12-2017

A Case Study of the Implementation of Activate, an Executive Function Intervention Program

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by

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A Dissertation

Submitted to the Graduate Faculty of

St. Cloud State University

in Partial Fulfillment of the Requirements

for the Degree of

Doctor of Education

in Educational Administration and Leadership

December, 2017

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Abstract

The purpose of this case study was to explore how three elementary schools located in the eastern region of the United States of America implemented the ACTIVATE executive function intervention program. The researcher investigated the practices used in these schools, the perceived benefits for children, the barriers to implementation and recommendations for schools initiating an implementation of this program. The case study format provided for the collection of responses, perspectives and insights through semi-structured interviews from seven individual educators most responsible for implementation of the program. Transcripts were coded for themes and frequency counts of the data were gathered. Analysis of the data for research question one indicated that physical activities used in the case study schools using the ACTIVATE program matched those articulated in the research as having beneficial effects on executive function. The selection of physical activities was driven by student feedback, space, and resources. The district wellness policy was not found to be a driver for the ACTIVATE implementation and training of teachers to implement the program was deemed insufficient. The conclusion from the second research question was that perceived benefits to children participating in the ACTIVATE program included improved executive function, reading and mathematics achievement scores. The analysis from the third research question identified scheduling, space and training as barriers to implementation of the ACTIVATE program. The findings and conclusions from the fourth research question identified recommendations for implementation to include establishment of the rationale with all stakeholders, more robust training for classroom teachers and integration of ACTIVATE programming into the school schedule. Limitations of the study, recommendations for professional practice and future studies were presented.

Acknowledgements

Thank you to my wife Jennifer, for your encouragement, compassion, loven, and support throughout this study. Thank you to my children Alec, Hunter, Savanna, Emman, and Tanner for inspiring me every day to be a better person and father. Thank you to my mentors, dissertation committee, instructors, family, friends, colleagues, and former students who cheered me on and said, “get it done.” Thank you to my mom and dad (Marguerite and Donald Smasal) for valuing education. You taught me well.

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Chapter I: Introduction

Introduction

The fundamental purpose of schools is to provide high levels of learning for all students using the most efficient and effective methods possible. To achieve this purpose, it may help if teachers more deeply understood factors that affect the ability of the brain to learn. One of the factors referenced in the study was the impact of physical movement of the body on the brain's ability to learn, specifically on executive function (Etnier & Chang, 2009). According to Diamond (2016), core executive functions of the brain include working memory (holding information in the brain long enough to use it for problem solving), cognitive flexibility (ability to mentally shift focus in response to changing tasks), inhibition/self-control (the ability to resist or ignore distractions). In the study, the researcher reviewed the literature to determine how humans have used exercise to promote healthy bodies and healthy brains, the relationship between exercise and achievement, the impact of exercise on executive function and how elementary schools utilize exercise interventions for learning, including barriers to implementation of exercise for executive function improvement.

For thousands of years, physical exercise has been a part of human culture including prescribing physical exercise to maintain health (Tipton, 2014). Citizens of Greece regarded physical exercise as part of their culture and as early as 375-300 BCE children were advised to exercise daily (Tipton, 2014). Intense training consumed much of the day of Spartans (Tipton, 2014) illustrating that the benefits of exercise to human physical and mental health have been known for thousands of years.

A few decades prior to the 20th century, physical education in schools regained priority as California became the first state to create legislation ensuring that physical education be part of the public school educational experience (Hackensmith, 1966). As national priorities shifted in the United States with the approach of World War I, an emphasis on individual physical fitness became critical as many recruits were found to be unfit (Lumpkin 2008). A similar emphasis occurred at the beginning of World War II (Lumpkin, 2008), but with the rise of popular sports and games in the 1960s and 70s, the shift was made to general physical education while at the same time, the research on the importance of physical movement for learning was beginning to emerge (Tomporowski, Lambourne, & Okumura,2011). The United States Department of Health and Human Services recommended that children engage in at least 60 minutes of moderate physical activity every day (Maese, 2015) which is still far less than that of our evolutionary ancestors (Cordain, Gotshall, Eaton, & Eaton, 1998).

Modern medical studies have provided strong empirical evidence that exercise improves blood flow to the brain, the development of new neurons (neurogenesis) and improved memory in animals (Fotuhi, 2013; Pereira et al., 2007). For example, mice which were allowed to exercise on an exercise wheel had greater Dentate Gyrus cerebral blood volume than control groups, and this increase in blood flow correlated with neurogenesis (Pereira et al., 2007). Aerobic exercise helped to increase blood flow and, thus, oxygen to the brain thereby enhancing its function (Fotuhi, 2013). Fotuhi (2013) explained that “a healthy vascular network with dense branches of blood vessels means more nourishment for neurons, helping them to stay vibrant and alive, and better retention of the brain’s highways, allowing different parts of the brain to communicate more efficiently” (p.69).

Even brief bouts of aerobic physical activity, whether voluntary or forced, greatly increased the construction of neurons in the hippocampus of both mice and rats (Clark, Brzezinska, Puchalski, Krone, & Justin, 2009). Exercise was shown to enhance the development of neurons and the formation of synapses in the human brain through the release of brain derived neurotrophic factor (BDNF) (Conyers & Wilson, 2016; Szuhany, Bugatti, & Otto, 2014). The effects of exercise on the brain are most obvious in the hippocampus and specifically in an area called the Dentate Gyrus, a part of the brain involved with learning and memory. Neurogenesis in the adult brain is observed in only two areas. The dentate gyrus of the hippocampus is one of them, and exercise is one of the few known stimuli of this neurogenesis (Wrann et al., 2014). Specific beneficial effects of exercise in the brain include increases in the size of and blood flow to the hippocampus in humans and morphological changes in dendrites and dendritic spines, increased synapse plasticity and neurogenesis in the dentate gyrus in mice (Wran et al., 2014).

There is significant evidence that indicated that exercise improves many different body systems (Tomporowski, McCullick, Pendelton, & Pesce, 2015) and changes structures and functions in the brain (Chaddock, Pontifex, Hillman, Kramer, 2011; Hillman, Erickson, Kramer, 2008;). Researchers found in the late 1990's that animals, like mice, changed the structure and networks of their brain because of exercise, specifically running (Tomporowski et al., 2015).

The research investigating the impact of exercise on achievement has grown substantially in the last 20 years, and much of the inspiration for these studies trace back to the rat and the running wheel experiments. Rats which were allowed to run on a running wheel for eight weeks had three times the amount of BNDF in their blood, and older rats which exercised were smarter than sedentary younger rats (Madigan, 2000). BDNF is a protein, which improves neurons

function, growth, and strengthens and protects them against cell death (Ratey, 2008). This major finding generated a renewed interest in the impact of exercise on the brain. (Ratey, 2008)

Many health organizations and members of scientific communities outlined and researched the benefits of physical activity in children and adolescents (Tomporowski et al., 2011; Sibley & Etnier, 2003). The results of numerous correlational studies indicated that a moderate to strong positive correlation existed between physical fitness levels and academic achievement (California Department of Education, 2005; Carlson et al., 2008; Roberts, Freed, & McCarthy, 2010). Exercise enhances reading and mathematics scores, a student's reading comprehension and analysis, raises IQ, correlates with higher grade point averages, enhances creativity, improves focus, reduces truancy and drop out statistics and improves language acquisition (Madigan, 2000). Even acute or short bouts of exercise positively correlate with achievement (Gabbard & Barton, 1979; McNaugthen & Gabbard, 1993; Roig, Nordbrandt, Geersten, & Nielsen, 2013).

In 2005, the state of California correlated FitnessGram data from over 300,000 students with achievement results on the Stanford Achievement Test. A dose response showed that the more FitnessGram tests the students passed, the higher their achievement scores were (Kedler, 2012). A parallel study was replicated in the state of Texas with similar findings (Kedler, 2012). Students with higher aerobic fitness had a higher probability of passing the Texas state achievement test, had higher global intelligence and higher attendance rates in school (Kedler, 2012).

Kedler (2012) discussed the results of a Center for Disease Control (CDC) report consisting of over 260 studies on exercise and achievement confirming that when physical

exercise was incorporated into the learning day, test scores and student achievement would increase. Supporting this conclusion, Ratey (2012) described a 26 year-long study in which 1.2 million fifteen-year-old Swedish boys, who improved their cardiovascular fitness, also raised their IQ's. This claim, according to Ratey (2012), was supported by evidence even while controlling for genetic factors (i.e., comparing brothers and twins).

A biological mechanism to explain the connection between exercise and achievement was described by Peat (2015). As the brain develops, its ability to control movement of the body improves in ways that lay the foundation for all future learning. Motor development provides a framework for the brain to sequence the patterns needed for academic concepts, and the body's vestibular system controls balance and spatial awareness and facilitates the student's ability to place words and letters on a page. Proper development and remediation of these systems are critical to a child's ability to learn (Peat, 2015).

Exercise prepares the learner for learning and it creates a better learner (Ratey, 2012). The correlation between exercise and achievement is well established in the literature; however, the construct explaining why this correlation exists remains unclear. The best and most popular explanation is that exercise affects executive functions that serve as the foundation for higher cognitive processes like planning and problem solving. Current exercise research psychology is dominated by this executive function hypothesis (Etnier & Chang, 2009).

Early executive function skills are correlated to long-term academic achievement in school (Best, Miller & Naglieri, 2011; Fuhs, Nesbitt, Farran, & Dong, 2014). Working memory is related to inhibition (Davidson, Amso, Anderson, & Diamond, 2006). Planning and organizing are critical for middle school success (Langberg, Dvorsky, & Evans, 2013), while improved

behavior is linked to improved general executive function (Young et al., 2009). Deficits in executive function can have life long lasting impacts related to social relationships and career success (Best et al., 2011; Bull & Lee, 2014).

The development of response inhibition, a core executive function, allowed human ancestors to resist immediate reward behavior that could have jeopardized their lives (Madigan, 2009). Children need proper development, enrichment, and remediation of these executive functions in order to learn. Rolling, crawling/walking and jumping correlate with the way that information travels in the brain (Madigan, 2009), and once developed, the brain uses these motor neural networks as a framework for other learning. Physical exercise provides the opportunity to practice and rewire brain systems to give the brain needed processing mechanisms for more complex problem solving later in life (Madigan, 2009). Best (2010) suggested that daily sedentary behavior in young children like watching television, reading or playing on the computer is not challenging enough to the brain and thus executive function growth is slower in sedentary children.

Meta-analysis results found that acute exercise improves inhibition/interference control (Verbugh, Konigs, Scherder, & Oosterlaan, 2013) which is particularly important for children with attention deficit/hyperactivity disorder who often have inhibition-related challenges in school (Scheres et al., 2004). Tomporowski et al. (2015) concluded that both acute and chronic sessions of exercise improved cognition. However, few studies have reported on the effects of chronic (long term) exercise on executive function specifically in healthy children (Fisher et al., 2011; Kamijo et al., 2011; Stroth, Hille, Spitzer, & Reinhardt, 2009).

Meta-analysis studies suggested that obese children and adolescents have cognitive deficits mostly related to executive function (Smith, Campbell, & Trollor, 2011). Some studies indicated that children, who are more fit, perform better and more accurately on executive function tests as compared to their less fit peers (Buck, Hillman, & Castelli, 2008; Hillman, Castelli, & Buck, 2005; Pontifex, Raine, Johnson, & Chaddock, 2011). Brain imaging indicated that children with higher fitness levels showed enhanced cognitive function (Chaddock et al., 2012).

Several researchers (Davis et al., 2011; Diamond, 2015) suggested that the effects of exercise on executive function became greater when the person shifted from simply moving to moving with thought which included activities such as Taekwondo and Yoga (Kamijo et al., 2011) and dance, band, drumming, and circus (Diamond, 2015). Activities that promote happy, calm, well rested, and socially supported students are especially critical to executive function (Diamond, 2012).

As a whole, executive function skills appear to be critical for school success (Alloway & Alloway, 2010; Borella, Carretti & Pelgrina, 2010; Duckworth & Seligman, 2005). Deficits in executive function often grow larger over time (O'Shaughnessy, Lane, Greshem, & Beebe-Frankenberger, 2003; Riggs, Blair & Greenburg, 2003). Long-term impacts in life include poorer health, less income, lower levels of happiness and higher likelihood of committing crime (Moffitt, 2012; Moffitt et al., 2011).

Schools are a quality environment to provide physical activity interventions since nearly all children spend approximately six hours each day in a school setting. The connection between physical activity and cognitive function exists both for acute (short) bouts of exercise (Hillman et

al., 2009) and chronic (long-term) exercise activity (Davis et al., 2007). The intensity of the exercise is an important factor related to improved cognitive function (Castelli, Hillman, Hirsch, Hirsch, & Drollette, 2011). This is a significant consideration for physical activity interventions as more vigorous physical activity has shown to produce improved cognitive function. Heart rate tracking is an effective way to ensure that the exercise is vigorous (Basset, 2000; Freedson & Miller, 2000; Laukkanen & Virtanen, 1998) and, thus, executive function impact maximized.

Educational policies would be advised to include recommendations for physical activity interventions with guidelines related to frequency, intensity, time and the type of physical activity. It is important to note that on average students were only active for nineteen minutes in a standard physical education experience (Coe, 2006) which is inconsistent with Davis et al. (2007) who cited that 40 minutes or more of vigorous physical exercise are needed to produce significantly better cognitive performance.

Exergames (video games that require physical movement, i.e., Nintendo's Wii Fit) may provide cognitive and academic performance benefits for children. Children who played more sessions of exergaming experienced larger executive function gains (Flynn, Richart, Staiano, Wartella, & Calvert, 2014) which may be important for school-related success. Core executive function skills support higher order skills such as problem-solving (Zelazo, Carter, Reznick, & Frye, 1997), and improved executive functions have been connected to improved reading and mathematics abilities (Blair & Razza, 2007; Riggs et al., 2004). Flynn et al. (2014) and Staiano, Abraham, and Calvert (2012) demonstrated that children are motivated and enjoyed playing exergames. When children perform tasks that they enjoy, their cognition is improved (Dias & Harris, 1990; Parker & Lepper, 1992).

Diamond and Lee (2011) stated that interventions must be sustainable to have the likelihood of improving executive function skills. Physical education curricula in many schools have begun to incorporate exergames as a valuable activity (Lieberman, 2006). Exergames are popular with adolescents and have power to promote physical activity even in children who typically are not involved with sports (Staiano & Calvert, 2011). Research on interventions of longer length would benefit from continuing to examine the long-term benefits of exergames on executive function (Flynn et al., 2014).

C8 Sciences (2015), a company created by Yale professors Bruce E. Wexler, M.D. and James F. Leckman, M.D., developed a program called ACTIVATE which capitalizes on an integrated brain, body and social intervention. The ACTIVATE program is designed to strengthen neurocognitive functions through a program which combines computer and physical exercises to treat children with ADHD and other executive function disorders. The program is adaptive, dynamic, and, when combined with the physical activity component of progressively challenging individual and group games, maintains the interest and engagement of the participants. According to the C8 Sciences (2015) website, the program dramatically improves working memory, self-control, sustained attention, cognitive flexibility, and other executive function skills. The program provides early cognitive intervention designed to help identify the causes of student cognition problems and uses National Institute of Health assessments to track a child's executive function development progress with real time data (C8 Sciences, 2015). The ACTIVATE program appears to be unique in that it is the only executive function intervention program that the researcher found to have an embedded executive function assessment contained in the intervention.

Specific physical activity interventions that are designed to incorporate both core executive functions and higher order cognitive processes may provide the right type of brain training to improve children's academic performance (Tomporowski et al., 2015). However, many obstacles exist to implementing this type of programming in schools.

While the research base is relatively limited, several recent well designed studies indicated that chronic (long term) exercise interventions benefit specific types of executive function skills in children (Tomporowski et al., 2011). These results parallel findings that older adults who participate in routine aerobic exercise conditioning show improved cognitive performance, particularly improved executive function (Colcombe & Kramer, 2003; Hillman et al., 2008; Tomporowski, 2006).

Promising strategies in schools involve integrating curriculum with physically active lessons, brain breaks to improve learning through activity, aerobic fitness sessions and mentally complex physical activity sessions (Peat, 2015). "A checklist for optimal brain function and learning should include balance, crossing the midline, motor skills, beat competency (keeping the beat) and beat awareness (hearing the beat), mirror neurons, visual fitness, and emotional safety" (Madigan, 2000, p. 291). Crossing the midline of the brain and the body aids in coordination of movements. These developmentally appropriate strategies appear to be the preferred approach in the future.

Poor knowledge of accepted guidelines for the desired amount of daily physical activity to achieve sound health may contribute to the problem of physical inactivity. It is reasonable to suggest that increasing this knowledge should be targeted by public health interventions (Zenko & Ekkekakis, 2015). Carlson et al. (2014) stated that only 45% of schools in United States

metropolitan areas are meeting the guideline of thirty minutes of moderate to vigorous physical activity per day. This is critical as research has indicated that moderate to vigorous activity has the most impact on priming the brain for learning.

It is important to understand those factors that may affect intrinsic motivation in children to exercise. “Most reviews of the motivational forces behind human exercise behavior still fail to recognize the role played by such affective factors as energy, exhaustion, excitement, boredom, pride, shame, gratification, embarrassment, happiness or fear” (Ekkekakis, Hargreaves, & Parfitt, 2013, p. 749)

In schools where greater environmental support for physical activity exists, students will be more physically active (Barnett, O'Loughlin, Gauvin, Paradis, & Hanley, 2006). However, factors that influence exercise opportunities for students in elementary schools have not been examined. Most research on children’s physical activity behavior today has focused on individual determinants of activity levels and little is known about environmental determinants. Barnett et al. (2006) described a study, which was the first to document physical activity opportunities available to children in elementary schools and to identify factors associated with increased availability. The level of physical activity opportunity in the study was related to the school principal’s level of physical activity and not that of the physical education teacher. Further, they found that school staff can influence the school environment by role modeling healthy behavior opportunities for physical activity, which may relate more to priority setting and decision-making by school principals. It would be advised that future study examine the role school principals play in implementing policies pertaining to physical education and physical activity and how personal preferences and lifestyle influences this process (Barnett et al., 2006).

Statement of the Problem

The literature review revealed that there is limited research that described successful implementation of the ACTIVATE executive function intervention program in elementary schools. The case study was an investigation of three elementary schools that have implemented the ACTIVATE program.

Purpose of the Study

There is a gap in the literature related to manner in which schools are using exercise to improve executive functions in preadolescent children. Recommendations for implementation will be summarized upon examining the case study elementary schools.

Assumptions of the Study

Assumptions are elements of the study that the researcher takes for granted (Roberts, 2010). The study assumed the following:

1. The principals and teacher leaders interviewed in the case study answered all of the interview questions with honesty.
2. The principals and teacher leaders interviewed in the study can remember and have processed the success factors and barriers to implementing the ACTIVATE program.
3. The principals and teacher leaders interviewed in the study were able to articulate their understanding of success and barriers to the ACTIVATE program.

Delimitations

Delimitations are choices made by the researcher, which should be mentioned. They describe the boundaries that have been set for the study (Roberts, 2010). The following are delimitations of the study:

1. The interviews were conducted in January through April of 2017 as part of a case study research design.
2. The location of the study was in the eastern region of the United States of
3. America.
4. The study included three elementary schools to ensure manageability.
5. Study participants included selected principals and/or teacher leaders at each participating elementary school. Principals provide program supervision for their schools and have decision-making abilities for their sites. Specific teacher leaders were typically in charge of implementation of programs and provided key insights into barriers and successes. The study did not control for either the principals' or teacher leaders' years of experience.
6. The study examined the barriers to and successes from implementing the ACTIVATE program for elementary aged children.

Research Questions

Upon review of the literature, gaps in knowledge were discovered regarding the implementation of exercise programs that improve executive function, specifically a program called ACTIVATE created by C8Sciences. The four research questions guiding the study were as follows:

1. What practices were used in the case study schools to implement the ACTIVATE executive function intervention program?
2. What benefits were reported for students who participated in the ACTIVATE program?

3. What barriers challenged the implementation of the ACTIVATE program?
4. What recommendations did case study schools provide for successful implementation of the ACTIVATE program?

Definition of the Terms

To clarify terminology in the review of literature, select terms and definitions have been provided. Specific types of executive functions are described below. C8Sceinces (2016) defines eight executive functions as follows:

BDNF (Brain Derived Neurotrophic Factor) is a protein which "improves the function of neurons, encourages their growth, and strengthens and protects them against the natural process of cell death. BDNF is a crucial biological link between thought, emotions, and movement" (Ratey, 2008, p. 40).

Category formation is the ability to prioritize tasks and organize information, skills, and concepts into meaningful categories to make the brain more efficient.

Cognitive flexibility is the ability to change what you are currently thinking or to switch thinking tasks.

FitnessGram is a physical assessment, which measures six areas of fitness including "aerobic capacity, percentage of body fat, abdominal strength and endurance, trunk strength and flexibility, upper body strength, and overall flexibility" (Ratey, 2008, p. 21).

Multiple simultaneous attention is the ability to maintain attention on two or more tasks with which the brain is engaged at the same time.

Pattern recognition is the ability of the brain to seek patterns and use those patterns to predict future events.

Response inhibition or *inhibitory control* refers to one's ability to control the response to events or distractions in the surrounding environment.

Speed of information processing is the ability to process simple information rapidly and efficiently.

Sustained attention is the ability to focus on tasks, either through listening, observing, or thinking over a period of time.

Working memory refers to the brain's ability to remember instructions or hold information long enough to perform complex tasks like interpreting language, thinking, and learning.

The review of literature includes tests of core executive function skills (van der Niet, Hartman, Smith, & Visscher, 2014) such as:

The *Stroop Test* (Golden version) measures inhibition and requires a participant to complete three reading segments in 45 seconds each. On the first portion, a child is expected to read aloud words of colors written in black ink (i.e., red, yellow, green). On the second portion, a child is expected to name the colors of colored rectangles. On the last portion of the test, a child is expected to indicate the color of the ink, rather than a printed word (i.e. Word is red, but printed in green ink). The higher the score, the more a child is able to control attention and behavior related to a task while ignoring extraneous information (Diamond, 2013).

The *Visual Memory Span Test* measures a child's ability to hold and manipulate information in the brain, also termed working memory. The test involves a child repeating the pattern of colored squares that were touched by the test administrator, but performing it in

backward order. The test is completed when a child is unable to repeat two sequences of patterns of the same length.

The *Trailmaking Test* measures cognitive flexibility or the ability to change attention and switch rapidly between different thoughts. In one part of the test, a child is asked to connect circles in numerical order. Then, the child is asked to connect circles but quickly alternate between both numerical and alphabetical order (Reitan, 1971).

The *Tower of London Test* measures planning ability. In the test a child has a limited number of moves to relocate three colored balls on three colored pegs to create a specific pattern (Shallice, 1982).

Summary

The study is organized in five chapters. Chapter I introduced the topic of the case study and provided background information and contributing research studies. Further, the chapter provided a statement of the research problem, purpose of the study, significance of the study, research questions, assumptions, delimitations, and definition of terms. Chapter II contained the review of literature which focused on the history of exercise to improve brain function, the link between exercise and achievement, the link between exercise and executive function, exercise related interventions used to improve executive function, and the barriers to implementing exercise for executive function. Chapter III furnished the study's research design, participants, instrumentation, data collection procedures, and data analysis. Chapter IV prepared the study findings. Chapter V presented conclusions, limitations, and recommendations for professional practice.

