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Implications of the Link Between

Physically Active Learning and Children’s Executive Function

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Continual changes in culture and society in Finland and other developed countries has resulted in a decrease of physical activity and an increase of time spent sitting. Negative health causes of physical inactivity are detrimental to wellbeing and school success. Physically active learning, promoted in Finland through the Finnish Schools on the Move program, is a teaching method for increasing physical activity during the academic lessons of a school day. This method has been considered difficult in practice by some teachers since the physical activity disrupts student concentration and lowers productivity of a lesson. The part of the human brain, the executive function, regulates concentration and is influenced by physical activity.

This thesis aims to synthesize what physical activity, physically active learning and executive function are, and what the implications of the link between physically active learning and executive function may be. Physical activity is movement produced by the skeletal muscles of the body, while physically active learning is the result of implementation of physical activity in a lesson. Executive functions (EF) are the cognitive processes that allow for goal-directed cognition and behavior that are used daily, such as when shifting attention from one task to the next. The link between physically active learning and executive function conveys potential that the physically active learning method may help activate and develop a child’s executive function.

The goal of this thesis is to present credible international literature on these topics in an accessible and understandable way. This thesis is a descriptive literature review that is largely based on the ideas of internationally distinguished researchers in the fields of physical activity, physically active learning and psychology, along with other credible research and empirical studies.

The use of physically active learning is not the only solution for increasing the amount of physical activity during everyday life or supporting school success in children, but is a potential tool to aid the development of learners. Implementing cognitively engaging physical activity learning should be used for optimal learning results and promoting a developing executive function in a child, especially concerning the problematic disruptive nature of physically active learning.

Key words: Physically active learning, Physical activity, Executive function, cognitive engagement, concentration
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1 Introduction

Health benefits of physical activity for students in school and during academic lessons are well established (Laakso et al. 2007, 42), and the promotion of physical activity in Finland during the school day is at the forefront with the Finnish schools on the Move project (Haapala 2017, 9). However, the health benefits researched in the Finnish context lacks comprehensive research of the connection of physical active learning and children’s executive function engagement and development.

The research process for this thesis began through visiting schools, listening to and discussing with middle years subject teachers in Oulu, Finland, during a project involving functional learning training for middle school teachers. Since many functional and active teaching methods were familiar for the teachers (due to the ongoing Finnish Schools on the Move promotion), the most intriguing discussions consisted of the challenges and barriers the teachers expressed to be undermining the benefits of active learning. The challenge voiced that concerned me most, was that the physically activating technique caused disturbance in the learning environment to the point of a loss in concentration and productiveness.

This concern led me to find the scientific terms for this concentration disturbing, wellbeing promoting learning technique and form the first research question; what is physical activity and physically active learning? During investigation of physical activity, the discovery of an alarming increase in inactive lifestyles in all age groups and the overwhelming health and wellbeing benefits of physical activity; emphasized the importance of addressing the lack of physical activity in the children’s school day (Malina, Bar-Or & Bouchard 2004, 467-474). Implementation of physically active learning has the potential to increase the physical activity, but the concerning challenge mentioned earlier requires consideration and validation.

Concentration and productiveness, among others, are life skills and are crucial to success in students’ lives (Romine & Reynolds 2005, 190; Best, Miller & Jones 2009, 3). This led me to the discovery of the frontal lobe of the brain housing the cognitive processes that allow for goal-directed thinking and behavior, the executive function, and its various components responsible for concentration and productiveness crucial to school readiness, participation and success (Riggs et al., 2006, Best et al. 2009, 15; Gathercole et al. 2004, 173; Zhou, Chen, & Main, 2012, 113). The second research question was formed after this discovery to be; what is executive
function and how does physically active learning affect the executive function? The question was examined by defining the executive function construct, its theoretical framework, use in daily life, as well as the connection to physically active learning.

In the Finnish context, with the introduction of the latest Finnish national core curriculum in 2014, use of a developed physically active learning concept in schools would aid to address some of the transversal competencies, especially with the connection to a child’s executive function. The last sections of this thesis examine physical activity and its connection and stimulation of the executive functions. This connection is significant for the teacher facilitation and the student’s individual benefits of physically active learning in the classroom.

This bachelor’s thesis can be defined as a literature review and the purpose of it is defined as the provision of a comprehensive background for understanding current research, knowledge and addressing the significance of further research (Cronin, Ryan & Coughlan 2008). The aim of this literature review will be to illustrate understanding of existing research addressing my research questions and discover areas where more research is needed. Although this literature review does not focus explicitly on the Finnish context, this thesis is an attempt at making the international literature on this currently significant topic more accessible and relatable for the Finnish context, while bringing attention to the approach many researchers in this field convey potential for development. The international literature that is reviewed in this thesis is well cited and the Finnish research is relevant especially for the application and recognition of the concepts in the Finnish context.
2 Physical activity and physically active learning

The purpose of this section of the thesis is to address the first question; what is physical activity and physically active learning? Physical activity is a concept that refers to the movement of our bodies (Caspersen, Powell & Christenson 1985, 126) and can be examined by the different motor skills it requires for various activities, as well as the development process. Since this thesis focuses on physical activity in a student’s school day lessons, literature on the factors affecting physical activity are reviewed as well as the health benefits it potentially holds. Recommendations of physical activity are alarmingly not reached by many children (Ogden et al. 2006, 295), which also signifies the importance of the promotion of physically active learning.

The alarming rate of a gap between the recommended physical activity amounts for children and the actual amount of physical activity children today experience, has led to the understanding that physical activity should be increased in the school day. (Aaltonen 2013, 16–17.) It is also understood that concentration abilities decrease over a long period of sitting, which is why the Finnish board of education (2009) recommends that a school day should consist of a variation of activity types including physical activity (Opetushallitus 2009, 49).

Physically active learning is one potential method of increasing physical activity in the school day and will be reviewed in this chapter. Physically active learning is grounded with Dewey’s theories of active learning and learning through experience, along with Vygotsky’s theories of socially constructed learning where the physically active learning takes place in classroom space. Therefore, physically active learning involves learning through collaboration with peers and teachers. (Dewey 1897, 77-80; Vygotsky 1978.) This method of physical activity incorporated into the school day, during a lesson, requires students to physically move (Wijnsma 2017, 8-9). With the aim to make the review of literature on physically active learning more relevant for Finnish educators, the Finnish Schools on the Move (Liikkuva Koulu) national program, which promotes a physically active culture in Finnish grade schools, will also be reviewed in this chapter (Haapala 2017, 6).

