The Effect of Physical Activity on Science Competence and Attitude towards Science Content

by

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Abstract

This study examines the effect of physical activity on science instruction. To combat the implications of physical inactivity, schools need to be willing to consider all possible opportunities for students to engage in moderate-to-vigorous physical activity (MVPA). Integrating physical activity with traditional classroom content is one instructional method to consider. Researchers have typically focused on integration with English/language arts (ELA) and mathematics. The purpose of this study was to determine the effect of physical activity on science competence and attitude towards science. Fifty-three third grade children participated in this investigation; one group received science instruction with a physical activity intervention while the other group received traditional science instruction. Participants in both groups completed a modified version of What I Really Think of Science attitude scale (Pell & Jarvis, 2001) and a physical science test of competence prior to and following the intervention. Children were videotaped during science instruction and their movement coded to measure the proportion of time spent in MVPA. Results revealed that children in the intervention group demonstrated greater MVPA during the instructional period. A moderate to large effect size (partial eta squared = .091) was seen in the intervention group science competence post-test indicating greater understanding of force, motion, work, and simple machines concepts than that of the control group who were less physically active. There was no statistically significant attitude difference between the intervention and control groups post-test, ($F(1,51) = .375$, $p = .543$). These results provide evidence that integration can effectively present physical science content

and have a positive impact on the number of minutes of health-enhancing physical activity in a school day.

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List of Abbreviations

AASA	American Association of School Administrators
ACSM	American College of Sports Medicine
AS! BC	Action Schools! British Columbia
AERA	American Educational Research Association
ANOVA	Analysis of Variance
ASCD	Association for Supervision and Curriculum Development
AYP	Adequate Yearly Progress
BMI	Body Mass Index
CAT – 3	Canadian Achievement Test, Third Edition
CDC	Centers for Disease Control and Prevention
COPEC	Council for Physical Education for Children
CTB	California Test Bureau
CTC	Canadian Test Centre
DECS	Department of Education and Children's Services
DIBELS	Dynamic Indicators of Basic Early Literacy Skills
ECLS-K	Early Childhood Longitudinal Study-Kindergarten
ELA	English/Language Arts
ESEA	Elementary and Secondary Education Act
FIT Kids	Fitness Integrated with Teaching Kids

HP 2010	Healthy People 2010
IOA	Interobserver Agreement
IRB	Institutional Review Board
ISF	Initial Sound Fluency
LSAY	Longitudinal Study of American Youth
LISREL	Linear Structural Relations
LNF	Letter-Naming Fluency
LSD	Least Significant Differences
MANOVA	Multivariate Analysis of Variance
MANCOVA	Multivariate Analysis of CoVariance
MAT-6	Metropolitan Achievement Test, Sixth Edition
MET	Metabolic Equivalent
MVPA	Moderate-to-Vigorous Physical Activity
NAEYC	National Association for the Education of Young Children
NASPE	National Association of Sport and Physical Education
NCLB	No Child Left Behind
NHLBI	National Heart Lung and Blood Institute
NIH	National Institutes of Health
NSF	National Science Foundation
NSTA	National Science Teachers Association
NUDIST	Non-numerical Unstructured Data Indexing Searching and Theorizing
PAAC	Physical Activity Across the Curriculum
PACI	Physical Activity Checklist Interview

PAQ – C	Physical Activity Questionnaire for Children
PISCES	Puppet Interview Scales of Competence in and Enjoyment of Science
PWC170	Physical Work Capacity
SAS	Statistical Analysis System
SAT-9	Stanford Achievement Test, Ninth Edition
SDQ-I	Self Description Questionaire I
SES	Socioeconomic Status
SISS	Sisters in Sport Science
SLP	Science Literacy Project
SOFIT	System for Observing Fitness Instruction Time
SPARK	Sports, Play, and Active Recreation for Kids
USDHHS	United States Department of Health and Human Services
WAIT-II	Wechsler Individual Achievement Test 2^{nd} Edition
WJ – III	Woodcock-Johnson III Tests of Achievement
YAQ	Youth/Adolescent Nutritional Questionnaire
3DPAR	Three-Day Physical Activity Recall