Chapter II: Literature Review

The fundamental purpose of schools is to provide high levels of learning for all students using the most efficient and effective methods possible. To achieve these high levels of learning, schools may benefit from understanding factors that affect the ability of the brain to learn. One of the factors studied in this review of literature is the impact of physical exercise on the brain's ability to learn including achievement and executive function.

Physical movement has historically allowed humans to locate and gather food sources and escape unsafe environmental situations. This movement brought with it new experiences and new stimuli for the brain to interpret. In the brain, this information from the environment either is processed, sorted and stored as important memories and knowledge (learning) or is dismissed. The health of the body allows for more movement, more opportunity for stimuli and potentially more opportunity for the brain to learn.

The review of literature will summarize how humans have used exercise to promote healthy bodies and brains, the relationship between exercise and academic achievement, the impact of exercise on executive function and will examine how elementary schools are utilizing exercise interventions for learning, including barriers to implementation in schools.

To better understand this literature review, definitions of some concepts and terms related to physical activity and exercise need to be clarified. Physical activity is movement of the body by the muscular system. Physical activity can range from low intensity, short duration to high intensity, long duration. The energy required to move the body vary based on the particular activities. Physical fitness describes the body's ability to respond to the intensity and duration of the activity. Exercise is a structured and repetitive type of activity chosen to improve the fitness

and health of the human body (Dishman et al., 2006). Exercise activities generally fall into four main categories: endurance, strength, balance and flexibility. Humans are the only organism to do planned exercise.

Benefits of Exercise on the Body and Brain

Physical exercise has long been part of human culture and the concept of prescribing physical exercise to maintain health has existed for thousands of years. A physician named Susruta in 600 BCE (Before Common Era) prescribed exercise daily as a means of maintaining the health of the human body (Tipton, 2014).

> Susruta advocated exercise because it made the body stout, strong, firm, compact, and light, enhanced the growth of limbs and muscles, improved digestion and complexion, prevented laziness, and reduced senility while being absolutely conducive to a better preservation of health. (Tipton, 2014, p. 110)

Citizens of Greece regarded physical exercise as part of their culture which led to the construction of many gathering places for exercise or public gymnasiums (Tipton, 2014). A disciple of Hippocrates, Diocles was a physician (375-300 BCE) who advised children to visit the gymnasium twice daily for its exercise benefits (Tipton, 2014). Tipton (2014) described how Spartan culture initiated physical exercise training with males at seven years old and put them on a track to be a physically fit warrior. Intense training consumed much of the day and at least one culture (the Aristophanes) claimed that Spartans were exercise addicts (Tipton, 2014).

The benefits of exercise to human physical and mental health have been known for thousands of years. Hippocrates (460-370 BCE) was one of many early physicians who prescribed exercise for patients (Tipton, 2014). Tomporowski et al. (2011) noted that ancient

Greek philosophers promoted exercise to create a sound mind in a sound body and the role of physical education can be traced back to ancient Greek and Roman cultures. Even though this knowledge existed in ancient cultures, its advancement in application through modern times has remained quite slow.

The history of offering physical education in schools in the United States is relatively sparse until near the end of the 19th century. In 1866, California became the first state to create legislation ensuring that physical education be part of the public school educational experience (Hackensmith, 1966). In 1893, Thomas Wood advocated for physical education as a means to foster social, emotional and intellectual development. He believed that physical education was critical for whole child development (Rice, Hutchinson, & Lee, 1969). As national priorities shifted in the United States, so did policy regarding the content of physical education. With the onset of World War I, an emphasis on individual physical fitness became critical as many recruits were found to be unfit (Lumpkin, 2008). A similar emphasis occurred at the beginning of World War II, where the physical fitness levels of soldiers became a matter of national security (Lumpkin, 2008). With the rise of popular sports and games in the 1960s and 70s, the shift was made to general physical education while at the same time the research on the importance of physical movement to learning was beginning to emerge (Tomporowski et al., 2011).

van Praag (2009) wrote that in 1975, physical fitness and physical education were not respected as critical school programming elements. Within 10 years, this attitude toward physical fitness and education began to change when exercise was listed as one of 15 areas of greatest importance for improving health of the public (van Praag, 2009). Studies consistently

illustrated that the probability of acquiring a particular disease is greatly reduced when participating in a regular exercise regimen (van Praag, 2009). However, these positive benefits on the health of the brain and its functions are still not well-appreciated (van Praag, 2009).

What has become clearer over time is the amount of exercise needed to maintain body health. In 2006, the American Heart Association, the United States Surgeon General, the Centers for Disease Control and Prevention (CDC), and the American College of Sports Medicine recommended at least 30 minutes of moderate-intensity physical activity on six to seven day per week cycle (Marcus et al., 2006). In the last decade, the United States Department of Health and Human Services recommended that children engage in at least 60 minutes of moderate physical activity every day. However, the children of the United States are not doing very well on this recommendation as the American College of Sports Medicine found that in 2014, only 25% of children ages 6-15 are active for 60 minutes a day. This may have implications for school programming since students spend a considerable portion of their day at school. In addition, as electronics become more popular, participation in youth sports has fallen about 10 percent since 2009 making the achievement of this recommendation even more challenging (Maese, 2015).

These recommendations still fall short of the physical activity levels from which the human brain has evolved. For typical Americans to approximate the energy expenditure of hunter-gathers (evolutionary ancestors) it would require adding a 12 mile walk to each day's current activity level (Cordain et al., 1998). At four miles per hour, this is the equivalent to three hours of physical movement in addition to a typical, modern human's daily activity level (Cordain et al., 1998). Understanding the conditions under which human brains have evolved is an important consideration for the structure of the learning environment as schools try to

maximize learning on any given day. Today's learning environment is more sedentary compared to the learning environment in the past.

There is significant evidence that regular physical exercise positively affects health across a wide range of variables. These benefits include reducing the risk of heart disease, cancers and diabetes (Blair, 2009). Approximately 16% of deaths in women and men can be attributed to low cardiorespiratory fitness (Blair, 2009). Blair (2009) continued to describe obese men who are moderately to highly fit as having less than half of the risk of death compared to their normal weight peers who are unfit.

Recently, programs have been designed to use exercise to improve health in adolescents. The CATCH (Child and Adolescent Trial for Cardiovascular Health) program had successfully changed student's nutrition intake and physical activity levels (Marcus et al., 2006). Marcus et al. (2006) stated that SPARK (Sports, Play and Active Recreation for Kids) is a health-related physical education program that produced several favorable outcomes as a large percentage of teachers continued to implement the program for students up to four years after initial training. School-based physical activity programs have had some long-term viability and can be diffused and maintained; however, the diffusion of additional evidence-based programs needs to be documented. Effective methods of spreading evidence-based programs need to be generated so learning from intervention studies related to physical exercise can be translated into improvements in overall public health (Marcus et al., 2006).

It is common knowledge that animal models have long been used in scientific studies to advance understanding of the human brain. The impacts of exercise on brain development were first reported in groundbreaking research, which included animal models, specifically rats and

mice. Some of the first studies involved the placement of running wheels inside the cages of mice. When doing so it was found that mice who had access to running wheels literally changed the structure of their brains. Mice housed with running wheels had about a threefold increase gain in vascular tissue in the dentate gyrus (Clark, Brzezinska, Puchalski, Krone, & Justin, 2009). The dentate gyrus is a part of the brain found in the hippocampus which is functionally tied to learning and memory (Clark et al., 2009). Aerobic physical activity (running on a wheel) whether voluntary or forced massively increased neurogenesis (new neuron formation) in the dentate gyrus of mice and rats (Clark et al., 2009).

> The brains of mice are a good model for the brains of humans. "The remarkable similarities between the exercise-induced cerebral blood volume changes in the hippocampal formation of mice and humans suggest that the effect is mediated by similar mechanisms. Of course, in contrast to mice, it is impossible to directly confirm whether the changes in dentate gyrus cerebral blood volume observed in humans are a reflection of neurogenesis. (Pereira et al., 2007, p. 56)

There is a positive relationship between blood flow and neuronal activity in the brain (Ekkekakis, 2009). Brains are studied through a variety of visualizations including Near-Infrared Spectroscopy which tracks where oxygenated blood travels in the brain (Ekkekakis, 2009). It does not take a lot of body movement to increase the oxygenation of the prefrontal cortex. Exercising for as little as 10 minutes at 60% of VO_{2max} can greatly increase the amount of oxygenated blood in the prefrontal cortex of the brain (Ekkekakis, 2009). van Praag (2009) described exercise as an activity that increases blood flow in the brain, which creates a

mechanism to fuel the construction of new neurons. Exercise selectively increases blood flow to the Dentate Gyrus of the Hippocampus and is correlated to aerobic fitness (Pereira et al., 2007).

Consistent physical activity after even a short time improves factors that control brain growth. For example, after one week of voluntary wheel running, the capacity for learning and memory in the brains of rats is improved (Dishman et al., 2006). Exercise increases the release of brain-derived neurotrophic factor in the hippocampus, a critical area responsible for learning and memory. The function of BDNF has been shown to be deeply involved in learning and memory (Gomez-Pinilla, Vaynman, & Ying, 2010). Other neurotrophic factors including nerve growth factor, vascular endothelial growth factor, granulocyte colony-stimulating factor and insulin-like growth factor have been shown to be increased by physical exercise in humans. These other neurotrophic factors play a critical role in the growth and survival of neurons which influences learning, memory and processes important for cognitive functioning (Dishman, et al., 2006; Ferris, Williams, & Shen, 2007; Floel et al., 2010; Voss, Nagamatsu, Liu-Ambrose, & Kramer, 2011).

Wrann et al. (2014) shared that exercise can improve brain function and has been linked to the quantity of BDNF (Brain Derived Neurotrophic Factor) released. Exercise changes body chemistry by releasing proteins, nutrients and other substances into the blood. Exercise stimulates the release of a muscle protein called $FNDC_5$ (Aguirre, 2015). Aguirre (2015) cited that this protein diffuses into the blood and makes its way to the brain where it tells the brain to release BDNF. BDNF acts like a "Miracle Grow" for the brain, helping to establish new neurons, nourish existing neurons and promote the survival of existing brain cells (Ratey, 2008). Other researchers have provided similar conclusions (Szuhany et al., 2014). For example,

physical exercise, specifically aerobic exercise, through a cascade of chemical events including the release of BDNF, promotes the development of new neurons and thus the opportunity for improved memory and learning (Aguirre, 2015). BDNF is rapidly and specifically released in the hippocampus during contextual learning events, and is critical for the formation of long-term memories that depend on the hippocampus (Barrientos et al., 2011). BDNF has been connected to the development of neurons that are linked to the executive function, impulse regulation (Hyman, et al., 1991; Knusel et al., 1991). Physical exercise increases hippocampal BDNF and enhances memory performance on tasks (Barrientos et al., 2011). To further demonstrate this strong connection, in humans that have a mutation in which the gene that regulates BDNF is restricted, brain development and memory function are impacted (Wrann et al., 2014).

The hippocampus is a small structure in the brain that is important for learning and memory. Exercise of the body causes the hippocampus to reproduce new neurons. Exercise also influences angiogenesis (expansion of vascular tissue) in the brain. Exercise is a quantifiable activity that improves cognition in young and aged animals and humans. According to Madigan (2000), exercise leads to:

> Twice as much learning power with the growth of an estimated 9000 thinking cells (neurons) daily, more neurons in the learning and memory center of the brain called the hippocampus, protection of the brain functions for increased brain function and health, more connections among existing neural pathways in the brain, increased brain organization and integration. (p. 5)

Exercise also increases the size of physical structures of the brain. Exercise helps improve the condition of the brain in elderly humans by protecting it against a decline in

cognitive functioning. Recent reports have established that aerobic exercise increases the volume of the hippocampus, improves spatial memory and reduces the decline in other cognitive functions of aging humans (Barrientos et al., 2011). Evidence suggests that exercise reduces the risk of dementia (Barrientos et al., 2011). Understanding the impact of exercise on the hippocampus is important because this is a critical area of the brain responsible for memory function and is also an area of the brain largely affected by aging (Pereira et al., 2007).

These studies provided a mechanism for how exercise can affect learning. Exercise causes an increase in blood flow, release of BDNF and promotes neuron growth in the Hippocampus which is an area of the brain responsible for memory formation (Barrientos et al., 2011). As an evolutionary construct, learning ability is related to skeletal movement as a way of obtaining energy balance by improving the human's ability to obtain food and survive in nature (Gomez-Pinilla et al., 2010). Learning and movement are linked in the brain (Ratey, 2008).

Wrann et al. (2014) reported that there is a positive correlation between endurance exercise capacity and human brain size, which suggests that human cognition and the ability to move the body greater distances evolved together. The ability to complete more complex tasks requires a more complex brain.

> Foraging in wide and open spaces in the savannas put high demands on spatial orientation, as well as the ability to acquire and retain new information. Therefore, individuals with a more complex brain who performed better at these tasks might have had an evolutionary advantage. On the other hand, since endurance exercise clearly increases expression of BDNF in the brain, improvements in the exercise capacity might

> have positively enforced brain growth, especially in the hippocampus. (Wrann et al., 2014, p. 7)

As humans move into late adulthood, the hippocampus shrinks which causes memory to erode and increases the possibility of dementia (Erickson et al., 2011). Erickson et al. (2011) articulated that the volume of the Hippocampus and medial temporal lobes of the brain is greater in older adults with higher fitness levels but the extent to which aerobic exercise can change this volume is not clear. In a randomized controlled trial with 120 older adults, aerobic exercise increased the size of the anterior hippocampus, leading to improvements in spatial memory. Exercise training increased hippocampal volume by 2%, which is equivalent to reversing age-related brain volume loss by 1-2 years. The researchers further demonstrated that increasing the volume of the Hippocampus is correlated with greater levels of BDNF in the blood stream and BDNF neurogenesis in the dentate gyrus. In the control group, the volume of the Hippocampus decreased. In summary, the researchers concluded that aerobic exercise training can effectively reverse hippocampal volume loss in late adult life, thus improving memory function (Erickson et al., 2011).

Erickson et al. (2011) also found that aerobic exercise training increases volume of gray and white matter in the prefrontal cortex of older adults and improves executive function. Greater amounts of physical activity were associated with the preservation of prefrontal and temporal brain regions over a nine-year period, which lowers the risk for loss in cognitive function. Several parts of the brain, including the hippocampus and medial temporal lobe were larger in volume in higher fit older adults and a brain with a larger hippocampus shows

improvements in spatial memory. The researchers concluded that overall, exercise promotes greater blood flow in the hippocampus (Erickson et al., 2011).

The Erickson et al. (2011) experiment was developed to determine whether exercise training increases the size of the hippocampus and improves spatial memory. It was a single blind, randomized controlled trial in which adults were randomly assigned to receive either moderate-intensity aerobic exercise (40 minutes of walking at 60-75 % of target heart range) three days per week or stretching and toning exercised that served as a control. One hundred and twenty adults without dementia were randomly assigned to either group. Magnetic Resonance Imaging (MRI) was used prior to experiment as a pre-assessment of current brain structures and six months after as a post assessment of brain structures. The researchers concluded that the front of the hippocampus grew in size and increased in both study groups but significantly more in the aerobic exercise group ($P < 0.0001$). The researchers suggested that higher aerobic fitness levels at baseline and after intervention were associated with better memory performance on the spatial memory task. $P < 0.004$. The spatial memory task asks participants to follow 1, 2, or 3 black dots on a screen, and wait two seconds to determine if a new red dot is a match to previous black dot locations (Erickson et al., 2011).

In one study, Fotuhi (2013) shared that 9- and 10-year-olds with higher levels of physical fitness had "hippocampi that were 12% larger relative to total brain size than their less fit peers" which is significant as the hippocampus is understood to be "the gateway for new memories and essential for learning" (p. 16).

Olga Kotelko is well known for becoming a dominant athlete beginning at the age of 77. When she died at age 95, her brain was studied and it was found that her brain, specifically the

hippocampus, was much larger than her same age peers (Reynolds, 2015). Reynolds (2015) described a study where physically active adults were found to have better oxygenation and healthier patterns of brain activity. He concluded that elderly people who walk, garden or simply move more each day have brains that appear to be in better shape than their same age peers.

Exercise Impacts on Immunity and Prevention of Disease

It is important to note that the impact of exercise on brain function in older adults parallels that found in children. However, as the brain ages, mental decline becomes more likely. If exercise helps fosters healthy brain development in children, then it is reasonable to assume it bolsters brain maintenance in older adults. The literature appears to support this. As adults age, the hippocampus begins to atrophy and may cause impaired memory. Decreased levels of BDNF have been found in these older brains, which may be further linked, to Alzheimer's (Erickson et al., 2012; Murer et al., 2001). Older adults with infection-induced cognitive loss have benefited from small to moderate amounts of physical activity (Barrientos et al., 2011). In patients with traumatic brain injury, exercise has shown improvements in healing (Dishman et al., 2006). Exercise, especially aerobic, has been used as a natural antidepressant, to ward of the effects of dementia and improve neurocognitive function all while reducing many intolerable side effects commonly found in many pharmaceutical treatments (Erickson et al., 2011; Madigan, 2009). Exercise even reverses damage to the brains of animals. In a population of rats that were subjected to memory impairment via bacterial infections, running wheel exercise completely eliminated the memory impairment in the span of six weeks (Barrientos et al., 2011).

Summary. Physical exercise has historically been part of human culture and the concept of prescribing physical exercise to maintain health has existed for thousands of years. A few

decades prior to the 20th century, physical education became more prominent as California became the first state to create legislation ensuring that physical education be part of the public school educational experience (Hackensmith, 1966). The United States Department of Health and Human Services now recommends that children engage in at least 60 minutes of moderate physical activity every day (Maese, 2015) which is still far less than that of our evolutionary ancestors (Cordain et al., 1998).

There is strong empirical evidence in the literature that exercise improves blood flow to the brain, the development of new neurons (neurogenesis) and improves memory in animals. Even brief bouts of aerobic physical activity, whether voluntary or forced, greatly increases the construction of neurons in the hippocampus of both mice and rats (Clark et al., 2009). There is significant evidence which indicates that exercise, specifically running (Tomporowski et al., 2015), improves many different body systems (Tomporowski et al., 2015) and changes structures and functions in the brain (Chaddock et al., 2011; Hillman et al., 2008). A mechanism for how exercise affects the human brain may explain why exercise affects a brain's ability to learn.

Impact of Exercise on Academic Achievement

The research investigating the impact of exercise on achievement has grown substantially in the last 20 years and much of the inspiration for these studies can be traced back to the rat and the running wheel experiments. Ratey (2012) cited a number of animal studies where exercise and achievement were strongly correlated. In one study, 200 male rats were subjected to stroke like surgery and then split into a control and experimental group. The experimental group was put on a passive exercise routine the next day. When the rats had to complete an escape task from a water maze, the rats who were on the exercise program were able to escape significantly

quicker. These rats were learning faster than the other groups and the only variable was exercise after stroke like conditions (Li et al., 2014).

Rats who were allowed to run on a running wheel for eight weeks had three times the amount of brain derived neurotrophic factor in their blood. The same study found that older rats who exercised were smarter than sedentary younger rats (Madigan, 2000). This major finding grew a field of research that went from 10 published papers per month to 40 published papers per week. The implications for the human brain gained renewed interest.

Health organizations and members of scientific communities have outlined and researched the benefits of physical activity in children and adolescents (Tomporowski et al., 2011). The physical health improvements to the body are well noted (Malina, Bouchard, & Bar-Or, 2004) and the probability that exercise also improves mental abilities had been raised through a ground breaking meta-analysis (Sibley & Etnier, 2003). In summary, the results of numerous correlational studies indicate that a moderate to strong positive correlation exists between physical fitness levels and academic achievement (California Department of Education, 2005; Carlson et al., 2008; Roberts et al., 2010).

The literature describing the correlation between aerobically fit children and achievement in school is vast. However, the first studies on children exploring the relationship of acute (short-term) exercise on classroom behavior and achievement were generated from anecdotal observations in which recess activities were believed to create over excitement in children. This was hypothesized to have a negative influence on learning (Tomporowski et al., 2011). Mid-20th century education programming often viewed recess and physical activity as distracting factors

that inhibited learning. However, the studies that followed this time period began to reject this hypothesis.

Gabbard and Barton (1979) tested 106 sixth-grade girls and boys immediately after 20, 30, 40, and 50 minute sessions of vigorous exercise. They found that the children's math computations improved dramatically after a 50-minute acute (short-term) exercise session. A similar result was found by McNaugthen and Gabbard (1993) in a replication study. In 2000, Madigan published a finding that exercise enhances reading and math scores, a student's reading comprehension and analysis, raises IQ, correlates with higher grade point averages, enhances creativity, improves focus, reduces truancy and drop out statistics, and improves language acquisition.

In 2005, the state of California reviewed their FitnessGram data (physical fitness test) and correlated it to achievement results on the Stanford Achievement Test. The data was analyzed from over 300,000 students. Students who only met one of the six physical fitness requirements on the FitnessGram had a statistically lower achievement test score than students who met all six of the physical fitness criteria (California Department of Education, 2005). In addition, it was noted that the more FitnessGram tests the students passed, the higher their achievement score tended to be (Kedler, 2012). A similar study was replicated with Grade 3-12 students in the state of Texas in 2009 with the same results. The data from over three million students was included in the study. Schools with high performance had more students scoring high on the FitnessGram (Kedler, 2012). Students with higher aerobic fitness had a higher probability of passing the Texas state achievement test, had higher global intelligence, and higher attendance rates in school

(Kedler, 2012). Legislation has since been proposed in the state of Texas, which would require 60 minutes of exercise each day for school age youth.

Kedler (2012) discussed the results of a CDC report consisting of over 260 studies on exercise and achievement. His research confirmed that in this time of high stakes standardized testing, ensuring that physical exercise is incorporated into the learning day would improve test scores and raise student achievement. Ratey (2012) described a 26-year-long study in which 1.2 million 15-year-old Swedish boys were baseline tested for cardiovascular fitness and IQ and then tested again at age 18. Those who improved their cardiovascular fitness also raised their IQ. One of the remarkable parts of the study is that the results were consistent even while controlling for genetic factors (i.e., comparing brothers and twins). The implication from their study was that an environment of physical exercise could change the brain enough to raise IQ. To some degree, IQ must then be malleable (Ratey, 2012).

In their 2013 meta-analysis exploring the effects of cardiovascular exercise on human memory, Roig et al. found that short bouts of exercise (acute exercise) had significant impacts on memory. As an example, two acute exercise sessions of only three minutes of intense treadmill running applied prior to an associative vocabulary task showed increased levels of dopamine (Chowdhury, Guitart-Masip, Bunzeck, Dólan, & Dűzel, 2012) and epinephrine (Cahill & Alkire, 2003), a 20% improvement in vocabulary learning and improvement in long-term word recall (Winter, et al., 2007). This research is consistent with a large body of evidence on rodent studies, which strongly show that repeated sessions of exercise produce large improvements in memory tasks involving the hippocampus (van Praag, Christie, Sejnowski, & Gage, 1999; Vaynman, Ying, & Gomez-Pinilla, 2004).

A biological framework to explain the connection between exercise and achievement is beginning to materialize (Peat, 2015). As the brain develops, its ability to control movement of the body improves in ways that lay the foundation for all future learning. Brain science strongly supports the link of movement to learning. The brain and body's movement and learning systems are interdependent and interactive. For example, motor development provides the framework that the brain uses to sequence the patterns needed for academic concepts. The body's vestibular system controls balance and spatial awareness and facilitates the student's ability to place words and letters on a page. Proper development and remediation of these systems are critical to a child's ability to learn (Peat, 2015).