2.1 Physical activity

Physical activity is a multidimensional concept, but is understood to consist of movement produced by skeletal muscles in the body and increases the need for and uses energy (Caspersen, Powell & Christenson 1985, 126). Caspersen et al. (1985, 126) also defined the various terms
used to refer to the concept of physical activity and this approach has been one of the most commonly accepted definitions. Exercise is any planned, structured, repetitive physical activity that has purpose to develop or maintain one or more aspects of a sport skill or physical fitness achievement as an objective. Physical fitness is another term that refers to physical activity, and is based on an individual’s physical attributes that can be improved in exercise programs appropriate for the individual. Lastly, sports are physical activities that require physical motor skills used in an organized game setting. (Caspersen, Powell & Christenson 1985, 126-131.)

Most of the basic motor skills used in physical activity are developed during infancy and early childhood while more advanced motor skill development continues during childhood and throughout adult years (Malina, Bar-Or & Bouchard 2004, 195). Jaakkola (2010) defines motor skills as the ability to voluntarily move the body and/or body parts to do what was intended (Jaakkola 2010, 45-46). Malina, Bar-Or and Bouchard (2004) further define motor development as a continuous process that occurs in the physical and social context in which the child is reared. Motor activity may be described as fine or gross motor activities. Fine motor activities require precision and dexterity, while gross motor activities involve major parts of the body or the body as a whole. For example, a fine motor activity requires hand-eye coordination and a gross motor activity could be done while running, jumping or throwing. The basic motor skills developed at 3-7 years of age include balancing skills, movement skills, and skills of handling equipment. (Malina, Bar-Or & Bouchard 2004, 196.) The years before starting school are significant in a child’s motor skill development process and is when a child needs a variety of physical active experiences to support the learning (Jaakkola 2013a, 174).

According to Malina, Bar-Or and Bouchard (2004) children’s physical activity between 3 to 10 years of age is commonly spontaneous and non-organized. A decline of physical activeness occurs in the second decade of a child’s life. The risk in this change in activity is if the amount of activity under 10 years of age is already close to inactivity before the decrease. (Malina, Bar-Or & Bouchard 2004, 467-468.) The concept of physical inactivity is described by National Institutes of Health (1995) as a level of activity less than needed to maintain good health (National Institutes of Health 1995, 6). Even with an increase of urbanization and electronics based lifestyles that may have a negative effect on children’s natural drive for physical activity, Pate (1997) argues that most children are active enough to maintain good health (Pate 1997, 210-214). Pate (1997) presented the case in 1997 and for a more recent study by Ogden et al. in 2006, the percentage of overweight children has risen to alarming levels in recent years. (Ogden
et al. 2006, 295.) Best (2010) relates that obesity in children is related to poor academic achievement and to sedentary behavior (Best 2010, 345).

2.1.1 Factors affecting physical activity

Physically active ness of a child is influenced by the individual’s biological makeup, social and physical environment. One aspect factor that is significantly lacking in the review of physical activity are changes related to growth and maturity. (Malina, Bar-Or & Bouchard 2004, 471-474.) Based on the literature that is available, only a various few factors have been thoroughly studied.

The biological factors on physical activity include the sex of the child, health status and sexual maturity and according to Eaton and Yu, (1988) evidence indicated that males have greater levels of energy expenditure than females (Eaton & Yu 1988, 1005). The health status influences the physical activity levels negatively if the child has a chronic disease or a mental or physical disability. The sexual maturing of a female also often lowers the amount of physical activity. (Malina, Bar-Or & Bouchard 2004, 472.)

Social factors including parental activeness, influence of peers, family socio-economic standard and societal factors all are significant in the activeness of the child. If the parents of a child are both active, the child will be more active than if the parents were inactive. (Moore et al. 1991, 63.) Later in life, the child is more significantly influenced by their peers in term of activeness, but the socio-economic standard of the family will continue to affect physical activeness by amount of resources to fund access to programs or facilities in developed countries (Malina, Bar-Or & Bouchard 2004, 473). Aaltonen (2013) refer to societal and cultural factors’ continual change affecting the type of physical activity performed. In Finland, physical activeness has decreased at work and during free time. Starting from the 1960s, the change has been rapidly happening and studies show that people are sitting increasingly more. (Aaltonen 2013, 16–17; Lintunen 2007, 26.) From another perspective, Borodulin, Harald, Jousilahti, Laatikainen, Männistö and Vartiainen (2015) analyzed the physical activity over time between 1982 and 2012 in Finland. They related that the free time physical activity has increased systematically while the commute to work and work time physical activity has decreased, resulting in the overall amount of physical activity to stay at the same rate over time. (Borodulin et al. 2015, 93-100.)
The physical environment of a child’s home, as to whether activity facilities are nearby, may influence the amount of physical activity that is typical for a child (Sallis et al. 1990, 179-182). In areas around the world that experience seasonal changes, weather often influences the amount of physical activity. Studies show that in mild to cold climatic areas, but not necessarily in warmer regions, physical activity increases in the summer months, especially in Finland. (Ross et al. 1985, 40-43, Telama et al. 1985, 173.) This also correlates with the studies that show that children are more active when time is spent outdoors (Klesges et al. 1990, 440).

2.1.2 Physical activity health benefits

Scientists have begun to study the relationship between physical activity and health related quality of life during the adolescent years. Results of a pediatric study found that over a long term, regular outdoor physical activity was associated with the higher health-related quality of life adolescents. On the other hand, youth with lower quality of life scores were among those observed to having the most screen-viewing activity time. (Gopinath, Hardy, Baur, Burlutsky, & Mitchell 2012, 168.) The nature of this study, which took place over 5 years, supports the concept that promoting more physical activity and less screen-viewing time may benefit not only weight and fitness, but also improve well-being during adolescence years and into adulthood.

The concept of improving well-being requires an individualistic approach that reaches all aspects of health. Regular and individually appropriate physical activity supports the development of a healthy cardiovascular system, neuromuscular awareness, healthy musculoskeletal tissues, and it also helps maintain a healthy body weight. (WHO 2011, 1.) Also, physical activity has been positively associated with psychological benefits in young people. These benefits include; improving control over symptoms of anxiety and depression, providing opportunities for self-expression, building self-confidence, social interaction and integration. Physical activity opportunities may also lead to development of social skills. (WHO 2011, 1.) Due to the nature and purpose of this thesis, only physical activity in terms of individual health benefits is addressed, but in practice, individual well-being requires effort in all spheres of life.

