

The Fueling Brain Curriculum integrates the hands-on, interactive instructional approach of Montessori with the creative, community-focused approach of Reggio Emilia with the physically active focus of Movement Learning to engage the whole child, left brain, right brain, and body, in the learning process. The Left Brain- focused activities bring peace, order and sense of routine in the child's daily life through practice, repetition and purposeful work. Children experience hands-on learning activities in language, mathematics, culture and geography. The goal is to build confidence, self-esteem and a 'can-do' attitude in children through practical, real-life experiences. The Right Brain-focused activities allow imagination and exploration to ignite your child's natural curiosity. They support creative thinking and expression through art, dance, and storytelling. The goal is to build a child's community through connections with others, relationship and friendship. The movement-focused activities support children's physical development through skill-based activities that encourage children to get stronger, faster and more balanced. These activities support the mind-body connection to enhance brain development. The goal is for children to stay moving and active to keep busy, burn energy, boost health and have fun.

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