If movement can improve learning then the opposite should also hold true in that being sedentary activity should inhibit learning. Peat (2015) found this to be the case. Sitting in a chair appears to inhibit learning. Sitting for longer than 17 minutes causes blood to settle in the upper and lower leg muscles reducing the level of oxygen and glucose being provided to the brain (Peat, 2015). Melatonin gets released by the brain, the brain slips into a resting state, since the body is not moving and the brain becomes lethargic, sleepy, struggles to focus and the ability to learn is decreased (Peat, 2015).

Summary. The research investigating the impact of exercise on achievement has grown substantially in the last 20 years and much of the inspiration for these studies can be traced back to the rat and the running wheel experiments (Madigan, 2000), which generated a renewed interest in the impact of exercise on the brain. As a result, health organizations and members of scientific communities have outlined and researched the benefits of physical activity in children and adolescents (Tomporowski et al., 2011; Sibley & Etnier, 2003). The literature describing the

correlation between aerobically fit children and achievement in school is vast and include benefits to reading and math scores (Kedler, 2012), reading comprehension and analysis, improved IQ (Ratey, 2012), higher grade point averages, creativity, focus, reduced truancy and drop out statistics and improves language acquisition (Madigan, 2000).

A biological framework to explain the connection between exercise and achievement is cited by Peat (2015), who explained that motor development provides a framework for the brain to sequence the patterns needed for academic concepts and the body's vestibular system controls balance and spatial awareness and facilitates the student's ability to place words and letters on a page. Proper development and remediation of these systems are critical to a child's ability to learn (Peat, 2015). Sitting inhibits learning (Peat, 2015) while exercise prepares the learner for learning and it makes a better learner (Ratey, 2012). Meta-analytic results indicate that, "there is substantial evidence that academic achievement and measures of executive function are correlated—both at a single point in time and as a predictor of future achievement, and for a variety of different constructs and age groups" (Jacob & Parkinson, 2015, p. 18).

The correlation between exercise and achievement has been presented however, the construct explaining why this correlation exists remains unclear. The best and most popular explanation is that exercise affects executive functions that serve as the foundation for higher cognitive processes like planning and problem solving (Etnier & Chang, 2009. Current exercise research psychology is dominated by this executive function hypothesis (Etnier & Chang, 2009).

Impact of Exercise on Executive Function of Elementary Aged Children

Executive function refers to core processes in the brain that occur in time periods ranging from seconds or milliseconds to those that occur across several seconds or minutes. Core or

baseline executive functions observed in early childhood include inhibition (thinking before acting), working memory (holding information in the mind for short-term work) and cognitive flexibility (ability to adjust to changing demands and priorities) (Steenbergen-Hu, Olszewski-Kubilius & Calvert, 2014).

Early executive function skills are correlated to long-term academic achievement in school (Best et al., 2011; Fuhs et al., 2014). Working memory is related to inhibition (Davidson et al., 2006). The executive functions of planning and organizing have been found to be critical for middle school success especially for students diagnosed with Attention Deficit and Hyperactivity Disorder (ADHD) (Langberg et al., 2013). Improved behavior has been linked to improved general executive function (Young et al., 2009). In order for these executive functions to develop to their capacity, they must be repeated and challenged through ever-increasing task difficulty to generate growth in children (Diamond, 2013). Deficits in executive function can have life long lasting impacts related to social relationships and career success (Best et al., 2011; Bull & Lee, 2014). The research highlights that quality executive function is critical to the success of the child in school and later as an adult in life.

From an evolutionary standpoint, growth in executive function may have improved human survival rates because physical movement was central to existence and moving intelligently through the environment was essential for survival (Ardila, 2008; Barkley, 1996). At some point in human evolution, brain systems developed to control voluntary motor actions and this was an important milestone in adapting behavior to improve chances for survival (Ardila, 2008; Barkley, 1996). The development of response inhibition, a critical executive function, allowed human ancestors to resist immediate reward behavior that could have

jeopardized their life. "Instead of responding reflexively and mindlessly to environmental events, our ancestors began to ponder the benefits of initiating later goal-directed behaviors. Behavioral inhibition is viewed as a cornerstone of executive function" (Tomporowski et al, 2011, p. 55). Thus, the framework for connecting physical movement to executive function can be found in the evolutionary past of human ancestors. Thinking is the evolutionary internalization of movement (Ratey, 2012).

The framework for learning is constructed through movement. Madigan (2009) described a student's physical movement, emotional, social and cognitive learning systems as interactive and interdependent. If a child does not have proper development, enrichment, and remediation of these systems, it may affect their long-term ability to learn. There are three basic human motor movements: rolling, crawling/walking and jumping. These correlate with the way that information travels in the brain: side to side across the corpus callosum, back to front across the motor cortex and up and down from the bottom to the top of the brain (Madigan, 2009). Once developed, the brain uses its motor patterns as the framework for other learning. If the body's motor, balance and vestibular systems are not developed properly then the brain may not have the mechanisms necessary to process information. For example, if a child did not crawl or crawl enough, the brain may not have developed its pathways to process information and could struggle to learn as efficiently (Madigan, 2009). Physical exercise provides the opportunity to practice and rewire brain systems to give the brain needed processing mechanisms for more complex problem solving later in life (Madigan, 2009).

The prefrontal cortex controls executive function of the brain and it is turned on when a student exercises (Ratey, 2012). Regular aerobic exercise performed at moderate to vigorous

intensity can create chemical and physical changes in the brain areas that are responsible for executive function (Best, 2010). Best (2012) continued to describe play and other childhood physical activities as being important to development of executive functions. The opposite of this may also be true as one study reported that sedentary behavior correlated with lower performance on the Stroop test (Best, 2010). The study suggested daily sedentary behavior in young children like watching TV, reading or playing on the computer is not challenging enough to stimulate the inhibition network in the brain and executive function growth is slower in sedentary children.

Benefits were cited in the literature for exercise even if the exercise sessions were very brief. The meta-analysis results presented by Verbugh et al. (2013) found current literature in support of improved executive function as a result of acute exercise. Acute exercise consists of a single, short-term activity usually lasting 10-40 minutes whereas chronic exercise consists of a regular exercise program, multiple days per week, typically lasting 6 to 30 weeks (Verbugh et al., 2013). Most of the studies of acute exercise focused on measuring the impact on the executive function of inhibition/interference control. These studies showed a positive correlation between acute exercise and this particular executive function (Verbugh et al, 2013). This is particularly important for children with ADHD who often have challenges related to inhibition, which can lead to a cascade of negative outcomes for traditional school including poor academic performance, disrupted cognitive performance, and lagging behavior and social skills (Scheres et al, 2004). Some researchers have reported positive outcomes for students with ADHD when they utilize a regular physical training routine including improved behavior and cognition (Maddigan & Hodgson, 2003; Tantillo, Kesick, Hynd, & Dishman, 2002).

Although no impact on executive function was observed in studies involving chronic exercise as reviewed by Verbugh et al. (2013), the researchers noted that a very limited number of studies (five, but only four in pre-adolescent children) met the inclusion criteria for the meta-analysis. Even broader, few studies in this the literature have reported on the effects of chronic exercise on executive function specifically in healthy children (Fisher et al., 2011; Kamijo et al., 2011; Stroth et al., 2009). Improvements in working memory (Kamijo et al., 2011) and inhibition and cognitive flexibility (Hillman et al., 2014) were found in two studies that did report improvement in executive function because of a monthly after school activity program.

A review of the literature revealed that researchers have hypothesized overall fitness levels to be linked to executive function. A recent meta-analysis suggested that obese children and adolescents had cognitive deficits mostly related to executive function (Smith, et al., 2011) and one study reported a significant positive impact of 40 minute sessions of chronic physical exercise on the executive function of overweight children (Davis et al., 2011). Some studies indicated that children, who are more fit, perform better and more accurately on executive function tests as compared to their less fit peers (Buck, Hillman, & Castelli, 2008; Pontifex, Raine, Johnson, & Chaddock, 2011).

Brain imaging has greatly improved scientists understanding of the brain. Using functioning magnetic resonance imaging (fMRI) researchers found that subjects with higher fitness levels showed, “a superior ability to activate frontal and parietal brain regions important for the monitoring, maintenance, and strategizing of higher-level cognitive control abilities, important skills for academic performance” (Chaddock et al., 2012, p. 266). In follow-up studies, 8- and 9-year-old children who completed a daily average of 77 minutes of vigorous

physical activity, had fMRI scans that showed more efficient functioning of the prefrontal cortex which is the area of the brain that manages executive function and higher order thinking (Chaddock et al., 2012).

Hillman et al. (2005) conducted a study which assessed the aerobic fitness and cognitive function of high vs low fit preadolescent children and adults. In the preadolescent group, 24 students were compared. Fitness levels were assessed using the FitnessGram test and cognitive function was assessed by measuring, "neuroelectric and behavioral responses to a stimulus discrimination task" (Hillman et al., 2005, p. 1). The researchers concluded that fitness levels were positively associated with attention, working memory and response speed in the preadolescent children. They suggested that improving fitness levels in children may be a route to improving cognitive function skills of the brain (Hillman et al., 2005).

The way in which the exercise program is administered may affect a measurable result in executive function. To improve executive function, an activity with incremental task difficulty is needed (Diamond & Lee, 2011). Budde, Voelcker-Rehage, Pietrabyk-Kendziorra, Ribeiro, and Tidow (2008) found that a 10-minute session of mentally engaging exercise resulted in greater improvements in pre-adolescent executive function than sessions of exercise that were not mentally engaging. Pesce, Crova, Cerreatti, Casella, and Bellucci (2009) reported similar findings after children participated in a 40-minute aerobic, mentally engaging exercise session they had improved memory performance compared to the control group. A review of 11 experiments in 2008 by Tomporowski et al. revealed that aerobic training improves children's executive function.

Diamond (2015), in her review of the literature (15 studies meeting criteria), suggested that the effects of exercise on executive function become greater when the person shifts from simply moving to moving with thought. In other words, if the exercise requires thinking or active engagement and challenge to the pre-frontal cortex the impact on executive function will be enhanced. Although aerobic running appears to improve executive function more than standard physical education (Kamijo et al., 2011), Taekwondo and Yoga appear to improve executive function more than simple aerobic activity. For example, students randomly assigned to Taekwondo showed greater improvement and post-test scores on all executive functions measured than students who were randomly assigned to regular physical exercise (Lakes & Hoyt, 2004). Additionally, students randomly assigned to yoga showed greater improvement on the Tower of London (multi-step problem solving) executive function task when compared to randomly placed students performing physical exercise (Manjunath & Telles, 2001). Davis et al. (2011) concluded that exercise that causes a child to think, has a greater impact on executive function growth than less cognitively engaging exercise. Diamond (2015) predicted that exercises like dance, band, drumming, circus, martial arts, yoga and, in particular, activities that require progressive improvement in bimanual coordination, hand-eye coordination, crossing the midline and or rhythmic movement, might be particularly valuable to study. The impact of these types of activities could provide insight as to effective executive function interventions. Diamond (2012) extended that prediction to include activities or interventions that promote happy, calm, well rested, and socially supported students as the absence of these elements can be detrimental to executive function.

Diamond (2015) suggested that there are three core executive function skills including inhibitory control (thinking before acting), working memory (holding information in the mind and working with it in the short term) and cognitive flexibility (able to adjust to changing demands or priorities). Diamond (2013) also suggested that higher order executive function skills reasoning, planning and creative problem solving are built upon this core. This is significant when examining interventions and their impact on core versus higher order executive functions as much of the literature studies focus on one or a few executive function measures.

Summary. Early executive function skills have been correlated to long-term academic achievement in school (Best et al., 2011; Fuhs et al., 2014). Working memory is related to inhibition (Davidson et al., 2006). Planning and organizing are critical for middle school success (Langberg et al., 2013) while improved behavior is linked to improved general executive function (Young et al., 2009). Rolling, crawling/walking and jumping correlate with the way that information travels in the brain and once developed the brain uses its motor patterns as the framework for other learning (Madigan, 2009). Best (2010) suggested that executive function growth is slower in sedentary children. Deficits in executive function can have life long lasting impacts related to social relationships and career success (Best et al.,2011; Bull & Lee, 2014).

Some studies indicated that children, who are more fit, perform better and more accurately on executive function tests as compared to their less fit peers (Buck et al., 2008; Hillman et al., 2011; Pontifex, Raine, Johnson, & Chaddock, 2011). Brain imaging indicates that children with higher fitness levels show enhanced cognitive function (Chaddock et al., 2012). Meta-analysis studies suggested that obese children and adolescents have cognitive deficits mostly related to executive function (Smith et al., 2011).

Tomporowski et al. (2015) concluded that both acute and chronic sessions of exercise and improved cognition. However, few studies have reported on the effects of chronic exercise on executive function specifically in healthy children (Fisher et al., 2011; Kamijo et al., 2011; Stroth et al., 2009).

Overall, executive function skills appear to be critical for school success (Alloway & Alloway, 2010; Borella et al., 2010; Duckworth & Seligman, 2005). Deficits in executive function often grow larger over time (O'Shaughnessy et al., 2003; Riggs et al. 2003). Long-term impacts in life include poorer health, less income, lower levels of happiness and higher likelihood of committing crime (Moffitt, 2012; Moffitt et al., 2011). A review of literature regarding exercise interventions designed to improve executive function is presented in the next theme.

Interventions that Utilize Exercise for Executive Function

Executive functions develop as a child matures and they play a key role in the behavioral and social-emotional development of children, which leads to success in school (Anderson, 2002). Activities that challenge executive function can lead to improved brain development (Diamond & Lee, 2011) and so incorporating these interventions into the school day may enhance learner success. Regular physical activity in early childhood can stimulate the development of executive function (Best, 2010). There is evidence from intervention studies that vigorous exercise can improve executive function (Davis et al., 2011; Fisher et al., 2011). Group games for example have shown to improve inhibition skills, working memory, the ability to shift attention and act according to a plan (Best, 2010) while sedentary behavior has shown to be

associated with executive function problems (Riggs et al., 2012). The evidence for use of physical activity interventions to improve executive function need to be explored.

A meta-analysis was conducted in 2015 to review the literature related to the impact of school based interventions that target executive function and academic achievement (Jacob & Parkinson, 2015). The meta-analysis results indicated that there is a moderate, unconditional association between executive function and achievement, at both a single point in time and as a predictor of future achievement regardless of age. Students with higher executive function do better on standardized achievement tests. The next question addressed in the Jacob and Parkinson study was whether interventions designed to improve executive functions would thus also improve student achievement. The limited number of studies available for such analysis did not produce compelling evidence that a causal relationship exists (Jacob & Parkinson, 2015). The authors found five studies that explore the predictive association between executive function and achievement. One of the studies showed a positive and statistically significant causal relationship. Jacob and Parkinson (2015) also looked at seven concurrent studies with fewer than half of those showing statistically significant causal relationships. Some of the interventions analyzed in the study are familiar to educators and were identified by title as *Tools of the Mind, Headstart, REDI, Chicago School Readiness Program, Red Light, Purple Light, and Computerized Attention Training*. Evidence that these executive function interventions improve student achievement is limited and by the authors description not compelling. According to van der Niet et al. (2014), these results should be reviewed with caution as many of the studies only used light intensity exercise, which may not have been rigorous enough to see effects that are more robust.

Jacob and Parkinson (2015) stated that understanding the impact of executive function interventions on academic achievement is a recent research field. Of the 67 studies that were included in their sample, more than half of them were published after 2010 and thus the research in this area is quite limited and new. Limitations in their meta-analysis included only using standardized test scores as a measure of academic achievement. Measures such as grades, attendance, and dropout rates are all important to a child's achievement but studies with these factors were not included in the meta-analysis. In addition, studies of students with ADHD specifically were not included in the meta-analysis. This is important because it could be hypothesized that if a causal relationship between executive function and achievement exists, it would be most readily observed in a population of students who have the most room for executive function improvement. In fact, some researchers have described ADHD as executive function deficits or dysfunction (Barkley, 1997, 2012). Not including ADHD children and still finding a correlation between achievement and exercise would provide the strongest evidence for a correlation.

According to Tomporowski et al. (2015), physical activity interventions can be organized into two categories: quantitative which include activities that require minimal cognitive demand such as running, jumping, sprinting, cycling, calisthenics and qualitative which require higher cognitive demand and include activities like strategy or learning games, multi-limb coordination games and active video games. The researchers concluded from their meta-analysis that both quantitative and qualitative types of exercise interventions, both acute and chronic, improve cognitive processing in children. Specific examples of types of interventions in these two categories are described next.

An elementary school in Kansas City inner city implemented an exercise program similar to that of the Naperville school district, which was made famous in John Ratey's book, *SPARK*. The exercise program was expanded from one day a week to five days a week and after one-year discipline, problems went down by 63% (Ratey, 2012). Another elementary school piloted an exercise for kids program and after four months, discipline problems went down by 83% (Ratey, 2012). Students had access to pogo sticks, cup-stacking activities, jump rope and had to rotate stations every eight minutes upon hearing their teacher blow a whistle. Mahar et al. (2006) found that physical exercise increased on-task behavior in the classroom by children in Grades K-4 when using the Energizers program, which consists of ten-minute bouts of exercise distributed throughout the day.

Castelli et al. (2011) reported that the FIT kids program (a chronic exercise, after school intervention) produced improvements in cognitive function as well as changes in brain neurological structure, function and activity. Their study was conducted with elementary school aged children over a period of nine months and included forty minutes of activities including fitness, motor skill development and cooperative games. Similar studies show improved cognitive functions because of exercise interventions including tennis skill instruction (Crova et al., 2013) and soccer-based exercise program for kindergartners (Chang, Tsai, & Chen, 2013).

Attention Deficit and Hyperactivity Disorder often results in lower achievement outcomes (Frazier, Youngstrom, Glutting, & Watkins, 2007) and significant impairment in planning, working memory and response inhibition (Wilcutt, Doyle, Nigg, Faraone, & Pennington, 2005). If physical exercise provides gains in executive function, then these gains should most greatly be observed in students with the greatest discrepancies like those who have

ADHD. Both Tette (2003) and Wendt (2001) found this to be the case. ADHD diagnosed children who participated in regular physical exercise for six weeks showed significant improvements in behavior comparted to controls.

Literature revealed that the intensity of exercise also appears to be a factor affecting executive function in ADHD children. In one study, Gapin and Etnier (2010) found that more vigorous physical exercise predicted better executive function skills specifically on four tasks in male children diagnosed with ADHD. In another study, Medina et al. (2009) showed there was a significant improvement to sustained attention, response time, and persistence in ADHD diagnosed boys on an acute bout of treadmill running for 30 minutes. Even though there are some studies showing positive correlation, there continues to be a very limited amount of research examining the impacts of acute exercise on executive function of children with ADHD (Gapin & Etnier, 2010).

Specific programs have been developed which utilize physical fitness and body movement as a means of improving cognitive function. Motor coordination activities have been shown to improve cognitive functions of attention and reading comprehension (Budde et al., 2008; Planinsec, 2002; Uhrich & Swalm, 2007). These effects are even observed after single bout (acute) exercise sessions of as little as 10 minutes (Budde et al., 2008). *Brain Gym* is a program developed in 1981, which claims to use 26 different exercises that involve using the extremities to cross the mid-line of the body to strengthen communication across the left and right hemispheres of the brain. Interhemispheric communication is important for executive function (Sauseng, Klimesch, Schabus, & Dippelmayr, 2005; Shibata et al., 1997; Shibata et al., 1998). In a study of 32 females, ages 19-30, crossing the mid-line exercises did not show

significantly improved outcomes for concentration and attention (Thomas, 2012). Thomas did indicate that both the control group and the experimental group improved their performance because of exercising, but the additional benefits of using exercises that cross the mid-line to improve cognitive abilities could not be confirmed.

Recess would seem to provide a great opportunity to improve executive function however most recess consists mostly of low intensities with brief stints of higher intensity physical activity (Ridgers, Stratton, & Fairclough, 2005). Researchers in the Netherlands examined recess as an opportunity for enhancing cognitive function through more intense physical activity. For their study, 53 children completed 22 weeks of a 30-minute recess intervention, two times per week, consisting of aerobic exercise and cognitively engaging physical activities. The researchers found that children who participated in the study showed significantly greater growth on executive functions for inhibition (Stroop test) and working memory (Digital Span test) than the control group of children participating in a regular recess period each day (van der Niet et al., 2015). These results were consistent with those of other researchers who found that working memory and inhibition can be improved significantly through physically and cognitively active interventions (Hillman et al., 2014; Kamijo et al., 2011).

Although evidence exists indicating that aerobic activity improves executive function, consideration of activities that motivate children is important to understand, as children will put time and effort into activities they love. In the study by van der Niet et al. (2015), emphasis on intensity and enjoyment were critical design factors in order to make the activities both challenging and interesting for students to want to continue. Running games, rope skipping, tag, modified football, and word relay were some of the activities played by the children.

The BOKS (Building Our Kids' Success) program has similar motivational elements embedded in it. This program is a before school, physical activity intervention that involves a running-related activity, a featured skill of the week and nutrition tips. The program is endorsed mainly by Reebok, is in more than 1000 schools, 40 states, six countries and has participant satisfaction survey of 96% as rated by children (Viering, 2016). Children are motivated by the program to continue with future sessions and the program's high satisfaction endorsement by children is evidence of its effectiveness at maintaining their engagement (Viering, 2016).

Children with poorer executive function skills have the most to gain from participating in these types of interventions (Diamond & Lee, 2011). The core executive function skills include inhibition, working memory and cognitive flexibility (Miyake et al., 2000), while reasoning, problem solving and planning represent higher order executive functions that build upon this core (Christoff, Ream, Geddes & Gabriele, 2003; Collins & Koechlin, 2012). This is important because physical exercise that improves the core executive functions such as inhibition could shift an entire set of higher order executive functions (Moffitt et al., 2011).

C8 Sciences (2015), a company created by Yale professors Bruce E. Wexler, M.D. and James F. Leckman, M.D., developed a program called ACTIVATE™, which capitalizes on an integrated brain, body and social intervention to treat children diagnosed with ADHD and other attention deficit disorders (B. K. Wexler, personal communication, December 2, 2016. Wexler and Leckman received a National Institute of Health grant to fund two randomized control trials of their new treatment program, one in Connecticut's Hamden public school system and the other in Beijing, China. The ACTIVATE™ program is designed to strengthen neurocognitive

functions through a program, which combines computer and physical exercises to help children with ADHD and other executive function disorders.

The computerized portion of the ACTIVATE program has a gaming structure to it and allows students to complete games and continue to "level up" to challenges that are more complex. The games require children to switch tasks, memorize sequences of items, put items into categories and promote thinking strategies (C8 Sciences, 2015). The program is adaptive, dynamic and when combined with the physical activity component of progressively challenging individual and group games, maintains the interest and engagement of the participants.

According to the C8 Sciences (2015) website, the program dramatically improves working memory, self-control, sustained attention, cognitive flexibility, and other executive function skills. The program claims to provide early cognitive intervention designed to help identify the causes of student cognition problems and uses National Institute of Health assessments to track a child's executive function development progress via real time data (C8 Sciences, 2015). The ACTIVATE program appears to be unique in that it is the only executive function intervention program that the researcher found to have an embedded executive function assessment built into the intervention.