It is important to realize in terms of physical activity health benefits, exercise and physical movement is always beneficial even if weight loss does not occur (Nordic Council of Ministers, 2014, 203). However, there is concern that intensive training for sport during childhood and adolescence can have a negative influence on growth and maturity on the health of an individual.
The various styles of physical exercise participation may potentially be more beneficial for one’s overall well-being if it is regular and consistent than if it is more demanding and sporadic (Nordic Council of Minister 2014, 203-205).

Studies performed in Finland, such as Jaakkola (2013b) and Kantomaa, Syväöja and Tammel (2013) explored the anatomical and physiological effects of exercise and found that they extend not only to the physical body, but also to the brain and its function. They continue that exercise improves brain circulation and oxygen supply, and everyday exercise generates new neurons and this effect is particularly evident in the hippocampus, which is the center of learning and remembering. Exercise also affects the connections of brain cells, brain structures and other existing nerve networks. These connections also increase human learning potential as nerve networks develop attention and concentration, and improve information processing and memory functions which may lead to student’s success in various cognitive tasks. (Jaakkola, 2013b; Kantomaa, Syväöja, & Tammel, 2013.).

Benefits of physical activity are proven to be global in development of the brain, physical aspects of health, and provide more mental stability for basic aspects of life rhythm such as improving school attendance. School attendance may be supported by the physical activity benefit of improving the quality of sleep and help make falling asleep easier. With these benefits; improvement of mood, self-esteem and creating opportunities for new social relationships, convey the importance for maintaining and increasing physical activity participation for all. (Terve koululainen 2013.)

2.1.3 Recommendations on physical activity

Recommendations for human physical activity are continuously renewed based on the latest research and the changing society. Physical activity in relation to health is based on the individual, but for purposes of recommendations, the amount, type and frequency is a way to clarify what may be typically beneficial for well-being. In Finland, the Minister of Education and the Nuori Suomi ry published physical activity recommendations for youth between ages seven and eighteen years of age in 2008. According to the experts in this article, Heinonen et al. (2008), all youth in the specified age range should be physically active in a versatile way between one to two hours each day. The time spent sitting should not exceed two hours and neither should screen time with electronics. These recommendations are specified to be reached daily, but if the target is not reached on one day it will not have a large impact on the child’s overall health.
However, if a child is inactive for an extended period, it will have a negative impact on several aspects of the individual's wellbeing. (Heinonen et al. 2008, 9.)

Laakso et al. (2007) found that physical activity for the grade school aged child has a significant role in the development of their physical, mental, and social aspects of wellbeing. Through physical activity an individual learns to be aware of their own body, its action and movement, along with their ability to perform using their body. These aspects support the development of self-knowledge and perception of themselves. (Laakso et al. 2007, 42.)

Similar recommendations for youth have been given in other countries around the world. In a study in the United States of America, Strong et al. (2005) concluded that school age youth should participate in at least one hour or more per day, of moderate to vigorous physical activity that has variety of activity types, developmentally appropriate and enjoyable (Strong et al. 2005, 732). The same recommendations have been given by Salmon and Shilton (2004, 405-406) in Australia and in England by Biddle et al. (1998, 3), differing only by not stating enjoyment. The World Health Organization, WHO, (2011) recommends physical activity for youth between ages five and seventeen to reach at least 60 minutes, daily. In addition to the everyday physical activity, youth should also participate in vigorous physical activity three times per week. (World Health Organization 2011, 1.)

When considering where school aged children spend most of their day, it is important to assess for example what the Finnish national curriculum includes about physical activity throughout the school day. Thinking and learning to learn (T1) is a transversal competency from the Finnish national core curriculum states that the development of thinking and learning are supported by diverse physical activities and motor skill activities. Also, the cultural competence, interaction and self-expression (T2) transversal competency in the curriculum includes the concept that positive interaction is encouraged in pupils through many opportunities including play and physical activity. Lastly, taking care of oneself and managing daily life (T3) is addressed and includes recognizing and developing emotional skills through play and drama, where play can be understood to include physical activity. (Finnish National Board of Education 2014, 105-107.)
2.2 Physically active learning

Most of the time students are at school in Finland and in other places in the world, is spent in the classroom (Heinonen et al. 2008, 9). Addressing the concerning amount of time students are sitting down in the classroom, Wijnsma (2017) uses the combination of physically active tasks with the learning content creating a possibility to engage the students and bring variety to the lessons. In her research, she also uses physical activity during the learning, practice and repetition stages of the learning process in her research. The physical activity incorporated in a lesson allows physically active learning to occur, requiring students to use their skeletal muscles voluntarily. (Wijnsma 2017, 8-9.)

The idea of physically active learning is anchored in Dewey’s theories of active learning and learning through experience. Dewey’s research (1897) worked towards changing the perspective on learning from receiving knowledge passively from a teacher to the understanding that learning proceeds from activity. (Dewey 1897, 77-80.) One variation of active learning is physically active learning such as the classroom-based physically active lessons facilitating body movement when teaching the core subjects in school (Grieco, Jowers, & Bartholomew 2009, 1921). In the implementation of physically active learning, the type of activity and physical movement used is crucial in success of facilitating a quality learning experience. According to Dewey (1938), not all activities and experiences are equally educational, and the benefit varies between learners. (Dewey 1938, 78.)

According to Bransford, Brown and Cocking (2003), physically active learning or physical activity in the classroom increases social interaction and therefore is tied to Vygotsky’s notion of social constructed learning. Social constructed learning defined by Vygotsky, focuses on the interaction and collaboration between students engaging the learners for higher academic performance. (Bransford, Brown & Cocking 2003.) Edwards (2015) addresses constructivist learning and assumes that the concept follows the action rather than preceding it. Physically active learning takes this understanding into practice by allowing the activity lead to the concepts, which is an important aspect for a successful implementation. (Edwards 2015, 67.) Vygotsky (1978) conveys that not only is social interaction crucial for knowledge understanding, but also allows students to confirm their understanding with peers, increase enthusiasm and make lessons seem less formal, which may lead students to step out of their comfort zone and deepen their understanding (Vygotsky 1978).
It is generally understood that people do not have the ability to effectively concentrate on a certain task for long stretches of time. The Finnish board of education (2009) recommends that a school day should consist of a variation of activity types. The types activities the board includes are; self-planned, direction oriented, quiet activities, loud activities, physically active and passive activities. The reasons for variation include increased concentration, improved wellbeing and reaching all types of learners. (Opetushallitus 2009, 49.)