CHAPTER I

INTRODUCTION

Television. Video Games. Computers. No matter which direction the finger points, the bottom line is children are inactive. The consequences of physical inactivity are well documented. In the short term, the physical and psychological health of children is in jeopardy as a sedentary lifestyle affects the maintenance of a healthy body weight, decreases muscular strength and endurance, increases feelings of anxiety and depression, and can lessen self-esteem. One long term consequence of childhood physical inactivity is a shortened lifespan with diminished quality of life. Within the text of House Resolution 1585, the U.S. Congress Bill cites, "more than 9,000,000 children and adolescents between the ages of 6 and 19 years are considered overweight on the basis of being in the 95th percentile or higher of BMI values in the 2000 CDC growth chart for the United States" (FIT Kids, 2009, Findings section ¶ 4). According to the Centers for Disease Control and Prevention (CDC) (2008a), "the prevalence of obesity among children aged 6 – 11 has more than doubled in the past 20 years, going from 6.5% in 1980 to 17.0% in 2006" (p. 3). Overweight and obese children risk the development of factors associated with chronic diseases as a result of physical inactivity. With the numbers presented by the CDC, it is apparent that children are becoming less active and are at risk.

We, as a society, can continue to worry about the level of inactivity in children due to numerous factors including time spent watching television, playing video games, or using the computer; or we can actively educate and encourage children to become physically active. All is not lost, the CDC (2008b) reports, "regular physical activity makes it less likely that….risk factors will develop and more likely that children will remain healthy as adults" (¶ 2). Replacing physical inactivity with activity seems to be an obvious solution. Yet, it has proven to be easier said than done.

The U.S. Department of Health and Human Services (USDHHS) has been responsible for drawing attention to the fact that physically active individuals experience health benefits. In the past three decades, three Healthy People documents have been published. Most recently, the Healthy People 2010 (HP2010) document acknowledges ten indicators toward improving health which, "illuminate individual behaviors, physical and social environmental factors, and important health system issues that greatly affect the health of individuals and communities" (USDHHS, 2000, p. 24). Physical activity sits at the top of the list of leading health indicators and makes a direct link to focus area 22 which specifically addresses physical activity.

In addition to federal legislation and publication, professional education associations have expressed their principles regarding physical activity. The Association for Supervision and Curriculum Development (ASCD) has been a powerful voice for educational excellence through the past half century. ASCD recognizes the responsibility of preparing today's children for tomorrow's work force and supports school leaders in this endeavor. In order to accomplish this effort, ASCD believes an inclusive approach to education will produce learners who are, "knowledgeable, emotionally and physically healthy, motivated, civically inspired, engaged in the arts, prepared for work and economic self-sufficiency, and ready for the world beyond their own borders" (ASCD, 2009, The Whole Child section ¶ 1). The American Association of School Administrators (AASA) advocates teaching the whole child as well. They endorse schools that provide an environment which includes, "access to healthy foods, opportunities for physical activity, clean air to breathe, access to preventive care and health services, including mental health" (AASA, 2007, Position Statement 12 section ¶ 1). Both organizations strongly favor excellence for all school children through rigorous instruction. This teaching includes not only a priority towards health and physical activity but also classroom academics.

A combination of curriculum, instruction, and best practices in assessment support school success. Academic achievement regardless of socioeconomic status (SES) was the premise of No Child Left Behind (NCLB). This law purported that every American child should demonstrate achievement in school and schools should be held accountable for high academic standards, regardless of child's background, ethnicity, or income. Starting in 2006, state and local educational agencies have been required to assess and report every child's progress in reading/language arts and mathematics for grades three – eight and at least once during grades 10 – 12. Beginning with the 2007-2008 school year, the administration of a science assessment became required once during grades three – five, grades six – nine, and grades 10 – 12.