Let's Move! Active Schools (2016) is established as a public-private partnership between the Alliance for a Healthier Generation, the Partnership for a Healthier America, the President's Council on Fitness, Sports & Nutrition, SHAPE America and the United States Departments of Health and Human Services. Over 20,000 schools have signed on to the program as a way to ensure that 60 minutes of physical activity is part of the learner experience each day. *Let's Move!* Active Schools provides schools with resources and tools to increase physical education and

physical activity opportunities for students, and helps build a school culture with an active school environment. The *Let's Move!* Active Schools website claims that the program improves achievement, attendance, concentration, focus, behavior, leadership skills and promotes healthy habits surrounding physical and mental health.

Other considerations for interventions to improve executive function include embedding increasing cognitive challenge into physical activities. The most significant changes in executive function interventions are observed when the limits of children's executive function skills are really challenged through rigorous cognitive tasks (Davis, et al., 2011; Diamond, Barnett, Thomas, & Munro, 2007; Manjunath & Telles, 2001). The increasing challenge motivates students to stay engaged and repeatedly practice. Activities like Tae Kwon Do have been shown to improve physical conditioning and maintain high engagement through increasingly complex cognitive tasks, which provide improved executive functions skills like inhibition (Diamond, 2015).

Exergames could be another option for engaging children in physical exercise which has been showing to produce both physical and cognitive benefits (Hillman et al., 2008; Tomporowski, 2003). Exergames are video games that require physical movement like that observed while playing Nintendo Wii Sports games. Some games cause movement of the hands and arms like bowling, boxing and tennis while others require complete body movements such as those observed while playing Nintendo Wii Fit, Nintendo Wii Active, Microsoft Kinect, and Konami Dance Revolution (Staiano & Calvert, 2011). Exergames require moderate energy expenditure (Bidess & Irwin, 2010; Daley, 2009; Peng, Lin, & Crouse, 2011) although some like Nintendo Wii Fit and Konami Dance Dance Revolution require higher levels (Ainsworth et al.,

2011; Graf, Pratt, Hester, & Short, 2009; Graves, Stratton, & Ridgers, 2008; Graves, Ridgers, & Stratton, 2008; Lanningham-Foster et al., 2006; Lanningham-Foster et al., 2009).

The combination of game play with physical exercise may affect executive function more than either in isolation (Anderson-Hanley, Tureck, & Schneiderman, 2011; Anderson-Hanley et al., 2012; Best, 2010; Staiano et al., 2012). Executive function skills support higher order skills such as problem-solving (Zelazo et al., 1997), improved reading and math abilities (Blair & Razza, 2007; Riggs, Blair, & Greenberg, 2004). Playing a sport with strategies and rules often requires executive function skills (Tomporowski, Davis, Miller, & Naglieri, 2008) while interactive games develop visual attention, spatial relations, and mental rotation (Bottio, Ferlino, Ott, & Tavella, 2007; De Lisi & Wolford, 2002; Subrahmanyam & Greenfield, 1994). Attention, inhibition and memory may also be improved by playing exergames (Best, 2010; Staiano et al., 2012). Staiano et al. (2012) showed that single bouts of exergames improved executive function and Flynn et al. (2014) found that children who played exergames for five weeks improved their executive function skills suggesting that long-term benefits of playing exergames exist.

Research that explained how exergames impact executive function is very limited (Flynn et al. 2014; Green & Bavelier, 2007; Staiano & Calvert, 2011). The study of exergames is important, as it is an activity that generates enjoyment and engagement, which are critical intrinsic factors underlying motivation. Lwin and Malik (2012) found that when children experienced exergames in their physical education class their attitudes toward physical activity improved. This is relevant as more than half of student's age 8-18 play video games, on average, an hour per day (Rideout, Foehr, & Roberts, 2010). Flynn et al. (2014) found that executive function skills were related to the amount of physical activity in the exergame and boredom was

a significant predictor of the degree to which executive function skills improved. Exergames as school programming or intervention, show promise based upon their impact on intrinsic motivation and executive function benefits.

Summary. The connection between physical activity and cognitive function has been shown for both acute bouts of exercise (Hillman et al., 2009) and chronic exercise activity (Davis et al., 2007). The intensity of the exercise is an important factor related to improved cognitive function (Castelli et al., 2011). This is a significant consideration for physical activity interventions as more vigorous physical activity has shown to produce improved cognitive function.

Diamond (2015) hypothesized that the most effective executive intervention programs will "challenge EFs continually and also bring children joy and pride, give them a feeling of social inclusion and belonging, and help their bodies to be strong, fit and healthy" (p. 59). Diamond and Lee (2011) stated that interventions must be sustainable to have the likelihood of improving executive function skills. Physical education curriculum in many schools have begun to incorporate exergames as a valuable activity (Lieberman, 2006).

Specific physical activity interventions designed to incorporate both core executive functions and higher order cognitive processes may provide the right type of brain training to improve children's academic performance (Tomporowski et al., 2015).

Factors that Promote or Impede Implementation

Implementing exercise to improve executive function of students in a public school setting may begin with policy. However, even when wellness policies are in place there are many identified barriers to their successful implementation. In 2006, a national research study

was conducted involving nearly 3000 individuals who participated in focus groups and online surveys pertaining to perceptions, barriers and opportunities related to the development, implementation and monitoring of school wellness policies (Agron, Berends, Ellis, & Gonzalez, 2010). Three barriers to implementation of wellness policies were identified: adequate funding, competing priorities for time and education of and support from various stakeholders (Agron et al., 2010). The surveys and focus group questions were administered to state public health nutrition directors, state school board association members, local school board members, and local wellness leaders. Without support for wellness policy implementation and without the addition of information related to the impacts of exercise on executive function in school district wellness policies, the hope of implementing exercise to improve executive function in students appears nebulous.

Belansky et al. (2013) conducted a pre-and post-test of the impact of the Local Wellness Policy federal mandate. In the Belansky et al. study, a survey was administered to a random sample of school principals, teachers of physical education and food service managers in 45 rural low-income elementary schools in Colorado. The purpose of their study was to evaluate the long-term effect of the Local Wellness Policy mandate and health practices of elementary schools in Colorado. The results of the study showed that the total minutes for physical education and recess did not increase over this time period. Some schools had adopted policies prohibiting teachers from restricting recess as a punishment for students or for those who need to make up missed work. The researchers stated that further investigation would be helpful to determine the attitudes, knowledge, skills, as well as physical and financial resources required for building leaders to make effective long term changes in school practices (Belansky et al., 2013).

Impact of the principal. In 2006, a Montreal study surveyed school principals and physical education teachers in 277 schools. The cross-sectional study explored opportunities for student physical activity in elementary schools and found substantial variation in physical activity opportunities among the schools surveyed. More opportunity for physical activity was linked to role modeling of physical activity by school principals, connections to the out of school environment, adequate funding, and access to facilities storage and physical space (Barnett et al., 2006).

Age-related sedentarism. As students age there is a decrease in their physical activity (Bunke, Apitzsch, & Bäckström, 2011). In a 2011 Sweden study of adolescent students, it was found that social influence affects students' current and intended physical activity. Understanding all barriers to physical activity become important to consider when implementing an exercise intervention program. It was also noted that boys engage in more physical activity than girls and the lower the social economic status, the less likely a student is to be physically active as compared to their higher social economic peers.

Impact of low social economic status. In the Carlson et al. (2014) study, 97 elementary schools in two regions of the United States were studied to examine the relationship between social economic status and physical activity related practices and children's physical activity. A survey was administered to physical education teachers and or principals at the schools regarding physical activity supportive practices. The percent of students on free and reduced priced meals was collected from the schools. Physical movement data was collected objectively and measured across the entire school day using accelerometers. One finding from the study was that lower social economic status schools were less likely to have a physical education teacher and these

schools had fewer physical activity supportive physical education practices. Contrary to that, these same schools had more students participating in active travel to school (Carlson et al., 2014).

The researchers noted that schools in low-income areas are less likely to offer recess and provide fewer physical activity supportive practices than higher income areas. Also, predominantly white non-Hispanic schools have better recess practices and facilities, including gymnasiums and playgrounds, when compared to predominately Black or Latino schools (Carlson et al., 2014).

Impact of school transitions. In 2009-10, 500 students participated in a longitudinal study to determine if their level of physical activity increased, stayed the same or decreased as they moved from the last year of primary school to the first year of secondary school in Belgin (De Meester, Van Dyck, De Bourdeaudhuij, Deforche, & Cardon, 2014). Accelerometers, Pedometers and the Flemish Physical Activity Questionnaire were used to measure physical activity. Principals responded to questions regarding school environmental characteristics. The study indicated that moderate to vigorous physical activity increased after the transition to secondary school while extracurricular physical activity and total physical activity decreased. Secondary schools scored higher on the school environmental characteristics, physical activities during lunch break, active schoolyards and playgrounds and in health education policy but lower on sports and physical activity after the school day than primary schools. Changes in the school environment characteristics, active commuting to school, active schoolyards, playgrounds and health education policy resulted in changes in self-reported extracurricular physical activity, total physical activity, step counts and moderate to vigorous physical activity. Secondary schools are

more likely to foster strategies to promote physical activity during school hours and primary schools are more likely to promote physical activity after school. De Meester et al. (2014) stated that the school environment plays a central role in the change in physical activity patterns however, contribution of other social and physical environmental factors to the changes in physical activity need to be further explored.

The Norwegian Ministry of Education published a white paper in 2007, which highlighted the fact that physical activity can improve student's health and learning in schools and it recommended daily physical activity in the school setting. To understand the impact of this policy, a qualitative case study of eight Norwegian schools' experience with the implementation of a national policy was analyzed (Larsen, Samdal, & Tjomsland, 2012). Their study explored and identified successes and barriers to implementation of increased student physical activity as perceived by school administration, teachers, project leaders and students. Schools were selected based on their participation in the *Physical Activity and Healthy School* Meals project. The researchers concluded that all schools were able to ensure extra time for physical ranging from 20 to 45 minutes per day; however, none had managed to meet the recommendation of 60 minutes per day. Factors promoting the implementation were related to formalizing and anchoring policies and establishment of a leadership group for this project. Factors hindering the implementation were related to the lack of allocated time by school leaders and the confidence and competence expressed by teachers (Larsen et al., 2012).

Even though evidence-based physical education programs have increased physical activity by as much as 18%, adoption has not happened in a systemic way. Lounsbery, McKenzie, Trost, and Smith (2011) surveyed pairs of principals and teachers from 150 schools

(75 adopters and 79 non-adopters) across 34 states. The differences between adopter and non-adopter schools were compared. The findings show that both principals and teachers reported distinct physical education curriculum adoption decision-making roles but few see themselves as integral to program evaluation. Teachers in adopter schools did state they were more satisfied with program outcomes and were more involved in program decision-making. When compared with teachers, principals were generally more satisfied with their schools physical education program outcomes and did not share the same perceptions of barriers to physical education programming. Principals also demonstrated a general lack of physical education program knowledge

Action Schools! British Columbia (2016) is a comprehensive school-based model that promotes physical activity and healthy eating in elementary schools in British Columbia, Canada. The expected outcomes of the program include increased student interest and attitude toward physical activity, improvement in overall student health, improved academic performance and better classroom behavior. A follow up study was conducted in 2008 and 2009 to determine to what degree the program was being implemented four years after the initial implementation phase. Surveys were administered to 133 principles and 587 teachers of grades 4-7. The results of the follow up study showed that three factors affected implementation: self-efficacy, training of staff and level of institutionalization. If teachers believed they could meet the expectations, they received training and if expectations were transparent through policy, then implementation was successful. The Action Schools, British Columbia study discusses the importance of academic performance as an expected outcome for increased physical activity but there is no

mention of overall impacts on cognition and executive functioning as a rationale for participation.

The Roslow Research Group (2009) administered a survey to 1375 physical education teachers from elementary, middle and high schools in the United States of America. One finding from the survey suggested that the majority (53%) of elementary teachers believe that a focus on motor skills and movement forms is the primary purpose for elementary physical education. In the survey, teachers stated that only 27% of principals were believed to be very knowledgeable about after school programming for physical education. Most teachers (58%) believed their principals were supportive however, only 11% of teachers reported being observed three or more times during the school year. Of the elementary teachers, 17% indicated that they had never been observed in the physical education class (Roslow Research Group, 2009).

In 2002, phone surveys were completed with 101 parents of children age 5 to 12 years in a New Zealand community. Four elementary principles were interviewed as part of the follow up to the study. Researchers were investigating the barriers and promoters of healthy eating and physical activity in this New Zealand community. Major barriers to physical activity identified included lack of facilities, coaches and equipment. Work commitments prevented 40% of parents from being physically active with their children. It also was found that 70% of parents thought their child preferred TV or computers to sports and games. Limited research has explored the barriers and promoters of healthy eating and physical activity for 5- to 12-year-olds (Romero et al., 2001).

The preference for sedentary leisure options could prove to be one of the greatest challenges faced by researchers when developing strategies to remove the barriers to healthier

behaviors. Children respond more positively if exercise is promoted rather than if physical activity is encouraged, perhaps because children feel forced to participate in physical activity, but perceive the choice is theirs when encouraged to decrease television time. In conclusion, these barriers included greater preference for sedentary activities, a lack of variety in the types of physical activities available and work commitments of parents.

Summary

The review of literature summarized research on how humans have used exercise to promote healthy bodies and brains, the relationship between exercise and academic achievement, the impact of exercise on executive function and how elementary schools have utilized specific exercise interventions for learning, including barriers to implementation in schools.

Physical exercise has historically been part of human culture and the concept of prescribing physical exercise to maintain health has existed for thousands of years. A few decades prior to the 20th century, physical education became more prominent in school curriculum and now the United States Department of Health and Human Services recommends that children do 60 minutes of moderate physical activity every day (Maese, 2015).

The literature suggested that exercise improves blood flow to the brain, the development of new neurons and improved memory in animals. There is significant evidence which indicates that exercise, specifically running (Tomporowski et al., 2015), improves many different body systems (Tomporowski et al., 2015) and changes structures and functions in the brain (Chaddock et al., 2011; Hillman et al., 2008).

The literature described the correlation between aerobically fit children and achievement in school and included benefits to student's reading and math scores (Kedler, 2012), reading

comprehension and analysis, improved IQ (Ratey, 2012), higher grade point averages, creativity, focus, reduced truancy and drop out statistics and improves language acquisition (Madigan, 2000). Meta-analytic results indicated that "there is substantial evidence that academic achievement and measures of executive function are correlated—both at a single point in time and as a predictor of future achievement, and for a variety of different constructs and age groups" (Jacob & Parkinson, 2015, p. 18). Current exercise research psychology is dominated by the hypothesis that improvements in executive function caused by exercise are the cause of increased academic achievement (Etnier & Chang, 2009).

Early executive function skills are correlated to long term academic achievement in school (Best et al., 2011; Fuhs et al., 2014) and deficits in executive function can have life long lasting impacts related to social relationships and career success (Best et al., 2011; Bull & Lee, 2014). Executive function skills appear to be critical for school success (Alloway & Alloway, 2010; Borella et al., 2010; Duckworth & Seligman, 2005) and deficits in executive function often grow larger over time (Riggs et al., 2003; O'Shaughnessy et al., 2003). Long-term impacts in life include poorer health, less income, lower levels of happiness and higher likelihood of committing crime (Moffitt, 2012, Moffitt et al., 2011).

Specific physical activity interventions that are designed to incorporate both core executive functions and higher order cognitive processes may provide the right type of brain training to improve children's academic performance (Tomporowski et al., 2015). ACTIVATE was the only executive function intervention program found by the researcher to have an embedded executive function assessment incorporated into the intervention.

Factors that promoted or impeded implementation of exercise intervention programs included wellness policy implementation (Agron et al., 2010), school leadership (Barnett et al., 2006), youth sedentarism (Bunke et al., 2011), social economic status of students (Carlson et al., 2014), and school transitions (De Meester et al., 2014).

Exploration of the implementation of ACTIVATE in case study schools was the subject of the study. In schools where greater environmental support for physical activity exist, students will be more physically active (Barnett et al., 2006). The literature could be enhanced by studying experienced practitioners and users to understand the practices, perceived benefits and barriers and recommendations for schools choosing to implement the ACTIVATE program, designed to improve executive function.

Chapter III: Research Methodology

The fundamental purpose of schools is to provide high levels of learning for all students using the most efficient and effective methods possible. To help achieve this goal, it may be beneficial to understand factors that affect the ability of the brain to learn. One of the factors referenced in the study is the impact of physical movement of the body on the brain's ability to learn, specifically on executive function.

Key studies in the review of literature summarized how humans have used exercise to promote healthy bodies and brains, the relationship between exercise and achievement, the impact of exercise on executive function and examine how elementary schools are utilizing exercise interventions for learning, including barriers to implementation in schools. A brief overview of these studies is provided hereafter.

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Exploring the barriers that have led to the successful implementation of exercise for executive function was also the subject of the study. The failure to apply what is known regarding this topic could affect educational systems by failing to support young children who would most benefit from enhanced executive function. Hope for change in policy and practice can be derived from examining pockets of excellence and sharing their story of barriers and success to implementation of ACTIVATE. A case study of three elementary schools with successful implementation of the ACTIVATE executive function intervention was conducted. The literature will be expanded by studying the perceptions of experienced practitioners to better understand the processes by which such programs are implemented and maintained in schools. The investigation included practices used in the case study schools, perceived benefits of and

barriers to implementation of the program. Finally, the researcher sought to identify recommendations from the case study schools for successful implementation of the ACTIVATE program.

Research Questions

Four research questions guided the study:

1. What practices were used in the case study schools to implement the ACTIVATE executive function intervention program?
2. What benefits were reported for students who participated in the ACTIVATE program?
3. What barriers challenged the implementation of the ACTIVATE program?
4. What recommendations did case study schools provide for successful implementation of the ACTIVATE program?

Research Design

There are two types of research, quantitative and qualitative, typically conducted to answer research questions. Quantitative research involves collecting numerical data and information from participants to determine the relationship between them (Slavin, 2007). Qualitative research methods focus on discovering and understanding the experiences, perspectives, and thoughts of participants (Hiatt, 1986). Since the intent of the research is to replicate a model which has successfully implemented the ACTIVATE program in elementary schools, a qualitative case study approach was utilized.

The case study format allows for the collection of individual interview responses regarding implementation benefits and barriers and helped to generate an in depth analysis

needed to provide replication potential in other schools. As stated by Cresswell (2009), a case study is a "strategy of inquiry in which the researcher explores in depth a program, event, activity, and process, of one or more individuals" (p. 13). The researcher sought opportunities to ask more in depth follow-up questions to elicit further details, which further clarified the study results (Creswell, 2007, 2009). Discovering key elements of successful implementation through a qualitative case study approach provided insight to barriers for implementation and factors promoting success.

Participants

The first step in identifying the list of participants for the case study was to develop the criteria for reviewing potential schools for the study. Those criteria included schools that have implemented the ACTIVATE program for at least two years and have measured the fidelity of implementation including the impact on the children.

The second step was to identify schools nationally to consider in the study population. For this step, the researcher contacted Dr. Wexler, owner of C8Sciences and creator of the ACTIVATE program, to conduct an initial interview to determine schools meeting criteria. In that interview, Dr. Wexler shared published and non-published research on the ACTIVATE program summarizing their successes and challenges. Controlled scientific studies of the impact of the ACTIVATE program on learning had been conducted by Dr. Wexler in some of the schools who first implemented the program indicating great growth in executive function and math and reading achievement scores. Dr. Wexler further indicated that a few schools districts had used the program for three years and both were using the physical component of the program but "we don't have any data on teacher's reactions to the program" (B. K. Wexler, personal

communication, December 2, 2016). Following the interview, Dr. Wexler contacted schools meeting criteria, who had implemented the program for at least three years, and requested their permission to release their names to the researcher. Upon receiving permission, Dr. Wexler forwarded the contact information to the researcher for initial contact.

The researcher contacted two different school district leaders, eliminating one school district because it was not using the physical activity portion of the ACTIVATE program. The school district that did meet criteria included seven elementary schools, three of which had been using the ACTIVATE program for over three years. Staff at the selected case study schools were contacted and asked to review the case study purpose using the form in Appendix A: Email Request for Identified Case Study School Principals/Teachers to Complete Interview. Nine teachers or principals were contacted and seven agreed to participate in the study. One principal was interviewed for the study. The principal was responsible for overall programming decisions in school, made final decisions related to budget and expenditures for the site and thus was an important voice to capture in the study. Six classroom teachers were selected for interviews included two district teacher leaders and four classroom teachers. Classroom teachers worked closely with students each day and had important information regarding the observable impact (both quantitative and qualitative) of the program on executive function in the school environment. Seven interviewees kept the scope of the study manageable. For a qualitative study that uses interviews, Kornuta and Germaine (2006) articulated that:

> Interviews in qualitative research are likely to produce large amounts of data, and therefore, the number of participants should be limited to keep the study manageable. For

this reason, few qualitative studies conducted by individual researchers have more than six participants. (p. 49)

Instrumentation

Data were collected using a semi-structured format and a specific set of interview questions. A specific interview instrument to utilize for the study was not found through examination of the literature. The researcher generated interview questions based on findings from the review of literature. Themes to be explored in the interviews were divided into sub questions listed in Appendix C: Matrix of Research Questions, Interview Questions and Relevant Literature. As an example, one study revealed that principal role modeling of the importance of physical activity impacted the number of minutes in which students were physically active (Barnett et al., 2006). Therefore, this was a question explored by the researcher.

Human Subject Approval

Upon approval of the research study in the preliminary process, the researcher submitted the necessary forms to the Institutional Review Board (IRB) for St. Cloud State University approval. The elementary principals and teachers interviewed in the study are anonymous. The schools that were referenced in the study have fictitious names or pseudonyms to protect their anonymity, i.e., Haset Elementary. Pseudonyms honor the confidentiality requirement of ethical research guidelines and the IRB approval requirements.

Instruments for Data Collection and Analysis

Since the literature review did not provide insight for a valid and reliable instrument for data collection, the instrument was developed by the researcher. The interview questions were aligned to the research questions and to literature citations as indicated in Appendix C: Matrix of

Research Questions, Interview Questions, and Relevant Literature. The crosswalk in Appendix C will ensured that the type of information solicited in the interview questions were aligned to the literature and reference gaps in the literature. The Interview questions were developed by field testing questions with a focus group of six elementary principals and six elementary teachers in a suburban school district in the mid-west United States of America. The elementary principals reviewed the questions during their monthly meeting. The elementary teachers were classroom teachers and were asked to review the questions during their regular Professional Learning Community meeting time. Interview questions were reviewed for clarity and understanding and modified based upon suggested feedback.

Analysis of Data

Bogdan and Biklen (2007) described data analysis as working with data, organizing and breaking it into manageable chunks, coding, and then synthesizing to search for themes and patterns. Transcribed responses from interviews were coded and analyzed for common themes with associated frequencies. These themes were verified by searching through the data while repeating the coding process in order to further develop the categories and themes (Pope, Ziebland, & Mays, 1999).

The first step was to read each interview transcript and write notes in the margin of words, and/or phrases that summarized what was stated (Burnard, Gill, Stewart, Treasure and Chadwick, 2008). If the respondent clearly goes off track while responding to a question, that response was simply uncoded. Next all words and phrases were collected and rewritten on a separate page. All duplications were crossed out and frequencies of responses were noted. This helped to reduce the number of categories (Burnard, 1991, 2006). Once the second list review

was completed the process was repeated a third time looking for redundant categories (Burnard, Gill, Stewart, Treasure, & Chadwick, 2008). Burnard et al. (2008) recommended that once the final categories are determined, the researcher should assign a color to each category and color code all transcribed responses. These responses were then collated and entered into a database. Data tables were constructed and organized to display themes by category and frequency. In terms of further data validation, there is debate in the literature as to the value of third party validation of coding (Barbour, 2001; Mays & Pope, 1995) so that option was not be utilized in the study.