2.2.1 Challenges of implementing physically active learning

The challenges with physically active teaching methods are many, but one that Grieco, Jowers and Bartholomew (2009) considered of importance, was to limit the sacrifice of instruction time. For positive outcomes in increased concentration and time on task of students in the classroom-based physically active lessons participated in required only ten to fifteen minutes of moderate to vigorous physical activity. This span of time allowed the rest of the lesson time to be spent on instruction and working time. (Grieco, Jowers, & Bartholomew 2009, 1921-1925.)

All children do not benefit from physically active lessons in the same way. Studies show that students with differing health conditions may struggle with the physical activeness especially if they have special needs or fall into the overweight category. (Grieco, Jowers, & Bartholomew 2009, 1922.) During the study performed by Grieco, Jowers and Bartholomew (2009), overweight students took less steps in the physically active lesson than their normal weight peers. This, however, may positively result in a more effective activity for the overweight children due to their overall movement during the day is significantly less than their normal weight peers. The results of this study of 95 students over the course of a year, conveyed that a physically active core subject lesson with a minimum of fifteen minutes of moderate to vigorous physical movement resulted in an increase of up to eight percent of time on task in all students. Not only did the change in lesson style increase time on task, the results represented a feasible way to decrease the amount of behavioral disruptions in the classroom following a physical activity academic lesson. (Grieco, Jowers, & Bartholomew 2009, 1924-1925.)

Although health benefits of physical activity in school and academic lessons for students are well established, teachers have informed concerns about the challenges of implementing physical activity in academic lessons. One concern is the amount of time physical activity integration takes away from instruction time in an academic lesson. The instruction time is needed for
academic content that is required for standardized testing, accountability and curriculum requirements in the United States. (Wood 2004, 33-37.)

Other challenges for implementing physically active learning are many, and may include an excess of the amount of new concepts teacher’s need to understand and implement in the classroom, the lack of introduction in teacher education, breaking the pupil’s concentration during a lesson, and the unfamiliarity of the approach to both students and teachers. In the context of schools in Finland, educators are working with and realizing these challenges through the promotion of the Finnish Schools on the Move project (Liikkuva Koulu). (LIKES Research Centre, n.d.)

According to Haapala (2017), Finnish Schools on the Move (Liikkuva Koulu) is a national program, funded by the Ministry of Education and Culture, with the goal to promote a physically active culture in Finnish grade schools. Although the program is organized by the Board of Education, and other organizations, each participating school and municipality implements their own plans for increasing physical activity during the school day. (Haapala 2017, 6.) The project has assisted teachers with implementation of physically active learning and brought awareness to the concept. However, the challenges teachers face are not researched enough to address them in more detail. (LIKES Research Centre, n.d.)

Currently, there is no research in the Finnish context, explicitly on the connection of physically active learning or Finnish Schools on the Move project, to the executive function. Knowledge on the implications of this connection may also help face the challenges that teachers and students experience with the implementation of physically active learning. This connection, reviewed in the next chapter, is significant for the Finnish context with relation to the Finnish National Core Curriculum and the individual needs of all children.
3 Children’s executive function and physically active learning

The first half of the question; what executive functions are, will be addressed in the beginning of the chapter to move onto the connection to physically active learning. Briefly, executive functions (EF) are the cognitive processes that allow for goal-directed cognition and behavior (Banich 2009; Best 2010, 331). The construct of executive functioning has been characterized by researchers in several ways and Zhou, Chen and Main (2012) categorized them into three framework models, which will be examined in the next section (Zhou, Chen & Main 2012, 113).

Development of EF especially in terms of working memory, shifting and planning; occurs predominantly after the age of 5 and continues through the lifespan (Best et al. 2009, 1; Romine & Reynolds 2005, 193). Since much of the development of EF and frontal lobe functioning occurs during the school years, it is known to be influential to school success. Frontal lobe functioning of the brain is understood to be central in human cognition, organizing and coordination brain functioning while supporting the executive functions, goal-directed and self-regulatory behavior. (Romine & Reynolds 2005, 190.) Uses of EF in daily life are many and are difficult to organize into specific categories. Best, Miller and Jones (2009) suggest aspects of EF used in school, concerning academic achievement, time management skills and school-related behavior (Best, Miller & Jones 2009, 3).

The second half of the question addressing the link between physically active learning and the executive function is significant and requires the literature on the more general link between physical activity and the EF to be examined first. In terms of the more general connection between physical activity and EF, exploration from a development perspective and definitions of research approaches will be related before moving onto the literature based review of the link between physically active learning and the EF.

Although there is not yet a comprehensive amount of research on the how physically active learning effects EF, this last section will consist of a brief overview of this link. This section will also lead into the discussion of what this literature review based thesis indicates for the implementation and consideration of physically active learning.
3.1 Executive function (EF) construct

Researching the EF construct can be misleading if the various theoretical framework models that researchers use, are not understood. Zhou, Chen and Main (2012) categorized the theoretical framework models into three types; EF as a unitary construct, EF as a unitary construct with dissociable components and EF as multiple separate components (Zhou, Chen & Main 2012, 113). For this thesis, I will focus on the last of the three types in order to observe the development in separate components of EF, and since this characterization is applicable for school aged children (Best, Miller & Jones 2009, 2).

Zelazo, Muller, Frye, and Marcovitch (2003) characterize EF as a unitary construct by reflecting that EF is an outcome of a series of processes including problem recognition, planning, evaluation and execution of a response. The development of EF in this case is conveyed through an individual’s ability to create, maintain, and flexibly use of increasingly complex rules. (Zelazo et al. 2003, 2-5.)

The second type of theoretical framework views EF as a unitary construct with dissociable components, with the common factor as voluntary and selective attention that mediates connections of various EF components (Garon, Bryson & Smith 2008, 32). Another view presented by Jacques and Marcovitch (2010) with a similar characterization, integrates working memory as the common factor (Jacques & Marcovitch 2010, 431-466). With this perspective in mind, some researchers relate that the unitary with integrated representations of EF work better with understanding younger children than with understanding older, school aged children or adolescents (Wiebe et al., 2008, 575-577; Garon, Bryson & Smith 2008, 31-60).