Procedures

Upon Institutional Review Board (IRB) approval, the forms necessary to protect the privacy and rights of the participants were generated. Those in agreeing to be interviewed were sent the forms in Appendix E: Informed Consent Form and Stamp and Appendix B: Interview Protocol to complete. Once signed consent forms were obtained, the researcher organized times and dates for the interviews with the respondents in the case study schools.

Limitations of the Study

Limitations of a study describe weaknesses that exist beyond the control of the researcher (Simon, 2011). The limitations within the study included the following:

1. The study was conducted in one school district, including three elementary schools. It was difficult to convince staff to participate in an extended interview regarding the ACTIVATE implementation. Therefore, it is difficult to generalize the results across other classrooms and schools due to the limited number of participants in the study.

2. Self-reported data was collected through the interview process. Staff bias regarding the ACTIVATE program may have influenced the description of benefits and barriers of the implementation.
3. Staff may have not fully shared information regarding the implementation of the ACTIVATE program thus generalizability of the data could be limited.

Summary

This chapter presented background information on exercise for executive function and the research methodology of the case study. Research questions and the case study design elements were articulated. Study criteria were outlined for the selection of elementary site participants and as well as individual participants. Instrumentation, data collection and data analysis were also presented. Finally, limitations of the study were described and Chapter IV presents the findings of the participant interviews designed to answer the research questions.

Chapter IV: Findings

The purpose of the study was to explore a research gap related to the use of exercise intervention for improvement in executive function of elementary aged children. The literature review revealed that there was limited research that described successful implementation of exercise interventions for improved executive function in elementary schools. To address the research gap, a case study investigating three elementary schools was conducted regarding the implementation of the ACTIVATE exercise intervention program which was designed to improve executive function. The researcher investigated the practices used in the participating schools, the perceived benefits for their children, the barriers to implementation and recommendations for schools initiating implementation of this program. This chapter provides an analysis of the findings from the study investigation.

Summary of Research Methodology

A case study format was used to examine the research questions pertaining to implementation of the ACTIVATE exercise intervention program. The case study design involved individual interviews of staff who were knowledgeable of the intervention. The literature did not reveal the availability of a specific interview tool appropriate for the study. Therefore, an instrument to was created by the researcher and field-tested with elementary principals in a mid-west united states school district. The interview instrument was also reviewed by Dr. Wexler, the creator of the ACTIVATE program. Interview questions were generated based on research recommendations for further study from the literature review: see Appendix C: Matrix of Research Questions, Interview Questions and Relevant Literature. Interviews were recorded, transcribed, and raw coded for common themes. Common theme coding was validated

and frequency counts were recorded. Data exemplars from interview transcripts were selected based on insight, depth of response and response clarity in answering interview questions.

Four research questions guided the study:

1. What practices were used in the case study schools to implement the ACTIVATE executive function intervention program?
2. What benefits were reported for students who participated in the ACTIVATE program?
3. What barriers challenged the implementation of the ACTIVATE program?
4. What recommendations did case study schools provide for successful implementation of the ACTIVATE program?

The schools in the study were selected on the basis of their implementation of ACTIVATE. ACTIVATE was the only exercise intervention program identified in the review of literature that contained a measure of executive function improvement. After the ACTIVATE program was identified, the researcher contacted the parent company of ACTIVATE, C8Sciences. The researcher requested references and permission to contact the schools that had been implementing the program. The researcher then established that the participating schools had been implementing the full ACTIVATE program, including both the computer and exercise game components, for at least three years. Two school districts were recommended by C8Sciences. Only one school district met the qualifying criteria for participating in the study. School district staff were contacted and permission was obtained to conduct the study. Staff members were expected to have been trained in the ACTIVATE program and have observed it in operation or were directly implementing it for one year. The participating school district included

three elementary schools, and the respondents were voluntary. A snowball sampling technique was used during interviews to determine additional potential respondents who would meet interview criteria. Nine respondents met these criteria; seven agreed to participate in the study. The three participating schools were located in the eastern region of the United States and were assigned pseudonyms to protect confidentiality of the respondents.

The research questions were investigated through in depth interviews of seven individuals who were actively implementing ACTIVATE either at the district level or in the schools in which they served. Interview questions, aligned to the research questions, were asked of participants in order to gather sufficient data to answer the research questions. Responses to the research questions were organized by theme with supporting quotations from the respondents to provide evidence for interpretation. Verbatim quotations, as recommended by Corden and Sainsbury (2006), were used to explain how something happened, illustrate themes, deepen understanding, provide a voice for respondents, and enhance readability. In summary, demonstrating the manner in which the findings emerged from the data increases credibility or trustworthiness of the data (Corden & Sainsbury, 2006).

Findings by Research Questions

Research Question 1. What practices were used in the case study schools to implement the ACTIVATE executive function intervention program? The findings revealed that staff employed many different practices to support the implementation of the ACTIVATE program. The most common reported practices are articulated in the following themed subsections: (a) identification of participants, (b) selection and use of physical activities, and (c) training and support.

Identification of ACTIVATE participants. The first practice examined by the researcher was the selection of student participants for the ACTIVATE program. In the literature review, improved executive function was found to correlate with improved achievement (Jacob & Parkinson, 2015), problem solving (Zelazo et al., 1997) and increased reading and mathematics abilities (Blair & Razza, 2007; Riggs et al., 2004). The researcher explored whether executive function deficiencies were used as a criteria to identify participation in the ACTIVATE program.

Two of the respondents shared a consistent story of the history of student participation in the program and how it had evolved over time. Both the District Reading Supervisor and the Principal at Haset Elementary shared that ACTIVATE was implemented as a pilot program in the 2012-13 school year with 25 students at Haset Elementary. The pilot expanded to 100 students, 25 in each of four elementary schools in the school district. Each elementary school had access to an unlimited number of participants, but all respondents shared that participation generally involved the neediest students. The District Reading Supervisor explained that:

> The kids participating now are the kids we have identified as having executive function weakness. Therefore, we have very few kids who are using ACTIVATE who don't have significant needs. We have been able to break out of that in a couple of places and try more of that whole class or whole building approach, but we haven't got the kind of traction we would like. They [the teachers] weren't able to keep up with it. It wasn't working so we modified it and decided to use it just with the most needy kids. We kept them on and pulled some of the other kids off just because logistically it wasn't working.

The researcher found that teachers from each of the three elementary schools reported similar practices for identifying student participants which included teacher observations, use of

an executive function checklist and district assessment results. These tools were used to assist teachers in identifying students for the ACTIVATE program. The Reading Specialist at Haset Elementary shared that:

> We have used teacher observation, and this year we've also used executive function checklists to determine the students that would need the program and which type of grouping may be the best fit. We have groups in kindergarten through fifth grade.

The Learning Support Specialist at Haset Elementary expanded upon the use of checklists as identification criteria:

> We starting trying to find students who showed signs of executive dysfunction, poor time management, messy desk area, can't stay organized, can't follow routines, poor working memory, all of those things. We don't have a standardized assessment for executive function . . . so instead what we did was we asked the classroom teacher and gave them a checklist and said look for these signs . . . We also have an assessment which assesses biological processing and in there is a rapid naming subtest which taps into working memory. The students who scored very low on this assessment, we would look at that as a qualifier for the program as well.

The Reading Specialist at Jetash Elementary explained that:

> We look at district reading assessments and any kind of testing the school psychology may have done with students to see if they would benefit from the executive functioning program during the school schedule they have . . . Maybe they have ADD, ADHD or are on some type of medication, or sometimes the classroom teacher will have voiced

concerns about the students lack of progress being in reading interventions and they think being in ACTIVATE will also help them.

The Reading Specialist at Raseth Elementary stated, "[students] may be selected based on lack of reading proficiency. It is kind of on a case-by-case basis. We look at each child and talk with the teachers." Although, as stated by the principal from Haset Elementary, "we really don't have a policy or set of procedures guiding the implementation of the ACTIVATE program," it was found that the three elementary schools utilized teacher observations, the executive function checklist and district assessment results as common criteria to identify the most needy learners for participation in the program.

Selection and use of physical activities. The second practice examined was the selection and use of physical activities to impact executive function of participating students. Physical activities are an important component of the ACTIVATE program and are specifically designed to grow executive function. The literature reports that when students participate in physical motor coordination activities the following effects occur: improved executive function (Best, 2010; Davis et al., 2011; Fisher et al., 2011, Gapin & Etnier, 2010), improved attention (Planinsec, 2002) and enhanced reading comprehension (Uhrich & Swalm, 2007; Budde et al., 2008).

The participants described the most common physical activities utilized by teachers of the ACTIVATE program and explained the reasons those activities were selected. Balancing activities (6 of 7 respondent responses), ball passing and dribbling activities (5 of 7 responses) and juggling (3 of 7 responses) were described as primary activities in which students would participate. Other activities mentioned less frequently by respondents included martial arts (3 of

7 responses), dance (2 of 7 responses), relay races (2 of 7 responses) and Yoga (1 of 7 responses).

The Reading Specialist at Raseth Elementary articulated use of the following activities at that school:

> When I taught I did the balancing activities. There is a whole set of lessons and format with a progression of balance activities. We did juggling, dribbling, passing, and built upon that. We worked on memory and there was dancing involved.

The Reading Specialist at Haset Elementary confirmed the use of these activities stating that:

> The physical activities are called large group, small group, energizer and cognitive supplement activities, and the types of activities used are based on the number of students in the group and the type of grouping. Teachers choose from different activities if the group is in the classroom or being pulled out of the classroom for a session. Many of the activities we use are balancing activities, yoga, martial arts, relay and specific activities that involve direction and changing direction, catching, and throwing activities. The kids love the variety of activities.

Lastly, an instructional coach from the district office shared the following observation made when visiting Haset Elementary:

> Some of the activities I observed were races, more like relay races, or obstacle courses. About halfway through I saw a lot of drills such as using a basketball but switching it up to passing to every second person, then to every third person, then to every girl, trying to do the cognitive flexibility piece. We had a custodian at one of the elementary schools

> that taught Tai Chi. He came in and worked with the students maybe once or twice a cycle on drills. These were just a few that I observed personally.

When asked why specific activities were selected, the responses of the respondents were, executive function need of child (6 of 7 responses), size of student group (3 of 7 responses), ease of set up and student feedback (2 of 7 responses). Other remaining responses mentioned by at least one respondent included available resources such as space, recommendations from the ACTIVATE manual and the degree of physical challenge.

The Reading Specialist at Haset Elementary shared the following reason for selecting specific activities:

> The activities were selected based on the executive function areas of need. C8 Sciences centers the need around eight core cognitive processes and this includes sustained attention, multiple simultaneous attention, impulse control, working memory, cognitive flexibility, task initiation, and speed of processing. All of those activities target one of those executive function areas, or multiple function areas at the same time.

The Reading Specialist at Raseth Elementary also shared the importance of building a child's executive function of sustained attention as follows:

> Well first we were looking for attention. With the balancing activities, they have to focus, sustain attention and they had to process all the stimuli coming in from the side, so we worked on their ability to balance while they worked on their other skills. We did juggling so they had multiple stimuli coming at them and they had to focus and then we worked on being faster. For the dribbling and passing, we were working on them being

able to do multiple things at one time and then obviously we did memory things to improve their working memory.

The Learning support teacher at Haset Elementary continued to describe reasons for selection of physical activities as follows:

The ones that we can easily implement in the classroom setting we are kind of go to first. So if we can grab some materials like some beanbags and some stopwatches and make a quick game in the moment we tend to use those activities first. We also try to look for the ones that the kids like and will be very vocal about. There is a game called max pass where all the kids stand in a circle and they have a ball and they all throw them in the air at the same time and you have to catch the one that's not the same color as the one you threw. They struggle to do that. So it is hard and sometimes they just do not want to play. We also use their feedback as well.

The findings for the selection and use of physical activities revealed that balancing activities, ball passing and dribbling, juggling, martial arts, dance, relay races, and Yoga were the most common activities utilized in the ACTIVATE program implementation. The study respondents also indicated that these activities were selected to promote executive function development, meet the needs of the size of a student group, were easy to set up, were popular with students, worked in the given space, were suggested by ACTIVATE and met an appropriate degree of physical challenge for the intended students. The researcher's findings summarize the methods in which the participating schools utilized physical activities, increasing cognitive demand and student feedback as a means to develop executive function for students using the ACTIVATE program.

Training and support. The third practice examined by the researcher was that of training and support provided for the ACTIVATE program implementation. The literature indicated that barriers to implementing wellness policies include adequate funding, competing priorities for time and education, and support from various stakeholders (Agron et al., 2010). Factors affecting physical activity implementation included lack of confidence and competence expressed by teachers (Larsen et al., 2012), the belief teachers had that they could meet expectations, amount of staff training, and transparent expectations of district policy (Action Schools, 2016). Respondents were asked the degree to which the district wellness policy helped advance the ACTIVATE implementation, and they were asked to describe whether or not training was sufficient.

Results of the respondent interviews found that six of the seven staff members interviewed either were not aware of the district wellness policy or were not familiar with it. Three of the interviewed respondents stated they were not aware of whether or not the district had a wellness policy. Three of the respondents were aware of the district wellness policy but were not familiar with it. One respondent was aware of the district policy and was familiar with it. Five of the seven respondents were confident that the ACTIVATE program was not referenced in the district wellness policy. As an example, the Reading Specialist from Raseth Elementary shared that "We do have one [a wellness policy]. I am not positive how it has affected our ACTIVATE implementation."

Results of the interviews suggested mixed perceptions regarding the degree to which training for implementation of the ACTIVATE program was sufficient. Three of the seven respondents expressed that the amount of training was sufficient while the other four

interviewees suggested more training was needed. The district reading specialist shared the following perception of the training:

> Yes, it was [sufficient]. Once you have people in the district who have done ACTIVATE for a longer period of time that is helpful. From the teacher's perspective, the biggest hurdles are not how to use it once you get kids into it. It is more like setting up the roster, and getting the right people access to the reports, that kind of logistical stuff and because we kind of have people, who have done it that is great for us.

Contrary to this perception, the learning support teacher at Haset Elementary shared this opinion:

> We did not really have a lot of training per se. There was a webinar on the portal site that we watched. It was somewhat like a learn as you go situation. So, a lot of it fell on us to train ourselves. We did have a conversation since we got in with ACTIVATE when they were relatively new and they were still trying to extend their reach, so they worked really well with us. We had conversations with them and I was also able to pilot an updated version of the program so again that put me in direct communication with the people behind ACTIVATE. As far as professional development and training there was really not a lot . . . So, I would say it was not very sufficient.

Additional findings addressed the types of training activities and depth of the professional development for staff members. Six respondents mentioned the use of webinars and or skype sessions for training. Four respondents cited the importance of questions and answers with C8Sciences, the developers of the ACTIVATE program. The reading specialist at Haset Elementary described the experience as follows:

> We actually received training through Skype and there were a couple of times when we could interact and talk with the team at C8 Sciences through this manner. ACTIVATE provides an online training course and it explains all avenues of the program in detail with examples. There are videos that are incorporated to share examples of how to complete the activities in the program for both the online and physical activity components. The Help Center is extremely valuable, as the team answers any questions that we have. There are detailed lesson plans that provide tips on coaching students during the physical and online components of the program. There are reports that share student progress and data explained in detail. The overall team at C8 Sciences goes above and beyond to answer all questions and make sure needs are met to better implement the program. They are very professional and they offer almost an immediate response. I feel as soon as I email them, they are coming back with an answer right away, which is really great.

Finally, website resources and trained district staff were described by two respondents as other, helpful training components.

Research Question 2. The second research question explored the benefits for students who participated in the program that were identified by staff members. Interview responses suggested the benefits included two main themes: (a) improved executive function and (b) increased academic performance in reading and mathematics.

***Improved executive function*.** Executive function pertains to core processes in the brain that affect a learner's cognitive ability (C8 Sciences, 2016). C8 Sciences (2016) defined critical processes involved with executive function as sustained attention, working memory, speed of

information processing, response inhibition, cognitive flexibility, category formation, pattern formation, simultaneous sustained attention. Interview transcript analysis suggested that many of these processes were observed when students participated in ACTIVATE. Responses from all seven respondents identified perceptions of improvement in overall executive function (three responses), attention span, self-regulation and focus (seven responses), working memory (two responses), ability to follow multi-step problems and cognitive flexibility (one response).

The reading specialist at Haset Elementary described the impact on executive function of students as follows:

> The students are engaged and are challenged with both the physical activities and the online portion of the program. Executive function deficits are targeted in all activities. The benefits are directly related to a student's growth in executive function and the idea of neuroplasticity, or the ability to reshape the brain through experiences. ACTIVATE helps provide experiences to strengthen the eight core cognitive capacities of executive function, which students need to thrive in classrooms today.

The instructional coach from the district office shared an explanation of the impact of the program on student's attention span with the following response:

> We did notice attention increased especially on high stakes testing. So, for example with our third, fourth, and fifth grade students, we definitely saw a shift in how long the students were attending to the task. Normally, particularly the students that participated in the ACTIVATE program, within 10 minutes they would be done. They came to the test and that's it they put their heads down. We saw them applying more time longer to sit and work through these problems. You know, they're actually holding on to this

> assessment longer. They are taking time to think things through and be a little bit more cautious and give me there attention longer to the task in front of them. It was just a noticeable shift in their thinking and their behavior.

A final and especially insightful response from the reading specialist at Raseth Elementary school described how students had become more aware of changes to their own executive functioning.

> I notice that they have an increased awareness of their executive functioning skills…they can control themselves longer or they may explain to you why they are doing something. I have had students say that I am working on better improving my attention span because in my class I want to be able to finish my math workbook page…they are able to adapt to change in directions. So, their awareness really has improved.

Increased academic performance in reading and mathematics. Increased reading and mathematics performance of students was found to be a benefit of implementation of the ACTIVATE program. Two respondents mentioned the increase in reading scores while one mentioned the increase in mathematics scores. The principal of Haset Elementary shared multiple studies conducted in the school over a several year period to track the learning progress of ACTIVATE students. The study revealed the following:

> We've done a couple of studies internally and we've looked at the longest data we have and it's on those students who are the most needy students with executive weaknesses and what we found is that on achievement, they score higher than our students who are participating in just a tier 3 intervention. We've measured them compared to peers who didn't have the ACTIVATE program (control group) but have a similar assessment

> profile who went to the exact same tier three interventions. The students that are participating in the ACTIVATE program are actually having more success with our benchmark assessments and our state assessments and they're scoring higher on those different assessments. We have looked at this for multiple years with those 25 students. We have looked at it across the board in terms of reading and math to see how they're performing and it is showing an increase in their student achievement scores and we were able to see that over a number of year.

Of the three schools in the school district, Haset Elementary school had been using the ACTIVATE program for the longest period of time. Longitudinal data on learner performance were data they believed needed to be collected to examine the long-term benefits of the program. They concluded that students participating in ACTIVATE programming achieved higher reading and mathematics scores than peers.

Another example of increased reading performance was linked to improved working memory. The reading supervisor at the district office described the mechanism by which improved working memory allows children to process words more effectively. The benefit was described as follows:

> I think definitely we have seen that specifically in literacy the working memory has increased. Some people may not see it as major, but because we work with kiddos that struggle in reading, the idea that you can hold phenomes in your head across a four phenome word and you couldn't do that four months ago, or last year, because you couldn't remember what the letter was that I have you, we have seen a lot of growth in our student's ability to decode across a word.

Research Question 3. The third research question explored the challenges school district licensed staff members experienced while implementing the ACTIVATE program. Factors limiting physical activity implementation included lack of allocated time by school leaders (Larsen et al., 2012), lack of confidence and competence expressed by teachers (Larsen et al., 2012), belief teachers had that they could meet expectations, amount of training, and transparent expectations as written in school district policy (Action Schools, British Columbia, 2016). However, limited research had explored the barriers and promotors of healthy eating and physical activity for 5- to 12-year-olds (Romero et al., 2001).

Through interview transcript analysis, eight types of barriers to implementing the ACTIVATE program were identified. In order of frequency, the barriers were time/schedule, available space, qualified staffing, sufficient technology, boredom on the part of the student, size of the student groups, limitations of resources and cost of the ACTIVATE program. The most frequent responses included (a) time/schedule, (b) available space, and (c) qualified and trained staff.

***Time/schedule*.** The barrier of time and schedule was mentioned by all seven respondents including those working at the district office and in each of the three elementary schools. The comments mainly reflected the lack of integration into the regular school programming. The reading specialist at Haset Elementary reflected on this issue as follows:

> I would say the biggest barriers are time and scheduling during the school day. There are many demands based on the curriculum and the many tasks that students and teachers have to complete during the day. Creatively finding the time, structuring the time, and

> integrating the program into your day, especially with a whole classroom, can be a challenge.

Adding one more intervention to students' schedules without removing something proved to be a challenge according to the district instructional coach.

> The biggest hurdle that I can speak to is scheduling conflicts and staffing . . . Because, as I said, these students have multiple other interventions in place and I think that was the biggest conflict for us.

Building schedules that allowed students to participate required that conflicts in their schedules be creatively solved. This was not always possible and at times students were not able to participate in ACTIVATE. Sometimes those conflicts occurred within core content classes like science and social studies. The reading specialist at Raseth Elementary school expressed the concern of students missing science and social studies classes:

> As a reading specialist, the amount of time we could pull our students from our classes was limited. We are already pulling them out of reading for reading support, and out of math for math support and they are missing science and social studies for ACTIVATE. So it was a fine balance of when and who was going to be teaching that and how we were going to manage.

At times, a schedule conflict could occur when students receive special services during their school day as described by the learning support teacher at Haset Elementary.

> The number one staff limitation is space and then time. Maybe time should be number one. A lot of kids that are in the ACTIVATE program have many needs. They are in with a learning specialist. They also have an IEP so they see me for support. They have maybe

> a teacher for language therapy so these kids are bounced around a lot and fitting it into their schedule is difficult.

Scheduling was a challenge expressed by all respondents, but followed closely by the challenge of available space.

Available space. Space is necessary to participate in the games in the ACTIVATE program. The small group games require less space than the large group games. Sometimes games are played in the classroom, and at times they are played in a gymnasium or on an outside field. Non-moveable desks and chairs often created barriers to available classroom space. The learning support teacher at Haset Elementary described this problem:

> It's really hard to with fidelity implement these physical activities when you have a classroom with desks and tables and chairs. We have one group who is literally in a hallway during their ACTIVATE time because we are a small school. We have some kids that go into a trailer that is outside of the school.

In addition, construction in one participating school proved a barrier as available space was reduced or temporarily unavailable. "Jetash has struggled to maintain ACTIVATE this year compared to how we had it last year because that building has been under construction" (Reading Supervisor, District Office).

The Jetash Elementary school reading specialist described the challenge presented by the classroom being smaller than in previous years as follows:

> Last year I had a bigger more spacious classroom where we could move desks, tables and chairs out of the way and we had more space to do the physical activities…Unfortunately my room is smaller now and I don't have as much physical space to do the physical

components of ACTIVATE. Our outdoor playground to use for larger groups in limited with construction still going on.

Having sufficient available space was presented as a barrier by four of the staff members who were interviewed.