The third view of EF as consisting of three separate components, is the perspective that this thesis will focus on, concerning school aged children. Three EF components that are related are suggested by Miyake, Friedman, Emerson, Witzki and Howerter (2000): inhibition, working memory and shifting. Their research used this three-factor model for analysis of adults’ performance on tests to measure EF development. (Miyake et al. 2000, 49-55.) Lehto, Juujärvi, Kooistra and Pulkkinen, (2003) along with others, also suggest that this three-factor model is similar in children’s EF construct although inhibition is possibly not as distinct of a component in children at an early age (Lehto et al. 2003, 59-70; Davidson et al. 2006, 2037-2078). According to Best, (2010) these EF components are understood to be connected by some underlying processes, but based on the task at hand, are put into use differentially to guide behavior (Best 2010, 332-333). This perspective that views EF as three components, (inhibition, working
memory and shifting) is a suitable choice for this thesis, since the focus is on children. The perspective will be described further in terms of development, assessed in terms of its use in daily life and lastly, in its connection to physically active learning.

Further research is needed to clarify EF as a construct since much of the research has contradicting conceptualizations of relations among the components and the development process of each component. The issues Best, Miller and Jones (2009) address that would need clarification are the relations between EF components throughout the development process and the actual development of the components. They suggest further research to focus also on older children through adolescence to support understanding of processes underlying the development of EF. (Best, Miller & Jones 2009, 2.)

### 3.2 Development of EF

To begin to understand children’s development of EF, simplified EF tasks have been developed for each of the various EF components (Garon, Bryson & Smith 2008, 31-60; Miyake et al. 2000, 49-100). The EF components this thesis will focus on are the “foundational” components Miyake, Friedman, Emerson, Witzki and Howarter (2000) suggested including: inhibition, working memory and shifting (Miyake et al. 2000, 49-100).

According to Garon, Bryson & Smith (2008), early childhood development of the foundational EF components occurs before and during preschool years. Development of EF components during the first year of organized school appear to be supported by the development of attention. (Garon, Bryson & Smith 2008, 33-34.) Although the early EF development is crucial to a child’s overall EF, significant improvement in EF tasks take place during the school years (Romine & Reynolds 2005, 199).

Although the development timing of the various components of EFs is important to distinguish, it is difficult to truly separate the components due to the integrative nature of the frontal lobe functioning (Romine & Reynolds 2005, 198). Romine and Reynolds (2005) go on to explain that the tasks used to measure memory in their study require executive functions of inhibition for attention and strategic thinking. This perspective, however, leans towards the understanding that EF is a unitary construct with dissociable components, connected with attention as mediator for the various EF components as Garon, Bryson and Smith (2008) described in their research. (Romine & Reynolds 2005, 198; Garon, Bryson & Smith 2008, 32.)
In the next sections, I will separate the foundational EF components’ development processes according to the three-factor model presented by Miyake, Friedman, Emerson, Witzki and Howarter (2000). When observing the development any components of EF, it is important to consider the complexity of the tasks used to measure development as a factor in performance (Best, Miller & Jones 2009, 6-13).

3.2.1 Inhibition

Inhibition is referred to by many as the ability to suppress or delay a response, interference control (such as avoiding distraction), emotional control and motor control (Nigg 2000, 200; Garon, Bryson & Smith 2008, 33-36). Rapid improvement of inhibition takes place during early childhood and has been documented by Hughes (1998) through simple tasks such as Luria’s fist and finger game. Luria’s fist and finger game requires the participant to make a fist when the experimenter points a finger and vice versa, and Hughes (1998) found that namely, preschool aged children, reduced their inhibition errors significantly in this task. (Hughes 1998, 233-253.)

According to Romine and Reynolds, (2005) the greatest development of inhibition perseverance and rudimentary planning skills occurs during the years between five and eight years of age. This development continues during the following years reaching mastery of the ability to inhibit attention to irrelevant stimuli by age twelve. (Romine & Reynolds 2005, 198.) Using more complex computer based tests in which children needed to respond to certain stimuli while inhibiting response to distractor stimuli, Best, Miller and Jones (2009) found that 8-year-old children had more difficulty to succeed in the task due to distraction, inattention and impulsiveness, than 12-year-old children. Best, Miller and Jones (2009) understood that development of inhibition in older children and during adolescence is mostly refining of speed, accuracy and focusing abilities. (Best, Miller & Jones 2009, 7-8.)

3.2.2 Working Memory

The EF component, working memory involves the ability to maintain, manipulate and apply information during brief periods of time (Gathercole et al. 2004, 170-173). According to Luciana and Nelson (1998), development of working memory in children begins with large improvements in early childhood so that young preschoolers can maintain a few items in their mind simultaneously. They also related that working memory development continued through

3.2.3 Shifting

The ability to shift between mental states, tasks or operations is a foundational EF component and referred to as shifting (Miyake et al. 2000, 49-100). Another common term used to describe this EF component is attention or attentional flexibility. This emphasizes the EF component as the ability to focus on one specific task. (Canti, Hund & Mann 2012, 20.)

The first sign of the use of the shifting component between two simple tasks is noticeable at age three or four, (Hughes 1998, 243) and development of set shifting, or more complex tasks continues during the years between five and eight years of age (Romine & Reynolds 2005, 193). It is interesting that speed and accuracy of children shifting between tasks increases between the ages of nine and thirteen, but as accuracy continues to develop into adolescence and adulthood, speed decreases. This is due to the older individuals sacrificing speed to ensure higher accuracy. (Best, Miller & Jones 2009, 10.)

3.3 Daily life uses of EF

The age when a child enters school, exposure to more social settings, along with the school setting, requires more self-control than previously in their lives (Best et al. 2009, 13). EF is significant in all forms of behavior and is the cornerstone for a child’s development (Best 2010, 345). Overall, EF has been proven to influence functioning in many areas of interest, such as academic, social, psychological, and behavioral domains (Zhou, Chen, & Main, 2012, 113). For example, a study by Gathercole et al. (2004) has proven that development and ability to use working memory EF correlates with a child’s development of language, writing, reading comprehension, counting, and mathematics (Gathercole et al. 2004, 173).