Qualified and trained staff. A second theme emerged from the analysis of barriers to the implementation of ACTIVATE in the case study schools. Four of the seven staff members interviewed described the level of training teachers received as a major barrier prior to and during implementation. As an example, the reading specialist at Jetash Elementary shared this statement: "I don't think the physical activity parts were modeled very well. I feel like we could have had a guest speaker in front of us doing the training and giving more information about the physical parts of the program." Modeling the physical activities was described as a barrier because the reading specialist was not confident in the activities he/she was asked to lead.

The training barrier was further described by one respondent as really a conflict that occurred due to the student's schedule. If students had only one block for intervention in their schedule, then having an interventionist who is trained in the ACTIVATE program in addition to other interventions would be more beneficial for that student. "You know, finding an interventionist who is trained in understanding the ACTIVATE program as well as understands executive function is critical" (Instructional Coach, District Office). An interventionist can then utilize the ACTIVATE program as needed for the children they are assigned to.

Keeping the students engaged and motivated to work through challenges were described by one staff member as essential for the ACTIVATE teacher. The principal at Haset Elementary described this need as follows:

> What we found is even in the district there are some staff who did not engage students as frequently and we have seen that if the students aren't engaged and there isn't somebody there coaching along with the process then the scores really suffered as a result of that. So I think the big barrier is finding that one staff member who can do that and keep the students motivated to play a game that they have seen on a regular basis.

The principal continued to explain the importance of the principal in leading this type of training:

> The other one I think is kind of going back to the barriers that we experience and encouraging principals to really educate their staff on a program like this and ways to make it motivating and encouraging to students and helping teachers understand that many students do have executive function weakness and they are struggling in these areas and that can be really hard for the student.

The principal explained that when students struggle with executive function they need to be stretched in their persistence. Consequently, training teachers who can motivate students through challenges is critical.

Research Question 4. What recommendations would case study school respondents provide for successful implementation of the ACTIVATE program? The fourth question solicited recommendations that would support effective implementation of the ACTIVATE program. In an interview with Dr. Wexler (personal communication, December2, 2016), he noted that a study of the implementation of the ACTIVATE program had not been conducted. As a result of this interview, the researcher was motivated to conduct this research. Insights into

effective implementation of ACTIVATE were gathered and summarized and recommendations prepared for school districts and schools considering implementation of this program.

Eleven types of responses were collected from staff members, summarized and themed. The findings from the staff interviews suggested that recommendations for implementation could be categorized into three themes: (a) establishing the purpose with stakeholders, (b) providing sufficient training, and (d) integration of the ACTIVATE program into the schedule.

Establishing the purpose. When asked about recommendations for implementing the ACTIVATE program, five of the seven respondents interviewed mentioned the importance of ascertaining the purpose of using the ACTIVATE program. Understanding the purpose required some background knowledge of executive function, its importance and how its development can be manipulated.

A staff member mentioned the importance of ensuring that families, teachers and staff members understand the purpose of ACTIVATE prior to its implementation:

> My first recommendation is that you understand executive function, first before you jump to the program. You have to understand why you are putting it into place. Your staff and your families have to understand why you're putting it into place. (Instructional Coach District Office)

The principal from Haset Elementary supported that statement with the following:

> So I think this recommendation would certainly be number one. I think it's important to understand executive function and cognitive capacity and how they all relate to the learning process, basically understanding purpose for a program like this and understanding why you would go through a process like this.

The reading specialist at Raseth Elementary school described the critical role of resources and the importance of staff effectively communicating what students are doing as follows:

> Provide professional development for the parents and the teachers. Make sure you have the time and resources to effectively and systematically implement the program so that you have fidelity and have the ability to explain to parents and everybody about what students are doing and what they are learning.

Finally, the learning support teacher at Haset Elementary stated as follows that the students should be informed about and understand the purpose of ACTIVATE:

> Explicitly teach the student what the purpose of ACTIVATE is. They need that knowledge to build their executive function. They really need explicit instruction on how to improve their executive function, why they are here, what their brain is doing, and what it should be doing.

The last set of responses were especially insightful as they addressed the importance of knowing that improvement in executive function in the present has a great impact on learning in the future. The reading supervisor from the district office stated that it is important to "help teachers understand that we can change kids' executive functioning trajectory. It doesn't have to stay the way it is and it is not something the kid is stuck with, and we can make it better." The impact on executive function development is an especially powerful reason for incorporating ACTIVATE into the schedule for certain learners. The reading specialist from Raseth Elementary also explained how improvement in executive function creates leverage for students across disciplines. This specialist reported a rationale for teaching students the purpose as follows "I think the overall importance of executive function across all settings [is critical]

because we are preparing our students for the future and it can have such an impact on today, tomorrow and the rest of their schooling." The importance of knowing that improvement in executive function affects important aspects of life was described as critical to the "why" message shared with stakeholders.

Sufficient training. Five respondents recommended the need for sufficient staff member training to achieve effective implementation of ACTIVATE. The responses included training on the brain and the mechanisms of learning, the impact of movement on executive function and learning, and capacity building through the use of mentors. The training focus begins with knowing how the brain works.

The principal of Haset Elementary explained the need for training staff members about brain function as follows:

> As educators we are trained in a lot of things but I think few universities and colleges are actually educating students on the brain and how the brain goes about learning and so we talk about all these great strategies and these great things that we can try and these tips to build a little teacher-toolbox but we don't really talk about how it affects the brain and the internal components of that. So one recommendation is to increase that professional development around the brain.

The principal's perception was that this type of brain training has not been a standard component of preservice teacher preparation programs and the need exists to do so. The reading specialist from Haset Elementary described how the gap in understanding brain function was changed because of participation in the ACTIVATE training experiences. The experience was summed up as:

> I have learned about executive function and the impact it has on all learners, including adults. I've learned more about brain connections and synapses between the brain and about neuroplasticity and its ability to reshape the brain through experiences. I've also used this knowledge and incorporated it into my daily instruction, whether it's actually an ACTIVATE class or the reading class I'm teaching.

The reading specialist described the relevance of learning about how the brain works and how that has influenced other areas of instruction beyond the use of the ACTIVATE intervention.

Another rationale presented for training staff about the brain is understanding its impact on success in the school environment. The district office reading supervisor articulated the importance of training staff on how the brain learns, its impact on being successful in school, and having a broader perspective. "The staff need an understanding of how kids learn and how executive function strengths and weaknesses fit into that. They need to have a wider lens" (Reading Supervisor, District Office). The reading specialist at Jetash Elementary described learning about the importance of brain breaks for school success as follows: "Doing the brain breaks and getting more physical activities throughout the day help the struggling students' needs with being able to pay attention in their work throughout school day." Understanding how the brain works and how it relates to school success was deemed critical training by the previously mentioned respondents.

The last component of training was described by one respondent as that of capacity. "Have mentors for the teachers so that you have someone to support the teachers and they can get their questions answered in a timely fashion" (Reading Specialist, Raseth Elementary). The

use of mentors was described in this interview as a way to build capacity and provide a response network for ongoing training and questions and thus was deemed an important training aspect.

Integration into the schedule. Finding ways to integrate the ACTIVATE program into the existing school schedule was shared as a strategy for a successful implementation. Four of the seven staff interviewed mentioned the need to start small, integrate the program into the existing schedule and reduce schedule conflict impacts by limiting participation to those students whose schedule accommodate the ACTIVATE program. The reading specialist from Haset Elementary shared this advice:

> Start small and try to integrate as much as you can with the schedule you already have. Look at what you're already doing, and then creatively include the ACTIVATE activities or expand upon them with what you're doing. This can be demanding with the demands that teachers have.

The reading supervisor at the district office stated that helping staff see how ACTIVATE fits in a schedule will help with implementation. The recommendation was to:

> Make sure that is has a place. Where does it fit into your school day, your day, your block, whatever is going on? If you show them how it is going to fit and that it isn't going to be one more thing on their plate, they are going to be more willing to come along with you.

Even after multiple years of implementation, making room for extra time to do the physical component of ACTIVATE proved to be an ongoing challenge. The principal at Haset Elementary shared this perspective:

> We're really trying to find creative ways to solve the physical component and finding time for the physical component. We were able to find lots of times where the students were able to do the online component. We can find that time. The challenge is trying to find time for the physical component. That seems to be where we're struggling so ensure that you're incorporating that physical component as well as the online component.

The learning support teacher at Haset Elementary suggested that the solution may be found through streamlining the process by which students are identified for the ACTIVATE program. "Finding time to incorporate the physical activity into their schedule is difficult, so I would be more selective about who's in the program and be okay with stopping it when it's not effective." Limiting participation in ACTIVATE only to students who would benefit the most helped to simply schedule conflicts.

Summary

Chapter IV presented the findings of the four research questions. Interview responses were analyzed from seven staff members regarding their expertise in the implementation of the ACTIVATE exercise intervention program. The first question addressed the practices that district, site and teacher leaders used to implement the ACTIVATE program. The findings revealed that staff used many different practices to support the implementation of the ACTIVATE program. However, the most common reported practices referred to identification of participants, selection and use of physical activities, and training and support of staff.

The second research question explored the benefits presented by staff for students who participated in the program. Interview responses suggest two main benefits including improved executive function and increased academic performance in reading and math. Responses from all

seven respondents included perceptions of improvement in overall executive function including attention span, self-regulation and focus, working memory, ability to follow multi-step problems and cognitive flexibility. Two respondents mentioned an increase in reading scores while one mentioned an increase in mathematics scores.

The third research question explored the challenges staff experienced while implementing the program. Through interview transcript analysis, eight types of barriers to implementing the ACTIVATE program were found. The most frequently reported barriers included time and the schedule, available space for the physical activities, and ensuring qualified and trained staff.

The fourth research question explored recommendations that would support an effective implementation of the ACTIVATE program. Eleven types of responses were collected from the seven interviews, summarized and themed. The findings suggested that recommendations for implementation were categorized into three themes including the importance of establishing the purpose with stakeholders, providing sufficient training, and integration into the schedule. Chapter V examines the findings, comparing and contrasting them to the literature. Conclusions of the study are presented followed by a description of limitations of the study. Lastly, the researcher provides recommendations for effectively implementing the ACTIVATE exercise intervention program and recommendations for potential research studies in the future are articulated.

Chapter V: Discussion

The purpose of the case study was to explore how three elementary schools implemented the ACTIVATE exercise intervention program with intentions to improve executive function. The researcher investigated the practices used in the participating schools, the perceived benefits for children, the barriers to implementation and recommendations for schools intending to implement the program. The case study format provided for the collection of responses, perspectives and insights from educators most responsible for implementation of the program. Chapter V will describe the conclusions of the study relative to the review of literature (Chapter II) on the effect of exercise intervention on executive function. Limitations of the case study, recommendations for educators and education leaders as well as potential future research studies are presented.

Conclusions

Research Question 1: Practices Used. The first research question explored how practices embedded in case study schools compared to literature findings regarding the use of exercise interventions to improve executive function. There are many practices that can support the use of exercise interventions to improve executive function in children (see Appendix C), but the research question and the staff responses focused on the following practices: identification of participants, selection and use of physical activities, and training and support of staff.

Identification of program participants. The researcher explored whether executive function deficiencies were being used as a criteria to identify student participation in the ACTIVATE program. All respondents reported that use of the program has generally occurred with the students who would benefit the most. The District Reading Supervisor explained that:

> The kids participating now are the kids we have identified as having executive function weakness. So we have very few kids who are using ACTIVATE who don't have significant needs. We've been able to break out of that in a couple of places and try more of that whole class or whole building approach, but we haven't got the kind of traction we would like. They [the teachers] weren't able to keep up with it. It wasn't working so we modified it and decided to use it just with the most needy kids.

The Learning Support Specialist at Haset Elementary expanded upon this with the following identification criteria:

> We starting trying to find students who showed signs of executive dysfunction, poor time management, messy desk area, can't stay organized, can't follow routines, poor working memory, all of those things. We don't have a standardized assessment for executive function . . . so instead what we did was we asked the classroom teacher and gave them a checklist and said look for these signs.

Although, as stated by the principal from Haset Elementary, "we really don't have a policy or set of procedures guiding the implementation of the ACTIVATE program" the researcher's findings indicated that the three elementary schools utilized teacher observations, an executive function checklist and district assessment results as common criteria to identify the most needy learners for the program.

It was found that the case study schools utilized the ACTIVATE program primarily for students who would benefit most from improved executive function. The decision to use the physical activity component of the ACTIVATE program was connected directly with the desire to improve children's executive function. That decision aligned with research which articulated

how physical exercise benefits executive function development (Best, 2010; Davis et al., 2011; Fisher et al., 2011).

Selection and use of physical activities. The researcher explored how the selection and use of physical activities matched recommendations from the literature related to impact on executive function. Staff responses stated that balancing activities, ball passing and dribbling activities and juggling were primary activities in which students would participate while martial arts, dance, relay races and Yoga were used less frequently. The Reading Specialist at Raseth Elementary described using balancing activities, juggling, dribbling, dribbling and passing and dancing. The Reading Specialist at Haset Elementary utilized large group, small group, energizer and cognitive supplement activities. The staff member indicated, "many of the activities we use are balancing activities, yoga, martial arts, relay and specific activities that involve direction and changing direction, catching, and throwing activities."

The researcher concluded that the physical activities utilized in the case study schools align with many of those recommended in the literature. The findings suggested that balancing activities, ball passing and dribbling, juggling, martial arts, dance, relay races and Yoga were the most frequently described activities utilized in the ACTIVATE program implementation. The following physical activities, among others, are recommended in the literature for their cognitive benefits: group games (Best, 2010), Tennis (Crova et al., 2013), Soccer (Chang et al., 2013), Exergames (Hillman et al., 2008; Tomporowski, 2003), Taekwondo and Yoga (Kamijo et al., 2011) dance, band, drumming, and circus (Diamond, 2015).

The researcher also found that the physical activities used in the case study schools were selected primarily to improve executive function. When asked why specific activities were

selected, the most common response of the respondents was to improve executive function of the child (6 of 7 responses). A district office instructional coach provided insight from an observation stating, "about halfway through I saw a lot of drills such as using a basketball but switching it up to passing to every second person, then to every third person, then to every girl, trying to do the cognitive flexibility piece." The reading specialist at Haset Elementary stated that "the activities were selected based on executive function areas of need . . . All of those activities target one of those executive function areas, or multiple function areas at the same time." The reading specialist at Raseth Elementary described the importance of the balancing activities as follows:

> With the balancing activities, they have to focus, sustain attention and they had to process all the stimuli coming in from the side, so we worked on their ability to balance while they worked on their other skills. We did juggling so they had multiple stimuli coming at them and they had to focus and then we worked on being faster. For the dribbling and passing we were working on them being able to do multiple things at one time and then obviously we did memory things to improve their working memory.

When children participate in physical motor coordination activities, they have improved executive function (Best, 2010; Davis et al., 2011; Fisher et al., 2011, Gapin & Etnier, 2010) including improved attention (Planinsec, 2002).

A third researcher conclusion was that the physical activities were designed to provide an ongoing cognitive challenge. Four respondents described this as increasing the physical challenge (speed or difficulty) while maintaining focus on a thinking task. Three of the seven respondents described this as increasing the thinking challenge while focusing on a physical task.

This approach aligned with research by Diamond (2015) and Davis et al. (2011) who suggested that the effects of exercise on executive function become greater when the person shifts from simply moving to moving with thought and that increased cognitive challenge of the physical activity improves executive function (Diamond et al., 2007, Diamond & Lee, 2011; Manjunath & Telles, 2001;). Although one respondent claimed that physical activities were not cognitively challenging enough, the findings suggested that the exercises used in the case study schools were primarily selected and designed to provide this ongoing cognitive challenge.

The fourth researcher conclusion was that other factors for selection of physical activities, including logistics and student feedback, impacted the decision making process regarding the selection of physical activities. The size of student group, ease of set up, student feedback and space were mentioned by at least one of the seven respondents as factors that affected which physical activities were selected for use. The Learning support teacher at Haset Elementary described the following reasons for selection of physical activities:

> The ones that we can easily implement in the classroom setting we're kind of go to first . . . We also try to look for the ones that the kids like and will be very vocal about . . . We also use their feedback as well.

Student feedback is important as activities that promote happy, calm, and socially supported students are especially critical to executive function (Diamond, 2012).

Training and support. The third practice examined was the depth of training and support provided for the ACTIVATE program implementation. Research based factors associated with successful implementation of physical activity intervention programs included lack of confidence and competence expressed by teachers (Larsen et al., 2012), belief teachers have that they can

meet expectations, depth of staff training, and transparent expectations of district policy (Action Schools, British Columbia, 2016).

The first conclusion determined by the researcher was that the district wellness policy was not instrumental in the implementation of the ACTIVATE program. The findings in the study indicated that six of the seven staff members interviewed either were not aware of the district wellness policy or if they were aware of the policy, they were not familiar with the content. Three of the respondents interviewed stated they were not aware of whether or not the district had a wellness policy while three of the respondents were aware of the district wellness policy but were not familiar with it. Only one respondent was aware of the district policy and was familiar with it. Five of the seven respondents were confident that the ACTIVATE program was not referenced in the district wellness policy. As an example, the Reading Specialist from Raseth Elementary shared that "We do have one [a wellness policy]. I am not positive how it has affected our ACTIVATE implementation." The literature reviewed by the researcher was sparse as to whether or not wellness policies successfully result in the implementation of practices promoting exercise intervention programs. Several researchers concluded that a local wellness policy was found not to have impacted the minutes of physical education instruction or recess over time however, though did suggest that further investigation would be helpful to determine the impact of wellness policies on long term changes in school practices (Belansky et al., 2013). The ACTIVATE intervention program implementation in the case study did not appear to have been initiated by the district wellness policy.

The second conclusion regarding training and support was that training was sufficient for staff leading the implementation of the ACTIVATE program but not sufficient for others. Three

of the seven respondents indicated the amount of training they received to be sufficient. The district reading specialist shared the following perception of the training:

> Yes it was [sufficient]. Once you have people in the district who have done ACTIVATE for a longer period of time, that is helpful. From the teacher's perspective, the biggest hurdles aren't how to use it once you get kids into it. It's more like setting up the roster, and getting the right people access to the reports, that kind of logistical stuff and because we kind of have people, who have done it that is great for us.

The reading specialist at Haset Elementary described the experience as follows:

> ACTIVATE provides an online training course, and it explains all avenues of the program in detail with examples. There are videos that are incorporated to share examples of how to complete the activities in the program for both the online and physical activity components. The Help Center is extremely valuable, as the team answers any questions that we have. There are detailed lesson plans that provide tips on coaching students during the physical and online components of the program. There are reports that share student progress and data explained in detail. The overall team at C8 Sciences goes above and beyond to answer all questions and makes sure needs are met to better implement the program. They are very professional, and they offer almost an immediate response. I feel as soon as I email them, they are coming back with an answer right away, which is really great.

Four respondents suggested that more training was desired. Upon reviewing the responses from respondents, the train the trainer model did not appear to be sufficient. The learning support teacher at Haset Elementary shared this opinion:

> We did not really have a lot of training per se. There was a webinar on the portal site that we watched. It was kind of like a learn as you go situation. So, a lot of it fell on us to train ourselves. We did have a conversation since we got in with ACTIVATE when they were relatively new and they were still trying to extend their reach, so they worked really well with us . . . As far as professional development and training, there was really not a lot . . . So, I would say it was not very sufficient.

Although the types of training activities provided by C8Sciences were deemed helpful by all seven staff members interviewed, it was found that staff not leading the district implementation felt too much of the training responsibility was left up to the teachers at the sites. A lack of confidence and competence expressed by teachers has been found to be a barrier affecting implementation of physical activity programs (Larsen et al., 2012).

Research Question 2: Benefits. The second research question explored the benefits shared by staff for students who participated in the ACTIVATE program. The staff responses suggested the benefits included two main themes: (a) improved executive function and (b) increased academic performance in reading and mathematics.

***Improved executive function*.** The researcher explored whether ACTIVATE was perceived to positively impact participants' executive functioning. Responses from all seven respondents included perceptions of improvement in overall executive function (three responses), attention span, self-regulation and focus (seven responses), working memory (two responses), ability to follow multi-step problems and cognitive flexibility (one response).

The researcher concluded that a perceived benefit of the ACTIVATE program was improved executive function in participating students. The reading specialist at Haset Elementary described impact on executive function as follows:

> The benefits are directly related to a student's growth in executive function and the idea of neuroplasticity, or the ability to reshape the brain through experiences. ACTIVATE helps provide experiences to strengthen the eight core cognitive capacities of executive function, which students need to thrive in classrooms today.

The stated benefits are consistent with several researchers' findings. When children participate in physical motor coordination activities they have improved executive function (Best, 2010; Davis et al., 2011; Fisher et al., 2011, Gapin & Etnier, 2010), specifically improved attention (Planinsec, 2002). The instructional coach from the district office verified this literature finding by stating that:

> We did notice attention increased especially on high stakes testing . . . with our third-, fourth-, and fifth-grade students, we definitely saw a shift in how long the students were attending to the task. Normally, particularly the students that participated in the ACTIVATE program, within 10 minutes they would be done. They came to the test…they put their heads down. We saw them applying more time longer to sit and work through these problems. You know, they're actually holding on to this assessment longer. They are taking time to think things through . . . be a little bit more careful and they give me their attention longer for the task in front of them. It was just a noticeable shift in their thinking and their behavior.

A final and especially insightful response was offered by the reading specialist at Raseth Elementary who described how students became more aware of changes to their own executive functioning:

> I notice that they have an increased awareness of their executive functioning skills…they can control themselves longer, or they may explain to you why they are doing something. I have had students say that I am working on better improving my attention span because in my class I want to be able to finish my math workbook page…they are able to adapt to change in directions. So, their awareness really has improved.

Student awareness of the impact on his or her own executive functioning appears to be a powerful motivator. This is significant because of the impact improved executive functioning can have a student's every day learning experiences and long-term success. Working memory is related to inhibition (Davidson et al., 2006). Enhanced inhibition improves behavior which is linked to improved general executive function (Young et al., 2009), and deficits in executive function can have life long lasting impacts related to social relationships and career success (Best et al., 2011; Bull & Lee, 2014). Overall, executive function skills appear to be critical for school success (Alloway & Alloway, 2010; Borella et al., 2010; Duckworth & Seligman, 2005). Deficits in executive function often grow larger over time (Riggs et al., 2003; O'Shaughnessy et al., 2003), and long term impacts in life include poorer health, less income, lower levels of happiness and higher likelihood of committing crime (Moffitt, 2012; Moffitt etal.,2011).

***Increased academic performance in reading and mathematics*.** Two respondents suggested a benefit of participation in the ACTIVATE program was an increase in reading scores while one mentioned the increase in mathematics scores. The principal at Haset Elementary

provided insight into the perceived reading and mathematics benefits of ACTIVATE with the following data story:

> We've done a couple of studies internally, and we've looked at the longest data we have and it's on those students who are the most needy students with executive weaknesses and what we found is that on achievement, they score higher than our students who are participating in just a Tier 3 intervention. We've measured them compared to peers who didn't have the ACTIVATE program (control group) but have a similar assessment profile who went to the exact same tier three interventions. The students that are participating in the ACTIVATE program are actually having more success with our benchmark assessments and our state assessments and they're scoring higher on those different assessments. We have looked at this for multiple years with those 25 students. We have looked at it across the board in terms of reading and math to see how they're performing and it is showing an increase in their student achievement scores and we were able to see that over a number of year.

A mechanism for how the ACTIVATE program impacts reading performance through improved working memory was articulated by the reading supervisor at the district office with the following statement:

> I think definitely we have seen that specifically in literacy the working memory has increased. We work with kiddos that struggle in reading. The idea that you can hold phenomes in your head across a four phenome word and you couldn't do that four months ago, or last year, because you couldn't remember what the letter was . . . we have seen a lot of growth in our student's ability to decode across a word.