EF’s association with academics is not limited to a specific academic subject. Instead, EF influences academic performance in an overarching manner that includes classroom behavior and emotional self-regulation. (Riggs et al., 2006, Best et al. 2009, 15.) The wide-reaching influence
of EF on school performance makes it a particularly important concept for school teachers, psychologists and other staff.

Among the countless correlations of EF development and school success, studies have proven the significance of bringing the attention of educators to the EF components. Canti, Hund and Mann (2012) suggest that in terms of temperament, inhibition is understood as a central aspect of general self-regulation as well as emotional self-regulation. They continue with the importance of attention or shifting for children’s academic and social success may be connected to the ability to avoid distractions and stay engaged with a task long enough to complete it. (Canti, Hund & Mann 2012, 20.)

As mentioned earlier, Blair and Diamond (2008) also relate that EF is important to emotional self-regulation which is especially crucial for school readiness and success. According to their approach, self-regulation, which may be used for following directions and maintaining attention seems to be more closely connected to success during the first school year than the obtainment of academic skills. (Blair & Diamond 2008, 10-11) Using a National Center for Education Statistics survey, Lewit and Baker (1995) found that teachers’ perceptions of a child’s lack of school readiness were based mainly on a lack of self-regulation for behavior (Lewit & Baker 1995, 128).

From another perspective, EF deficiencies have been found to correlate with early developing psychopathologies (e.g., attention deficit hyperactivity disorder [ADHD];) and developmental disorders (e.g., autism spectrum disorder; Barkley 1997, 65). Schoot et al. (2000) found that children with ADHD appear to have EF inhibition deficiencies that are conveyed by behaviors such as responding or answering before understanding a task or allowing attention to stray to irrelevant stimuli. Another type of disorder, dyslexia, in a certain form called dyslexic guessers, have a deficiency of EF inhibition and tend to guess letters in word before recognition. (Schoot et al. 2000, 298.) Also, a child with the diagnosis of ADHD may lack EF shifting making it difficult to avoid distractions and learn to focus in a setting with other stimulants (Canti, Hund & Mann 2012, 20). Lastly, deficits in working memory may lead to difficulties with academic skills, especially mathematics, and has also been linked with ADHD (Barkley 1997, 65). Children with inhibition deficiencies, whether diagnosed with ADHD or not, also have difficulty regulating thoughts, actions and behavior necessary for goal-directed activities (Canti, Hund & Mann 2012, 20).
Since the development stage EF is significant factor of behavior and learning of a child, it is natural to relate the daily uses to success of reaching learning goals (Best 2010, 345). Therefore, use and development of EF in the school relates to the Finnish national core curriculum goals. The connection of EF and daily life for a student in school is necessary to reach the objectives of transversal competencies. Development of EF is quite clearly addressed in the first three objectives, thinking and learning to learn (T1), cultural competence, interaction and self-expression (T2), and taking care of oneself and managing daily life. (T3; National Core Curriculum 2014, 21-23.)

The Finnish Board of Education (2014) defines transversal competencies as bodies of knowledge, skills and attitudes that also includes the ability to apply these aspects in practice. The significance of the competencies in the curriculum is defined by the changes in the surrounding world in the twenty first century and the understanding that some competencies cross borders between different fields of knowledge. The Board goes onto to describe that these competencies develop especially by how interaction the learner and environment functions work as well as how the students work. (National Core Curriculum 2014, 21.) The environment where students work and how they work is determined by the teacher and therefore the significance of this method of physically active learning is only implemented in the school day if the teacher should decide to do so.

3.4 Physically active learning and EF

For this thesis to increase the accessibility of the knowledge in this field, the focus of this section begins with an exploration of the various ways physical activity may impact the EF and what development might occur. It is important that this connection between physical activity and EF is explored from a development perspective when attempting to understand this link (Best 2010, 342). Following the review on the development perspective, the way research performed by the type of evaluation is reviewed to understand what links might exist between physical activity and EF.

Later in this section, the significance of the connection of physical activity and EF is emphasized through research on the type of physical activity that promotes the use and therefore development of EF in children. The findings of Best (2010) lead to the concept that physically active learning is a potential path to the development, activation and attention to a child’s EF during the school years (Best 2010, 345). Addressing of the second half the research question;
3.4.1 Physical activity and EF

Understanding that physical activity and EF are connected during a child’s development process, is a significant aspect when examining what type of physical activity could be used in the learning environment (Best 2010, 342). After briefly reviewing the connection during early development, research on the effect of physical activity on EF can be categorized into two types. The two research types, acute and chronic physical activity research, are different due to the timing of the evaluation. For acute physical activity research, evaluation takes place immediately after physical activity, and evaluation after a long term physical activity program is chronic physical activity research. (Pesce et al. 2009, 16.)

Adolph (2000) found that the link between physical activity or movement and EF in children is found to be present already during infancy. Also, regular engagement in physical movement during the early years of childhood facilitates the development of EF. For example, attentional development might occur through action repetition or use of movement or exploration’s connection with flexible ways of thinking. (Adolph 2000, 294.) It is challenging to perform research on infants in terms of EF development, however Adolph (2000) is a well cited and therefore, can be considered a reliable source.

In the school age years of a child, research on the effect of physical activity on EF can be examined at different points after the activity is complete. Acute physical activity research is characterized by the evaluation of the immediate effects on cognition or EF, after single bouts of physical activity. (Best 2010, 331-347; Pesce et al. 2009, 16.) Immediate effects acute physical activity includes increased activity in the brain which may improve attention in students (Best 2010, 336). Best (2010) also found that some forms of physical activity may benefit EF in children differently depending on their age. Such as, unstructured pretend play benefiting younger children while older children may benefit more from complex and sophisticated games. (Best 2010, 347.)

Drollette et al. (2013) performed a study where children, categorized in two groups of lower or higher task performance, participated in a task to examine the effects of acute physical activity on aspects of EF. Their findings resonated with other research with similar research questions,
indicating that acute physical activity benefits cognitive performance and use of EF in children. (Drollette et al. 2013, 59-63; Best 2010; Drollette et al. 2012.) In addition, Drollette et al. (2013) found that children with lower inhibition EF may benefit the most from these single bouts of physical activity. These lower task performers with lower inhibition EF are the most in need of this activation of the children tested. (Drollette et al. 2013, 59-63.)

Chronic physical activity research is usually performed by evaluating the participants possible physical, cognitive and social effects after a long-term habitual exercise program (Best 2010, 333; Pesce et al. 2009, 16). Studies focusing on the effects of chronic physical activity on the EF, such as Davis et al. (2011), have used primarily aerobic training as the exercise program. The findings of the study of young children by Davis et al. (2011) provide evidence that EF is amenable to chronic aerobic training. After completing the program of aerobic training, children completed tasks that assessed EF and academic skills. In comparison to the control children who received no intervention of any sort, but participated in the tests; the task results conveyed that aerobic training influenced EF and a marginal positive effect on mathematical achievement. (Davis et al. 2011, 91-98.)

3.4.2 Cognitively engaging physical activity and EF

The benefits of physical activity have both immediate and long-term effects on the brain’s cognitive activity (Wijnsma 2017, 9; Drollette et al. 2012, 53; Best 2010, 338). Best (2010) also found that the type of physical activity has various results in learning capacity. The intention of the study Best (2010) performed, was to find how physical activity in its different forms affects executive functioning. Cognitively engaging physical activity indicates a stronger effect than non-engaging physical activity on children’s EF. (Best 2010, 344-345.) Cognitively engaging physical activity can include games such as logical or strategy games requiring the components of EF.

Previous research that assesses the difference of effect on EF, between cognitively engaging and non-engaging physical activity, more often uses an acute physical activity study model. Pesce et al. (2009) performed a quantitative research that aimed to determine if the working memory EF in children, aged 11 to 12, is affected differently by physical activity that requires either lower or higher cognitive and social engagement. Both activities required similar physical intensity and took place during physical education lessons by the same sixty students. The lower cognitive engagement activity was a circuit training while the higher cognitive engagement
activity consisted of team games requiring motor skills to be applied in competitive and socially interactive setting. During the circuit training activity, students worked alone with continuous intervention from the teacher while team games had minimal teacher intervention. A working memory test was taken after no exercise as well as immediately after both activities, and the results were compared. Pesce et al. (2009) found that after the higher cognitive and social engagement team game activity, the children received in highest scores in the working memory test, while the lowest scores after no exercise. This led to the conclusion that physical activity in general stimulates the EF with the most benefit for the working memory EF influenced by higher cognitive engagement activities. (Pesce et al. 2009, 16-22.) Although this is a promising study for the benefits of cognitively engaging physical activity for learning and the use and development of the EF, many other factors are also influencing the difference in the results. It is important realize the other factors, such as social interaction, affecting these results. Therefore, there is a need for further research on this specific phenomenon. (Best 2010, 347.)

3.4.3 Connection of physically active learning and EF

This chapter up to this point has mainly focused on the impact of physical activity, in various forms, on the EF. The purpose of this thesis brings the focus back to physically active learning as an approach to learning in the classroom. Grieco et al. (2009) reviews the integration of physical activity into academic lessons as a newly explored learning approach, with implications of improvement with academic achievement and potentially EF in children. They also emphasized the need for support of students and teachers to adjusts to this practice. (Grieco, Jowers, & Bartholomew 2009, 1924.) This section will also explore the more recent literature that has studied the correlation of physically active lessons and programs and the change in EF components.

Physically active learning is the implementation of physical activity into the classroom, into the lesson (Wijnsma 2017, 8-9). Best (2010) concluded that physical activity in general is a cognitive activity that requires use of the EF and adaptive thinking. Therefore, a teacher’s use of physically active learning with students is an opportunity to discover a child’s EF level and need for attention. (Best 2010, 348.) In terms of applying physically active learning in the school, Best (2010) continued that it is important consider the student’s current development stage and implement an appropriate method. Whether it may be a more imaginative game or activity for the younger children or a more complex, strategic game for the older children, the
physically active aspect may possibly help facilitate a connection, possible emergence and development of a child’s EF. (Best 2010, 344-348.)

Wijnsma (2017) found evidence for acute effects of physical active lessons on children’s time-on-task, and demonstrated prolonged effect of the physically active lessons on academic achievement. These findings are both related to the EF’s although the test did not separate the EF’s in the various tests. The research also explored the benefits of physically active lessons for socially disadvantaged children. They suggested the method to aid to minimize the gap of achievement between disadvantaged children and more socially advantaged children. (Wijnsma 2017, 97.)

Hillman et al. (2014) performed a large quantitative study of 221 children ages seven to nine. The children participated in a physical activity program (Fitness Improves Thinking in Kids [FIT Kids] program) that took place after school for 9 months. The program included at least 70 minutes of moderate to vigorous physical activity per day. Improvements were found in the children’s cardiovascular fitness as well as in EF components were found through tests on working memory, inhibition and shifting. The greatest improvements were found in attention inhibition and flexible shifting between tasks. The improvements found in the participants group were greater than that of the control group. Also, there was no changes for tasks requiring use of non-executive cognition, which infers that physical active learning benefits are more specifically related to the EF part of the brain. (Hillman et al. 2014, e1069-e1070.) In contrast, the study by de Greeff (2016) conveyed that there was no significant improvement in children’s results on four tests representing EF after 2 years of physically active learning intervention (de Greeff 2016, 80). The conflicting conclusions could possibly result from the study’s variation with cardiovascular emphasis and improvement in first study and the second studies less frequent interventions of physically active learning.

The challenge with the studies of analyzing the improvement of EF with a physically active learning program like Hillman et al. (2014), is the addition factors that benefit the children's development, motivation and improvement. These additional factors may include; social interaction with peers and teachers and refining of motor skills. (Hillman et al. 2014, e1069.) The review in this section is focused on literature that explores this connection, but is lacking in many aspects. For example, the direct correlation of specific types of physically active learning to specific components of EF would be beneficial for increasing the accessibility for teachers. Reasons for the lack of these perspectives is due to the lack the amount high quality of research
in this field. Simply, this is a recent research area for physically active learning with most studies published only in the last five years.
4 Discussion

The purpose of this thesis was to explore physical active learning and executive function components as well as the correlation between the two concepts. In addition to this exploration, the literature that contemplated implications of this link for educators would be made more accessible in this thesis. The aims of this thesis were clear and reached during the extent of the research, even with complicated constructs and lack of extensive material on the connection of the two concepts. Beginning the research process with the concern of physically active learning causing a loss of concentration, voiced by teachers in Oulu area schools, was influential in finding this focus on executive function when reviewing literature. The concern voiced was especially significant since it convinced many teachers to avoid using the physically active learning method.