The respondent explained that an improved working memory because of participating in the ACTIVATE program has enhanced a children's abilities to remember parts of a word in their head as they are learning to sound out the word or determine the words meaning. A small improvement in working memory could provide greater access to literacy gains.

The researcher concluded that a perceived benefit of ACTIVATE participation is improved mathematics and reading scores. Several researchers have made similar claims for physical motor coordination activities in general. When children participated in physical motor coordination activities they had enhanced reading comprehension (Budde et al., 2008; Uhrich & Swalm, 2007). Other researchers suggested that improved executive function correlates with improved achievement (Jacob & Parkinson, 2015), problem solving (Zelazo et al., 1997) and increased reading and mathematics abilities (Blair & Razza, 2007; Riggs et al., 2004) and long-term academic achievement in school (Best et al., 2011; Fuhs et al., 2014).

Research Question 3: Barriers. Research factors which limited physical activity implementation included a lack of allocated time by school leaders (Larsen et al., 2012), lack of confidence and competence expressed by teachers (Larsen et al., 2012), belief teachers have that they can meet expectations, amount of staff training, and transparent expectations via district policy (Action Schools, British Columbia, 2016). Limited research was found that explored the barriers to physical activity for 5- to 12-year-olds (Romero et al., 2001) or more specifically barriers to implementation of the ACTIVATE program (B. K. Wexler, personal communication, December 2, 2016). The participant responses regarding barriers to the ACTIVATE implementation focused on three main themes: (a) time/schedule, (b) available space, and (c) qualified and trained staff.

Time/schedule. Time and the schedule was the most frequently mentioned barrier to implementation of the ACTIVATE program. All seven respondents mentioned this barrier. The respondents mentioned the lack of ACTIVATE's integration into the regular school day programming as a barrier. The reading specialist at Haset Elementary reflected:

> I would say the biggest barriers are time and scheduling during the school day. There are many demands based on the curriculum and the many tasks that students and teachers have to complete during the day. Creatively finding the time, structuring the time, and integrating the program into your day, especially with a whole classroom, can be a challenge.

Many struggling learners that would benefit from the ACTIVATE program already had a schedule that required time for special services. Adding one more service/intervention to their schedule without removing something was shared as a challenge according to the district instructional coach who stated, "the biggest hurdle that I can speak to is scheduling conflicts and staffing . . . because, as I said, these students have multiple other interventions in place." Building a schedule that allowed students to participate required that conflicts in the child's schedule were creatively solved. This was not always possible and at times students were not able to participate in the ACTIVATE program because of this. Sometimes those conflicts occurred with core content areas like science and social studies. The reading specialist at Raseth Elementary confirmed this as follows:

> As a reading specialist the amount of time we could pull our students from our classes was limited. We are already pulling them out of reading for reading support, and out of math for math support, and they are missing science and social studies for ACTIVATE.

> So it was a fine balance of when and who was going to be teaching that and how we were going to manage.

At times, conflicts may have occurred with other special services that a student was receiving such as those described in the narrative from the learning support teacher at Haset Elementary.

> The number one staff limitation is space and then time. Maybe time should be number one. A lot of kids that are in the ACTIVATE program have many needs. They are in with a learning specialist. They also have an IEP so they see me for support. They have maybe a teacher for language therapy so these kids are bounced around a lot and fitting it into their schedule is difficult.

Factors limiting physical activity implementation included the lack of allocated time by school leaders (Larsen et al., 2012). Scheduling proved to be a challenge and was expressed strongly by all respondents.

Available space. Adequate space was the second most mentioned by respondents as a barrier for staff implementing the ACTIVATE program. Four out of seven respondents described adequate space including lack of mobile furniture as major barrier to overcome when implementing small and larger group games. The learning support teacher at Haset Elementary described the problem as follows:

> It's really hard to with fidelity implement these physical activities when you have a classroom with desks and tables and chairs. We have one group who is literally in a hallway during their ACTIVATE time because we are a small school. We have some kids that go into a trailer that is outside of the school.

In addition, construction proved a barrier as available space was reduced or temporarily unavailable. "[Jetash elementary] has struggled to maintain ACTIVATE this year compared to how we had it last year because that building has been under construction" (Reading Supervisor, District Office). The Jetash Elementary reading specialist described how the classroom was smaller than previous years and the challenge that presented:

> Last year I had a bigger more spacious classroom where we could move desks, tables and chairs out of the way and we had more space to do the physical activities . . .
>
> Unfortunately my room is smaller now and I don't have as much physical space to do the physical components of ACTIVATE. Our outdoor playground to use for larger groups is limited with construction still going on.

Adequate space due to lack of mobile furniture and the current construction plans proved to be a significant barrier to implementing the ACTIVATE program.

***Qualified and trained staff*.** Training to support implementation of the ACTIVATE program was perceived to be sufficient only by those most closely associated with that implementation (district and teacher leaders) and insufficient by others. Four of the seven staff respondents perceived that the level of training staff received was a barrier prior to and during implementation. As evidence of this claim, the reading specialist at Jetash Elementary shared this statement: "I don't think the physical activity parts were modeled very well. I feel like we could have had a guest speaker in front of us doing the training and giving more information about the physical parts of the program." Additionally, an instructional coach at the district office described the importance of intervention teachers being trained in the ACTIVATE program. If students have only one block for intervention in their schedule, then having an interventionist

who is trained in the ACTIVATE program in addition to other interventions provides greater flexibility. “You know, finding an interventionist who is trained in understanding the ACTIVATE program as well as understands executive function is critical” (Instructional Coach, District Office).

Finally, engaging and motivating the students to keep them working through program challenges was described by one staff member as a critical skill for the ACTIVATE teacher. The Principal at Haset Elementary described this need as follows:

> What we found is even in the district there are some staff who did not engage students as frequently and we have seen that if the students aren’t engaged and there isn’t somebody there coaching along with the process then the scores really suffered as a result of that. So I think the big barrier is finding that one staff member who can do that and keep the students motivated to play a game that they have seen on a regular basis.

The principal continued to describe the importance of encouraging “principals to really educate their staff on a program like this and ways to make it motivating and encouraging to students.” The principal explained that when students struggle with executive function they need teachers who can motivate them through the completion of ACTIVATE challenges. The degree of confidence that staff members have in implementing a program was consistent with conclusions reached by Larsen et al. (2012) who claimed that a lack of confidence and competence expressed by teachers was a significant factor impacting physical activity implementation.

Research Question 4: Recommendations. The fourth research question explored recommendations to consider for schools and school districts choosing to implement the

ACTIVATE program in the future. Based on participant responses, recommendations for implementation were divided into three categories: (a) establishing the purpose with stakeholders, (b) providing sufficient training, and (c) integration of the ACTIVATE program into the schedule.

Establishing the purpose. Stakeholder understanding of the rationale for use of ACTIVATE is critical to successful implementation. Five of the seven staff interviewed mentioned the importance of explaining the purpose for using the ACTIVATE program to all stakeholders. The district office instructional coach shared "that you [have to] understand executive function first before you jump to the program. You have to understand why you are putting it into place. Your staff and your families have to understand why you're putting it into place." The principal from Haset Elementary shared similar thinking:

> So I think this recommendation would certainly be number one. I think it's important to understand executive function and cognitive capacity and how they all relate to the learning process, understanding purpose for a program like this and understanding why you would go through a process like this.

The reading specialist at Raseth Elementary said to make sure you "have the ability to explain to parents and everybody about what students are doing and what they are learning." Finally, a staff member at Haset Elementary said to "explicitly teach the student what the purpose of ACTIVATE is . . . They really need explicit instruction on how to improve their executive function, why they are here, what their brain is doing, and what it should be doing."

One of the most powerful stated recommendations for explaining the rationale of the program to teachers was to help them understand how an improvement in executive function

development creates access to learning for a child. For example, the district office reading supervisor recommended to "help teachers understand that we can change kids' executive functioning trajectory. It doesn't have to stay the way it is and it is not something the kid is stuck with, and we can make it better." The reading specialist from Raseth Elementary School also explained how improvement in executive function creates leverage for students throughout their school experience stating that "I think the overall importance of executive function across all settings [is critical] because we are preparing our students for the future, and it can have such an impact on today, tomorrow and the rest of their schooling." The importance of knowing that improvement in executive function affects all aspects of life was described as critical to the rationale shared with stakeholders. The two statements align with the literature which express that improved executive function correlates with long term academic achievement in school (Best et al., 2011; Fuhs et al., 2014), and deficits in executive function can have life long lasting impacts related to social relationships and career success (Best et al., 2011; Bull & Lee, 2014).

Sufficient training. Staff perceived that ACTIVATE program implementation would be enhanced by offering a more robust training model. Five of the seven respondents specifically recommended staff training regarding the brain and the mechanisms of learning, training on the impact of movement on executive function and learning, and use of mentors to build capacity. The principal of Haset Elementary School shared that "few universities and colleges are actually educating students about the brain and how the brain goes about learning…so one recommendation is to increase that professional development around the brain."

A rationale for training staff is to help them in understanding the brain's impact on success in the school environment. The district office reading supervisor articulated, "staff need

an understanding of how kids learn and how executive function strengths and weaknesses fit into that. They need to have a wider lens." The reading specialist at Jetash Elementary School described learning about the importance of brain breaks for school success as follows: "Doing the brain breaks and getting more physical activities throughout the day help the struggling students' needs with being able to pay attention in their work throughout school day." Understanding how the brain works and how it relates to school success was deemed critical training by the reading specialist at Jetash Elementary School. This aligns with research from Tomporowski et al. (2015) who stated that specific physical activity interventions designed to incorporate both core executive functions and higher order cognitive processes may provide the right type of brain training to improve children's academic performance (Tomporowski et al., 2015).

The last component of training was described by one staff member as that of capacity. "Have mentors for the teachers so that you have someone to support the teachers, and they can get their questions answered in a timely fashion" (Reading Specialist, Raseth Elementary). The use of mentors was described in the interview as a method for building capacity and providing a response network for ongoing training and questions.

Integration into the schedule. Integrating the ACTIVATE program into the schedule was believed to be a critical component of successful implementation. Four of the seven staff interviewed mentioned the need to start small, integrate the program into the existing schedule and reduce schedule conflict impacts by streamlining the identification of the participants. The reading specialist from Haset Elementary School recommended to "start small and try to integrate as much as you can with the schedule you already have." Look at what you're already

doing, and then creatively include the ACTIVATE activities or expand upon them with what you're doing." Similarly, the reading supervisor at the district office stated that helping staff see how ACTIVATE fits and convincing classroom teachers that it is not simply one more task on their plate will help with the implementation. The recommendation was to:

> Make sure that is has a place. Where does it fit into your school day, your day, your block, whatever is going on? If you show them how it is going to fit and that it isn't going to be one more thing on their plate, they are going to be more willing to come along with you.

Integrating the ACTIVATE program into the schedule was reported as a challenge. Even after multiple years of implementation, providing time to perform the physical component of ACTIVATE proved to be a continuous challenge for the case study schools. The principal at Haset Elementary School elaborated on this challenge stating the following:

> We were able to find lots of times where the students were able to do the online component . . . The challenge is trying to find time for the physical component. That seems to be where we're struggling so ensure that you're incorporating that physical component as well as the online component.

The learning support teacher at Haset Elementary School stated that "finding time to incorporate the physical activity into their schedule is difficult, so I would be more selective about who's in the program and be okay with stopping it when it's not effective." Streamlining the identification process by restricting the participants was perceived to be a solution to scheduling conflicts.

The review of literature found that some factors which limit physical activity implementation included a failure by school leaders to provide allocated time (Larsen et al., 2012), a lack of confidence and competence expressed by teachers (Larsen et al., 2012), a belief teachers have that they can meet expectations, the amount of staff training, and transparent expectations of district policy (Action Schools, British Columbia, 2016). Recommendations from staff members included articulation of the program benefits to all stakeholders, implementation with a robust training model and scheduling that seamlessly incorporates the ACTIVATE program into a student's day.

Limitations

Limitations of a study describe weaknesses that exist beyond the control of the researcher (Simon, 2011). The limitations of the study included the following:

1. The study was conducted in one school district, including three elementary schools. It was difficult to convince staff members to participate in an extended interview regarding the implementation of the ACTIVATE program. Therefore, it is difficult to generalize the results across other classrooms and schools due to the limited number of participants in the study.
2. Self-reported data was collected through the interview process. Staff member bias regarding the ACTIVATE program may have influenced the description of benefits and barriers of the program implementation.
3. Staff members may have not fully shared information regarding the implementation of the ACTIVATE program. Thus generalizability of the study results could be limited.

Recommendations

The following recommendations were generated from the case study interviews and the conclusions developed through the research study. Five recommendations were identified for successful implementation of the ACTIVATE executive function intervention program. In addition, three recommendations for future research questions were developed.

Recommendations for the professional practice.

1. Teachers would benefit from training on how the brain learns, factors affecting executive function and how the developmental trajectory of executive function can be altered through physical activity intervention to positively impact a student's academic and life success.
2. School district leaders are encouraged to support implementation of ACTIVATE by articulating implementation parameters or minimal standards in their local wellness policies. School policy offers important guidance to leaders who are responsible for leading the design of learning environments at their sites. District-wide policies will also help to ensure that resources between schools are equitable et al., 2006).
3. School district leaders should initiate discussions about the rationale for implementation of the ACTIVATE program with stakeholders including staff, parents and students. An establishment of the rationale or the "why," with stakeholders, would create "buy-in" through shared understanding, reduce barriers related to confusion and thereby enhance implementation.

4. Providing sufficient training for all staff involved with implementation is a critical design element for leaders to consider. A robust feedback system should be in place to monitor staff confidence, competence and needs during implementation.
5. Leaders should examine the resources of time and space to support an implementation being especially sensitive to the ACTIVATE physical activities. These activities require planning, set up and dedicated physical space and time. Building this into the schedule frees the classroom teachers to focus on implementing the activities and monitoring the associated impact on executive function of the children.

Recommendations for future research. Results of the study and review of the related literature provided context for recommendations for the following future research:

1. Future research should be conducted on additional schools that have implemented ACTIVATE including various stakeholders impacted by the program. Barriers (schedule, space and training) and benefits (improved executive function and academic success) reported in the study could be verified or refuted across a broader range of stakeholders to enhance generalizability.
2. Future research should explore the impact of the principal on the implementation of the ACTIVATE program. As an example, a factor limiting physical activity implementation includes a lack of allocated time by school leaders (Larsen et al., 2012). It would be beneficial to examine other factors associated with the principal leadership that impact implementation.
3. Related future research should be conducted on the intrinsic motivation of children to exercise. “Most reviews of the motivational forces behind human exercise behavior

> still fail to recognize the role played by such affective factors as energy, exhaustion, excitement, boredom, pride, shame, gratification, embarrassment, happiness or fear" (Ekkekakis et al., 2013).

Summary

The purpose of the case study was to explore how three elementary schools implemented the ACTIVATE exercise intervention program with intentions to improve executive function in elementary aged students. The researcher investigated the practices used in these schools, the perceived benefits for children, the barriers to implementation and recommendations for schools proposing to implement this program. The researcher concluded that the types of physical activities and the way the physical activities and feedback from children were being used to target executive function aligned with practices appearing in the literature. The perceived benefits of using ACTIVATE included improvement in executive function, reading and mathematics scores while perceived barriers to the implementation included insufficient resources such as sufficient time, space and training. Staff recommendations regarding a successful implementation of ACTIVATE included establishment of the rationale with all stakeholders, sufficient training for those in the classroom and a conducive schedule for the intervention. Limitations of the case study, recommendations for implementation of the ACTIVATE program by educators and recommendations for future research studies were also presented.

Perhaps the greatest insight obtained from the case study was a staff member's statement that a small improvement in executive function at an early age makes a real and significant difference for a child. "I think the overall importance of executive function across all settings [is

critical] because we are preparing our students for the future and it can have such an impact on today, tomorrow and the rest of their schooling" (reading specialist at Raseth elementary). The insight of a small improvement in executive function altering a child's success in life provides worthy rationale to explore the topic of the exercise intervention and executive function.

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Appendix A: Email Request for Identified Case Study School Principals/Teachers to Complete Interview

Date:

To: (Insert Principal/Teacher Name, Title and School)

Hello (Principal or Teacher)

My name is Randal Jay Smasal and I am conducting a study on the implementation of the ACTIVATE program at selected elementary schools. I reached out to Dr. Wexler from C8Sciences and he recommended your school as one that could provide great insight for others hoping to implement the ACTIVATE program. I am conducting this study independent of C8Sciences and as part of the requirements of a doctoral degree in Educational Administration and Leadership at St. Cloud State University.

Thank you for taking the time to review this request and consideration of participation in this research study. Your school is on the cutting edge for its implementation of a program like ACTIVATE and your insight would be very valuable to other elementary principals and classroom teachers.

Participants who agree to participate in the case study be asked questions regarding their perspective on effective practices, barriers and benefits of implementing the ACTIVATE program in elementary schools.

The interview would take about one hour and would take place at your school building, at a location of your preference within the school district or via digital communication tools of your preference (i.e., Skype, Zoom, Google Hangout, etc.). The audio from each interview will be recorded and later transcribed. Quotes may be used from the interviews for the final dissertation, however the source of any quote will remain confidential and interview participants will be referred to as Teacher #1, #2, etc.

The anticipated benefits of this research include knowledge regarding how to effectively implement the ACTIVATE Intervention program from C8 Sciences, in order to grow the executive function of elementary age students. Although, improved executive function leads to higher achievement in school and has been associated with career success in life, the literature indicates that much is yet to be learned regarding effective implementation of programs like ACTIVATE. Barriers, challenges and successes will be investigated in this case study in order to better understand factors that affect implementation.

All participants have the option to refrain from responding if they are not comfortable with a question and know that if a participant wishes to discontinue the interview, they may do so at any time. There are no perceived risks to the participant and all data will remain confidential and anonymous. The only person who will have access to the data is the principal

researcher. Participant responses are completely confidential. The audio transcripts and interview data will be kept confidential under lock and key and will be destroyed on June 1, 2017.

Participants interested in learning more about the findings of the study, should contact me at rjsmasal@stcloudstate.edu or my adviser Dr. John Eller at jteller@stcloudstate.edu or (320) 308-4241. If you have questions right now, please ask. If you have additional questions later, you may contact me by email at rjsmasal@stcloudstate.edu or by phone at 952.484.2123.

If you agree to participate in this case study, please notify me at rjsmasal@stcloudstate.edu or by phone at 952.484.2123. I will promptly send you an informed consent form to sign. This form contains much of the same information as stated above, but ensures that you understand the purpose, benefits, and perceived risks of participating in the case study. Thank you for your time and considering this request. I look forward to your response.

Sincerely,

Randal Jay Smasal
Doctoral Student, Saint Cloud State University

Appendix B: Interview Protocol

PRE-INTERVIEW

Date:
Interviewer: Randal J. Smasal
School (#1, #2)
Interviewee/Participant (P, T#1, T#2, T#3):

1. Welcome the participant
2. Share information about myself and the study

I am interested in your perspective on the implementation of the ACTIVATE program. This interview is intended to be noninvasive and confidential. You may ask questions at any time. It will last approximately one hour, and you are free to choose not to respond to a particular question or stop the interview at any time.

INTERVIEW QUESTIONS

1. Which students are participating in the ACTTIVATE physical activity program?
2. How were those students selected?
3. Which types of physical activity from the ACTIVATE program are used?
4. Why were these activities selected?
5. Rate how much physical activity students typically participate in each day
    a. 0 min
    b. Up to 10 min
    c. 11-30 min
    d. 31-60 min
    e. >60 min
6. On a scale of 1 to 10 with one being low and 10 being high, rate the level of vigor of physical activities in which students participate.
7. What makes the physical activities vigorous?
8. Describe how other short (acute) bouts of physical activity are used throughout the school day.
9. Describe how the cognitive challenge of the physical activities change over time.

10. How is the level of enjoyment of children engaged in physical activities being measured?

11. What student benefits are observed when students participate in the ACTIVATE program?

12. Describe your district's and or school's wellness policy and to what degree it supports the implementation of the ACTIVATE program?

13. What is the ratio of physical education teachers to students in your school?

14. To what degree was the amount of training received to implement the ACTIVATE program sufficient?

15. What are the barriers to implementing the ACTIVATE program?

16. In what ways do you role model physical activity for improving your brain?

17. On a scale of 1 -10, 10 being the highest, how knowledgeable are you about the impact of exercise on the brain?

18. What did you learn through the implementation of the ACTIVATE program?

19. What would you do differently if you were starting over with the implementation?

20. What are three recommendations you would give others elementary schools who are implementing a program like this?

POST-INTERVIEW

1. What questions or comments do you have?

2. *Thank the participant for their participation.*

Appendix C: Matrix of Research Questions, Interview Questions, and Relevant Literature

This matrix aligns the research questions, interview questions, and relevant literature for this study. Research questions and interview questions were generated from articulated studies.

Research Question	Interview Questions	Research Summary
What practices were used in the case study schools to implement the ACTIVATE executive function intervention program?	Which students are participating in the ACTTIVATE physical activity program?	Deficits in executive function often grow larger over time (Riggs, Blair & Greenburg, 2003; O'Shaughnessy, Lane, Gresham & Beebe-Frankenberger, 2003) Long-term impacts in life include poorer health, less income, lower levels of happiness and higher likelihood of committing crime (Moffitt, 2012; Moffitt et al., 2011)
	How were those students selected?	More boys than girls participate in physical activity and students with lower social economic status tend to participate in less physical activity (Bunke, Apitzsch, & Backstrom, 2011)
	Which types of physical activity from the ACTIVATE program are used?	The following activities improve cognitive function: Tennis (Crova et al., 2013), Soccer (Chang, Tsai, & Chen, 2013) and Exergames (Hillman, Erickson, & Kramer, 2008; Tomporowski, 2003) Tae Kwon Doe improves the executive function inhibition (Diamond, 2014) and group games improve core executive function of inhibition, working memory and cognitive flexibility (Best, 2010)
	Why were these activities selected?	Motor coordination physical activity improves attention (Planinsec, 2002) and reading comprehension (Uhrich & Swalm, 2007; Budde et al., 2008)
	Rate how much physical activity students typically participate in each day a. 0 min b. Up to 10 min c. 11-30 min d. 31-60 min e. >60 min	Only 25% of children ages 6-15 are active for the recommended 60 minutes each day (American College of Sports Medicine, 2014)

	On a scale of 1 to 10 with one being low and 10 being high, rate the level of vigor of physical activities in which students participate in.	Physical activity improves executive function (Best, 2010; Davis et al., 2011; Fisher et al., 2011), the more vigorous the more the physical activity improves executive function in ADHD diagnosed children (Gapin & Etnier, 2010)
	What makes the physical activities vigorous?	
	Describe how other short (acute) bouts of physical activity are used throughout the school day.	10 min bouts of exercise improve on task behavior (Mahar, 2006)
	Describe how the cognitive challenge of the physical activities change over time.	Increasing the cognitive challenge of the physical activity improves executive function Diamond et al., 2007, Diamond, 2011; Manjunath & Telles, 2001)
	How is the level of enjoyment of children engaged in physical activities being measured?	Intensity of physical activity and enjoyment are critical design factors for motivation in children (van der Niet et al., 2015)
What benefits were reported for students who participated in the ACTIVATE program?	What student benefits are observed when students participate in the ACTIVATE program?	Improved executive function correlates with improved achievement (Jacob and Parkinson, 2015), problem solving (Zelazo, Carter, Reznick, & Frye, 1997) and increased reading and math abilities (Blair & Razz, 2007; Riggs, Blair, & Greenberg, 2004)
What barriers challenged the implementation of the ACTIVATE program?	Describe your district's and or school's wellness policy and to what degree it supports the implementation of the ACTIVATE program?	Barriers to implementing wellness policies in adequate funding, competing priorities for time and education, and support from various stakeholders (Agron et al., 2010)
	What is the ratio of physical education teachers to students in your school?	Schools with higher poverty tend to have fewer physical education teachers and less recess time (Carlson et al., 2014)
	To what degree was the amount of training received to implement the ACTIVATE program sufficient?	Factors impacting physical activity implementation include lack of confidence and competence expressed by teachers (Larsen et al., 2012), belief teachers have that they can meet expectations, amount of staff training, and transparent expectations via district policy (Action Schools, British Columbia)

	What are the barriers to implementing the ACTIVATE program?	Limited research has explored the barriers and promotors of healthy eating and physical activity for 5- to 12-year-olds (Romero et al., 2001) Factors limiting physical activity implementation include lack of allocated time by school leaders (Larsen et al., 2012)
	In what ways do you role model physical activity for improving your brain?	There are more opportunities for physical activity in schools when role modeled by the principal (Barnett, O'Loughlin, Gauvin, Paradis, & Hanley, 2006)
	On a scale of 1 -10, 10 being the highest, how knowledgeable are you about the impact of exercise on the brain?	Principals have a general lack of knowledge regarding physical education (Lounsbery et al., 2011)
What recommendations did case study schools provide for successful implementation of the ACTIVATE program?	What did you learn through the implementation of the ACTIVATE program?	
	What would you do differently if you were starting over with the implementation?	
	What are three recommendations you would give others elementary schools who are implementing a program like this?	