The technique of a systematic literature review was beneficial for reaching my aims in this thesis since it not only supported building my understanding of the concepts of physical active learning and executive function, but allowed my research process to advance to reviewing what literature conveys on the implications of this connection for the educator and student. The process was challenging in the beginning when I was not yet familiar with the executive function construct, and required a dedication to not only read and learn about it, but to be able to write a cohesive review on the construct found in literature.

Performing the literature review for this thesis was interesting and informative with a variety of sources to develop the process as I went along. Since this area of studies is personally an important part of my own learning processes during grade school with my own learning difficulties, the depth the review provided was satisfying to experience. It was also personally motivating to find research that understands the significance of the connection between physical activity and the executive brain function in relation to learning disabilities.

The relation of physically active learning with the development of executive function is a recently researched area, and the relevance is clear in Finland. Finnish School’s on the Move program and its promotion of physical activity during the school day is one clear example. Throughout this research process, I came across aspects of physical activity and executive function in children’s development process that emphasize their significance; benefits of this connection for learning and challenges with implementation of physically active learning. Additionally, physically active learning might support the move towards a more inclusive classroom.
in Finland. The inclusion of students with all types of learning challenges, or the integration of students to the mainstream classroom for some lessons results in a challenge for the teacher to reach all children. These areas of research I would address as potential areas for further studies.

The first chapter includes a comprehensive overview on physical activity as a concept including factor affecting an individual’s performance of physical activity, health benefits and recommendations. This way of organizing this chapter was done purposefully since these aspects of physical activity emphasize its significance as well as the connection to physically active learning is clear. One aspect of physical activity that Klesges et al. (1990) provided, needs to be remembered when planning use of physically active learning in schools, is that children are more active when time is spent outdoors (Klesges et al. 1990, 440). Research on physically active learning may have also been accomplished by separating learning and physical activity. Although I am aware of the construct of learning in general, I will not break it down in this fashion due to the learning construct’s broad and vague nature that has countless factors and approaches affecting its occurrence which are unnecessary for this thesis.

Continuing the literature review on the EF construct led me to contradicting ideas on the construct form and the relations between components. This required a choice as the researcher to select one framework to perform the review. Due to the amount of studies on children’s development using the three-separate component definition I chose this framework. The awareness of the contradicting ideas was crucial when choosing the literature throughout the thesis, making sure all literature is based on this framework to avoid confusion and maintain credibility.

The section on the EF construct related to physically active learning since this was the intended focus of the thesis. A question formed as I read about this connection that although physically active learning as a method is ideal, how can one, with the understanding of EF’s connection, make it more beneficial in practice? The connection with executive function outlined in this thesis is significant for the aspects of implementations. A few of the implications of this link’s significance are supported with the following; the potential of further studies may support teachers with how to implement the method, ability to reach the lower performing students, supporting the development of EF in all learners especially those with EF deficiencies and potentially reaching those with learning disabilities such as ADHD.

With the support of Best (2010), and his claim that physical activity in general is a cognitive activity and requires use of the EF and adaptive thinking, the call for more research on this
connection is necessary. Along the same lines, this research can be supporting the implementation of physically active learning with the understanding that it requires the teacher to be aware of the type of cognitive activation the physical activity facilitates and match it with a concept to be learned for increased concentration and potential learning for the lower achieving students. (Best 2010, 348.) The lower achieving students are proven to benefit the most from a single bout of exercise, which is another reason to emphasize the significance of this connection (Drollette et al. 2013, 59-63).

Research on this link of physically active learning methods to tapping EF in children, still needs more credible research to be performed and assessed. However, the potential that applying the knowledge of this link to a learning environment could not only help teachers facilitate the appropriate learning environment, but also help develop students EF and therefore with daily uses of EF. (Hillman et al. 2014, e1067-e1070.)

The literature in this field also has the balancing perspective that physically active learning is not always the best option for learning, but the implication of physical activity on EF is significant enough for the learning method to be taken into consideration in practice. Potentially, if the students and teacher adapt to the practice, physically active learning in the lesson could develop and improve the concentration and productivity. I began this thesis with the concern that physical activity depletes the concentration and productivity, but according to studies, physical activity affects concentration, use of EF, immediately and over a long-term practice, if it is implemented with a cognitive connection to the lesson goals.

Further study of the link between physical activity and EF in the development process of a child would be beneficial and could have potentially aided my research process, leading to a more coherent direction of focus. This part of my thesis is lacking, but due to the lack of literature in with this perspective and the focus of this thesis leading to a potentially more accessible connection of how this knowledge could be applied in the physically active learning method, I did not include more literature on this perspective. Best (2010) relates that there has not been enough discussion between development psychologists and kinesiologists to know whether a specific EF component is sensitive to physical activity. Also, more discussion between those two field of expertise would possibly lead to knowledge of whether certain a physical activity will be cognitively engaging for the various development levels during the life of a child. (Best 2010, 347.)
The central concepts that can be taken away from this thesis are based on the idea that the type of physical activity is considered, as to what parts of the EF it might influence, is important for implementation of physically active learning. The idea Best (2010) presented that the interplay of physical activity and cognitive engagement has even a stronger effect on the development of EF than non-cognitive engaging physical activity (Best 2010, 347). Therefore, Wijnsma’s (2017) suggestion of using physical exercises requiring memory when teaching a math or language lesson with an emphasis on repetition and memorization, is an example of using cognitive engagement to influence the development of EF (Wijnsma 2017, 98).

Another important idea presented in this thesis is the possible reduction of ADHD symptoms through physical activity, due to its proven positive effects on EF, (Best 2010, 345) and should be researched further. If this possible reduction of ADHD symptoms with physical activity is researched further and results in positive correlation, it could be used in practice to aid teachers with the integration of students with learning disabilities into mainstream classrooms. Integration of students with various learning challenges and disabilities is increasing with the change of curriculum in Finland, (Finnish National Board of Education 2014). Therefore, teachers in Finland may benefit from further research on physically active learning and its effect on students with learning disabilities, such as ADHD.

Although this thesis on physical active learning and its connection with executive function has uncovered a positive correlation, we still face countless practical challenges of implementing physically active learning. Overall, this research exploration has helped clarify what the main concepts in this area of research mean, how they are connected, what kind of research is needed for improving the application of physically active learning and lastly, possible directions for my master’s thesis and empirical study.
References