Appendix D: IRB Application

ST. CLOUD STATE UNIVERSITY
EDUCATION FOR LIFE.

Institutional Review Board (IRB)

720 4th Avenue South AS 210, St. Cloud, MN 56301-4498

Name: Randal Jay Smasal

Address
Saint Cloud, MN 56301 USA

Email: rjsmasal@stcloudstate.edu

IRB PROTOCOL DETERMINATION: Exempt Review

Project Title: A case study of implementation of an exercise intervention program to improve executive funciton in elementary aged students

Advisor Dr. John Eller

The Institutional Review Board has reviewed your protocol to conduct research involving human subjects. Your project has been: **APPROVED**

Please note the following important information concerning IRB projects:

- The principal investigator assumes the responsibilities for the protection of participants in this project. Any adverse events must be reported to the IRB as soon as possible (ex. research related injuries, harmful outcomes, significant withdrawal of subject population, etc.).

- For expedited or full board review, the principal investigator must submit a Continuing Review/Final Report form in advance of the expiration date indicated on this letter to report conclusion of the research or request an extension.

-Exempt review only requires the submission of a Continuing Review/Final Report form in advance of the expiration date indicated in this letter if an extension of time is needed.

- Approved consent forms display the official IRB stamp which documents approval and expiration dates. If a renewal is requested and approved, new consent forms will be officially stamped and reflect the new approval and expiration dates.

- The principal investigator must seek approval for any changes to the study (ex. research design, consent process, survey/interview instruments, funding source, etc.). The IRB reserves the right to review the research at any time.

If we can be of further assistance, feel free to contact the IRB at 320-308-3290 or email ri@stcloudstate.edu and please reference the SCSU IRB number when corresponding.

IRB Institutional Official:

Latha Ramakrishnan

Dr. Latha Ramakrishnan
Interim Associate Provost for Research
Dean of Graduate Studies

OFFICE USE ONLY

SCSU IRB# 1658 - 2073	**Type:** Exempt Review	**Today's Date:** 1/9/2017
1st Year Approval Date: 1/9/2017	**2nd Year Approval Date:**	**3rd Year Approval Date:**
1st Year Expiration Date: 1/8/2017	**2nd Year Expiration Date:**	**3rd Year Expiration Date:**

Appendix E: Informed Consent Form and Stamp

Primary Investigator: Randal Jay Smasal

Advisor: Dr. John Eller

Thank you for taking the time to participate in a research study on the implementation of the ACTIVATE executive function intervention program. Your school is unique in its implementation of the ACTIVATE program and you were selected as a participant because of your insight regarding this implementation.

This research study is being conducted by Randal Jay. Smasal to satisfy the requirements of a doctoral degree in Educational Administration and Leadership at St. Cloud State University.

Background Information and Purpose
Some identified elementary schools are implementing programs that utilize exercise to improve executive function in elementary age students. The purpose of this study is to gather your perspective on effective practices, barriers, and benefits of implementing the ACTIVATE program in your school.

Procedures
If you decide to participate, you will be asked a list of questions that will take approximately one hour to verbally respond to. The interview will take place at your school building, at a location of your preference within the school district or via digital communication tools of your preference (i.e. Skype, Zoom, Google Hangout, etc.). The audio from the interview will be recorded and transcribed. Quotes may be used from the interview for the dissertation, however the source of any quote will remain confidential and interview participants will be referred to as Teacher #1, #2, etc. Please feel free to refrain from responding if you are not comfortable with a question and know that at any point, if a participant wishes to discontinue the interview, they may do so at any time.

Benefits
The anticipated benefits of this research include knowledge regarding how to effectively implement the ACTIVATE Intervention program from C8 Sciences, in order to grow the executive function of elementary age students. Core executive functions include working memory, inhibition response, and cognitively flexibility. Improved executive function leads to higher achievement in school and has been associated with career success in life. The literature indicates that there are barriers to implementing programs such as the ACTIVATE program. These barriers, challenges and successes will be investigated in this case study in order to better understand practices, benefits and barriers to implementing the ACTIVATE program.

Confidentiality
The only person who will have access to the data is the principal researcher. Your responses are completely confidential. In addition, data will be presented with no more than 1-2 demographic descriptors presented together. In the dissertation study, interview participants will be referred to as Principal #1, Teacher #1, Teacher #2, Teacher #3, etc. The audio transcripts and interview data will be kept confidential under lock and key and will be destroyed on June 1, 2017.

Study Results
If you are interested in learning more about the findings of the study, feel free to contact me at rjsmasal@stcloudstate.edu or John Eller at jteller@stcloudstate.edu or (320) 308-4241.

Contact Information
If you have questions right now, please ask. If you have additional questions later, you may contact me by email at rjsmasal@stcloudstate.edu or by phone at 952.484.2123. You will be given a copy of this form for your records.

Voluntary Participation/Withdrawal
Participation is voluntary. Your decision whether or not to participate will not affect your current or future relations with St. Cloud State University or the researcher. You may request to stop the interview at any time or refrain from responding to questions you choose not to answer.

Acceptance to Participate
I understand that I may withdraw from the study at any time without penalty after signing this form. I have read all the information on this consent from and agree to participate in the study

_____ _____

Signature Date

.

Note: My advisor changed from Dr. John Eller, to Dr. Kay Worner after data collection was completed.

Appendix F: Descriptions of Common Executive Function Tests Referred to in the Literature Review

Executive Function	Test	Test Description
Inhibition (Inhibitory Control)	Flanker Task	The person being assessed is informed to pay attention to a central stimulus while distractor stimuli are presented on the perimeter to create confusion.
	Stroop Task	A set of colored-words appear in colors that match or contradict the words themselves. The person being assessed has to carefully classify each presented word as a match or mismatch. For example, the word Red may appear in green print, which would be a mismatch.
Working Memory	Visual Memory Span test	The child has to replicate in reverse order a sequence of movements made by the researcher pointing at colored squares on a paper (van der Niet et al., 2015).
	Digit Span Test	For the Digit Span Test, a child has to repeat in backward order a sequence of spoken numbers from the researcher (van der Niet et al., 2015).
Cognitive Flexibility	Trailmaking Test	For this test, children are asked to connect circles in either a numerical or an alphabetical order by drawing from one point to another as quickly as they can (van der Niet et al., 2015).
	Wisconsin Sorting Task	The person being assessed sorts a set of illustrated cards into piles. The person doing the test is not told how to do the sorting but have to figure out their own system based on instructions by the person conducting the test. Then, the person conducting the test, changes a sorting instruction and the person being assessed must adapt the new instruction and figure out the new rule.
Planning	Tower of London	These are related puzzle-based tasks where the subject generally has to figure out how to move different-sized discs or balls between different locations, in a particular order, in order to produce a stack where the discs or balls are ordered by size or in a particular order. (van der Niet et al., 2015)

Appendix G: Excerpts from Interviews

Which students are participating in the ACTTIVATE physical activity program?

So this year we were allotted unlimited licenses to the ACTIVATE program as a thank you for participating in some webinars with them. We were gifted with some unlimited licenses. So this year we have mostly have primary, kindergarten, 1st and 2nd grades using it. They're doing this whole class and they're all doing it a little bit differently and then consistently for the past four years we've had students participate in small groups with ACTIVATE. We have about seven classrooms doing it whole class then we have a group of about 20, fourth and fifth graders who are doing it less frequently during intervention time which turns out to be three or four days per six-day school cycle. Then we have about 10 third graders who are doing it daily. We have six fourth and fifth graders who are in a small group doing it daily and this is the ACTIVATE program. On the activity days for the kids who are doing it daily they do activity days two out of six days and I'm not sure how the teachers are incorporating the physical part into the whole group. When we do ACTIVATE how we've consistently done it and identifying a small population of students pulling them into another classroom and doing that daily we have six-day cycles numbered one through six. We do physical activities on days 2 + 4. It was always consistent and it was always routine.

How were those students selected?

So when we first started, and we started a while ago, I think it was 4 or 5 years ago, and it was myself and one other teacher and that teacher did not really do it correctly in the building and they had stopped after one year. They were kind of like a trial for the ACTIVATE program. At that time, we looked at our neediest population. These were all kids severely below grade level, had IEPs, had learning difficulties, behavior difficulties and we said oh here's another thing we can give them to help them. After doing that for about two years we kind of took a step back and said they might not have executive dysfunction so just because we have this program and they are needy students doesn't mean they would qualify for this program. So then, we started trying to find students who showed signs of executive dysfunction, poor time management, messy desk area, can't stay organized, can't follow routines, poor working memory, all of those things. We don't have a standardized assessment for executive function and I don't know if there is one out there somewhere, but we don't have one so instead what we did was we asked the classroom teacher and gave them a check list and said look for these signs and asked them do you have students who you think would fit this profile. Then we also have an assessment which assesses biological processing and in there is a rapid naming subtest which taps into working memory. The students who scored very low on this assessment we would look at that as a qualifier for the program as well. Now that we have unlimited licenses, teachers are doing this with their whole class because we don't feel that it's going to hurt them to be in ACTIVATE.

Which types of physical activity from the ACTIVATE program are being used?

The physical activities are called Large group, Small group, Energizer and Cognitive supplement activities and the types of activities used are based on the number of students in the group and the type of grouping. Teachers choose from different activities if the group is in the classroom or being pulled out of the classroom for a session. Many of the activities we use are balancing activities, yoga, martial arts, relay and specific activities that involve direction and changing direction, catching, and throwing activities. The kids love the variety of activities.

Why were these activities selected?

The activities were selected based on the executive function areas of need. C8 Sciences centers the need around the eight core cognitive processes and this includes sustained attention, multiple simultaneous attention, impulse control, working memory, cognitive flexibility, task initiation, and speed of processing. All of those activities target one of those executive functions areas or multiple function areas at the same time.

Describe how the cognitive challenge of the physical activities change over time.

The cognitive challenge of the physical activity changes over time because the demand and vigor of the activities change over time. More executive function capacity can be placed on the student as they complete the task. For example, in the beginning of a tossing activity the only demand may be simply catching or throwing the ball with a partner. Then the demand can increase by having the student throw and catch at a greater distance from their partner. Next, you could add a group of students who could work to throw and catch a ball in a specific sequence. As the students are successful with the sequence, you can add more balls to the sequence. Having multiple balls being thrown at the same time really challenges all the different capacities that students have to do such as paying attention, focusing, and coordination. The sequence can also be reversed, challenging students to be flexible with working memory.

How is the level of enjoyment of children engaged in physical activities being measured?

I have written down teacher observations and what students say. They are very vocal about whether that was a fun game or not. A lot of times if I didn't have time to prepare something I would just say okay let's take a vote. They would give suggestions of what games we should play and I wrote them on the board and then we voted. So getting their input to let you know what games they like and then if they're running around kids seem to do this thing that if they're happy and they're running, they scream. So the level of screaming is a sign that they're enjoying it. Smiling faces or at the same time pouts, stomps and refusal let you know that they're not having a great time.

What student benefits are observed when students participate in the ACTIVATE program?

We've done a couple of studies internally and we've looked at the longest data that we have and it's on those students who are the most needy students with executive weakness. What we found is that on achievement they score higher than our students who are participating in just a tier 3 intervention. So a student who is participating in ACTIVATE will go to that program and then to their tier 3 intervention which might be a tier 3 reading intervention. We've measured them compared to peers who didn't have the ACTIVATE program (control group) but have a similar assessment profile who went to the exact same tier 3 interventions. So if you take two students, one goes to Wilson (an intervention), one goes to Wilson and ACTIVATE then the students that are participating in the ACTIVATE program are actually having more success with our benchmark assessments and our state assessments and they're scoring higher on those different assessments. We have looked at this for multiple years with those 25 students. We have looked at it across the board to see how they're performing and it is showing an increase in their student achievement scores and we were able to see that over a number of years. And are next step is about how to expand that beyond those 25 most needy students and we talked a lot about the ACTIVATE program for all of us and for even the adults who have executive function weaknesses. Some of us are really good with organization, some of us are really good with self-control, some of us are really good with cognitive flexibility, et cetera. So we are trying to move to a larger scale and to say how can we try to read some of these executive function weaknesses that students have and how do we develop them and increase them to help the students get better at those executive function weaknesses. That's something that we really want to see in terms of long-term. So if we had a particular grade level or an entire class in that ACTIVATE program and we're doing it consistent and pervasively how did their scores look compared to what they were scoring the year before or compared to class before. There are some larger studies that we would like to try to expand upon once we are really able to incorporate this more on a larger scale. We found that achievement increases across the board in terms of reading and math because we looked at our state assessment in math and reading and across the board we saw improvement in that.

Describe your district's and or school's wellness policy and to what degree it supports the implementation of the ACTIVATE program?

We do yes. We do have one. I am not positive about how it has affected our ACTIVATE implementation. I do know that it does support lifelong skills and creates lifelong enhancing benefits. In my mind this is their executive functioning that they are going to need every day for the rest of their lives. So I would say that it falls under the Instruction and Skills part of our policy that they remain physically active. It's just another way to incorporate that into their day.

To what degree was the amount of training received to implement the ACTIVATE program sufficient?

We did not really have a lot of training per se. There was a webinar on the portal site that we watched. It was kind of like a learn as you go situation. So a lot of it fell on us to train ourselves. We did have a conversation since we got in with ACTIVATE when they were relatively new. They were still trying to extend their reach, so they worked really well with us and we had conversations with them and I was also able to Pilot an updated version of the program so again that put me in direct communication with the people behind ACTIVATE. As far as professional development and training there was really not a lot. I see that since we have unlimited licenses this year we kind of gave them (teachers) an iPad, some games and some kids and it really does take more development and training than that. So, I would say it was not very sufficient.

What are the barriers to implementing the ACTIVATE program?

Number one is staff limitations, space and time. Maybe time should be number one. A lot of kids that are in the ACTIVATE program have many needs. They are in with a learning specialist. They also have an IEP, so they see me for support. They have maybe a teacher for language therapy, so these kids are bounced around a lot and fitting it into their schedule is difficult. For the classroom teachers they have a very rigorous day of learning every day. So finding time to implement ACTIVATE, if we're doing a small group then staffing that, is a problem. It's really hard to, with fidelity; implement these physical activities when you have a classroom with desks and tables and chairs. We have one group who is literally in a hallway during their ACTIVATE time because we are a small school. We have some kids that go into a trailer that is outside of the school. So space, time and staffing.

What did you learn through the implementation of the ACTIVATE program?

So I have found that it's not just something that you can give a student or assign a student to the ACTIVATE program, give them an iPad, tell them how to play a game, a physical game and it will work. They really need explicit instructions on how to improve their executive function. Why are they here, what is their brain doing, what should it be doing? Students need coaching when they're playing the program and the physical activity. It's not something that we can let them do on their own. I mean you kind of can but you need to keep an eye on them and make sure they're actually doing the program correctly and we try to implement it with fidelity as it's not written to be a stand-alone piece to support executive function. So if we see a student who is very disorganized and we think okay that's executive function and they come in here and play on an iPad and they play a game and they go back to their disorganized desk and if we didn't give them a plan to be organized and follow through with that and check in with that and reward that then it's not going to make an impact. So it's one piece but it's also a piece that has to be done correctly. So there has to be follow-through and something else to support the kids.

What would you do differently if you were starting over with the implementation?

I would make sure we had enough space and time instead of trying to fit the program into what we have. I would try to make our resources better rather than fit the program into them. I would like to see the training and the development, and I think there has to be some kind of, you don't ever want to stop the kids unless they become disinterested but it's every year that our fifth graders who have been in it for the longest time, they just don't care anymore. They're not as motivated. Seeing a monkey's face pop up on the screen doesn't do anything for them. Finding time to incorporate the physical activity into their existing schedule is difficult. So I would be more selective about who's in the program and be okay with stopping it when it's not effective.

What are three recommendations you would give others elementary schools who are implementing a program like this?

So I think this recommendation would certainly be number one. I think it's important to understand executive function and cognitive capacity and how they all relate to the learning process, basically understanding the purpose for a program like this and understanding why you would go through a process like this. A lot of that is professional development that takes time and as educators we are trained in a lot of things but I think few universities and colleges are actually educating students on the brain and how the brain goes about learning and so we talk about all these great strategies and these great things that we can try and these tips to build a little teacher-toolbox but we don't really talk about how it affects the brain and the internal components of that. So one recommendation is to increase that professional development around the brain.

The other one I think is kind of going back to the barriers that we experienced and encouraging principals to really educate their staff on a program like this and ways to make it motivating and encouraging for the students and helping teachers understand that many students do have executive function weaknesses. They are struggling in these areas and that that can be really hard for the students.

The third one would be that one of the things we recognize that is special about ACTIVATE is that physical component. This is something that is held to be true here at xxxx. And in all the years that we've been implementing this program we've really maintained one day of doing the online component and one day of doing the physical component. There were numerous times with the stress of schedules and the stress of trying to get through curriculum that we were engaged in conversations regarding whether we stop doing the physical component and just do the online component or have them participate in some other intervention for some curriculum or instructional need that they have. We truly kept coming back to the importance of that physical component due to the overall success that they've had in the ACTIVATE program. So, I think it's very easy to kind of push the physical component off to the side and not have students participate with that but we really saw a lot of value with that and that's why as we go a little bit

more global with this and we try to encourage more teachers and try to get more students on board. We're really trying to find creative ways to solve the physical component and finding time for the physical component. We were able to find lots of times where the students were able to do the online component. We can find that time. The challenge is trying to find time for the physical component. That seems to be where we're struggling so ensure that you're incorporating that physical component as well as the online component.

Appendix H: Coding Samples

What benefits were reported for students who participated in the ACTIVATE program?						
Themes		Frequencies				
		District	Haset	Raseth	Jetash	Total
Achievement	Increased reading scores	1	1			2
	Increased math scores		1			1
	Helps in other classes				1	1
Executive Function Improvement	Imrpoved executive function overall		3			3
	Increased attention span, self regulation, focus	3	1	3	1	8
	Increased working memory	1	1			2
	Improved cognitive flexibility			1		1
	Using more time to think	1				1
	Increased ability to follow multi-step problems	2				2
Awareness of Executive Function	Increased awareness of the executive function			1		1
Cooperation skills	Improved cooperation skills		1			1
	Totals	8	8	5	2	23

What barriers challenged the implementation of the ACTIVATE program?						
Themes		Frequencies				
		District	Haset	Raseth	Jetash	Total
Students	Boredome and complacency of students, reach platuea in games		2			2
	Many needs of kids, size of groups		1	1		2
Resources	Technology	1		1	1	3
	Cost	1				1
	Limited resources			1		1
	Time (schedule)	2	3	1	1	7
	Space, lack of mobile furniture		2		2	4
	Staffing (qualified, healthy, program needs a coach)	1	2		1	4
	Total	5	10	4	5	24

What recommendations did case study schools provide for successful implementation of the ACTIVATE program?						
Themes		Frequencies				
		District	Haset	Raseth	Jetash	Total
Professional Development	The Why: Research on impact of Executive Function on Learning	3	3	1		7
	Research behind ACTIVATE program/benefits	3			3	6
	How physical activity and brain breaks help struggling learners		1		1	2
	Resources offered by ACTIVATE portal		1			1
	Specific activities to use for executive function needs		1		1	2
	Need for mentor teachers/train the trainer model			1		1
Implementation	Sufficient materials for physcial activities/games			1		1
	Sufficient technology	1				1
	Build into schedule (sufficient time)	1	2			3
	Don't skip physical component (fidelity)		2			2
	Start small, expand upon what is currently being done, i.e. movement and brain breaks		2			2
	Totals	8	12	3	5	28

Appendix I: Websites Utilized in Participant Searches and Selection Criteria Development

2016 Let's Move! Active Schools National Award Recipients: http://static1.squarespace.com/static/53b1a843e4b0dcbabf4b4b85/t/55eed98ae4b0d8cb341a611f/1441716618610/2015+LMAS+National+Awardees.pdf

Action Based Learning: http://actionbasedlearning.3dcartstores.com/

Action Schools! BC: http://www.actionschoolsbc.ca/node/3900

Adele Peters Blog: https://www.fastcoexist.com/3036607/this-school-has-bikes-instead-of-desks-and-it-turns-out-thats-a-better-way-to-learn

BOKS (Build Our Kids Success): https://www.bokskids.org/

Brain Gym International: http://www.braingym.org/

C^8Sciences: http://www.c8sciences.com/c8-sciences-founder-bruce-wexler-awarded-4-million-nih-grant-for-adhd-research/

Developmental Cognitive Neuroscience Lab of Adele Diamond: http://www.devcogneuro.com/

FIT KIDS: http://www.fitkids.org/

Great Schools: http://www.greatschools.org/gk/articles/spark-exercise-and-the-brain/

Healthy Zone Schools: https://www.healthyzoneschool.com/

Human Kinetics: http://www.humankinetics.com/products/all-products/Enhancing-Childrens-Cognition-With-Physical-Activity-Games-Online-CE-Course

National Dance Institute: http://www.nationaldance.org/

PLAY 60 Kids: http://www.nflrush.com/play60/kids/

Polar Showcase Schools: http://education.polarusa.com/education/teachercorner/showcaseschools.asp

Shape America: http://www.shapeamerica.org/recognition/awards/teacherof-theyear-intro.cfm

SPARK: http://www.sparkpe.org/

The Cooper Institute FITNESSGRAM: https://www.cooperinstitute.org/youth/fitnessgram

The Physical Activity and Learning PAL program: https://dar.uga.edu/funder/campaigns/the-physical-activity-and-learning-pal-program/

Washington Post: http://www.washingtonpost.com/sf/sports/wp/2015/10/20/educational-movement/

WII Fit Kids.org: http://www.wiifittogether.org/