In the past, the pressure associated with NCLB has led school leaders to direct time and resources toward language arts and mathematics while instructional time for science was diminished, "twice as much time was spent on English/reading/language arts as on arithmetic and mathematics, and almost twice as much time was spent on arithmetic and mathematics as on social studies/history or science" (Department of Education, 1997, p. 10). Because student outcomes in reading/language arts and mathematics affected school accountability status, "science was taught when time allowed, if at all, and this was typically after testing was complete for the year" (Marx & Harris, 2006, p. 470). In 2007, student progress in science became a yearly assessment requirement, though these results are not reported via adequate yearly progress (AYP). This requirement has given the content of science more equal status than it has formerly received. It is imperative that scientific thinking and reasoning through investigation, replace instructional time previously spent on recall of informational facts. The National Science Teachers Association (NSTA) advocates that, “inquiry science must be a basic in the daily curriculum of every elementary school student at every grade level” (NTSA, 2002, ¶ 1). It was suggested that linking science to language arts and mathematics, in terms of integrating content, might help students move beyond the mere recall of information (Marx & Harris, 2006).

Schools are accountable for producing academic achievement due to mandates of NCLB and feel extraordinary pressure to show their effectiveness by meeting student achievement criteria in core subjects. Thus, there seems to be two dilemmas that need to be addressed: (1) children are inactive and (2) children need greater exposure to science content. Research indicates that students who make higher grades are more active than students who make lower grades (CDC, 2008c). The quality or intensity of physical activity and the quantity or time spent in physical activity affect or has a relationship with academic achievement, “the link between activity and academic performance was most significant when kids met Healthy People 2010 (HP2010) guidelines for vigorous activity 20 minutes a day, at least three days a week” (American College of Sports Medicine (ACSM), 2006, ¶ 2). Conversely, research shows that reducing the amount of time children spend in noncore subjects such as art or physical education in order to increase time spent on core content fails to correlate with higher test scores (Wilkins, Graham, Parker, Westfall, Fraser, & Tembo, 2003).

On March 18, 2009, U.S. House Representatives Ron Kind (D-WI), Zach Wamp (R-TN), Jay Inslee (D-WA) and Senator Tom Harkin (D-IA) re-introduced the Fitness Integrated with Teaching Kids (FIT Kids) Act. This bill amends the Elementary and Secondary Education Act (ESEA) and NCLB by supporting quality physical education and activity for all school children. It also advocates that children understand how to stay healthy through exercise and diet.

Although it is beyond the scope of this study to determine accountability towards meeting national physical education standards, investigating academic competence is feasible.

In summary, twenty-first century learners are surrounded by an electronic culture that includes Gameboy®, iPod®, and text messaging. This environment encourages a sedentary lifestyle. Yet, research shows students need to be moderately-to-vigorously active to improve their health. Neither government documents nor federal legislation can create a tide of change in which children are instantly physically active or more competent in science. Yearly assessment will document student progress in science but it will be non-traditional approaches to instruction like integration that will advance science from a marginalized content. Thus, this study merged two constructs to address these problems. In chapter two, physical activity, integration, and competence will be operational defined and the literature pertaining to physical activity and science will be reviewed.

Statement of the Purpose

The purposes of this study are to examine the effects of physical activity on science competence and to examine the effects of physical activity on attitude towards science.

CHAPTER II

REVIEW OF LITERATURE

Children reside in a culture rich in technology but physical inactivity is an unfortunate by-product. Creating learning environments that simultaneously meet the physical, cognitive, and social needs of children is imperative regardless of the pressures to demonstrate student achievement. Students deserve a balanced menu of core content. The purpose of this study is to examine the effect of physical activity on student competence in science and student attitude towards science content. First, this review defines physical activity and describes various opportunities to achieve physical activity within a typical school day. Specifically, the integration of physical activity and subject area content is presented as one way to achieve health-enhancing physical activity while positively affecting academic competence. Finally, this review of literature concludes with a three-part discussion of science. The discipline of science will be defined prior to examining the literature pertaining to science competence and the value of attitude towards science content.

Physical Activity

Exercise physiology explains physical activity by describing the energy expended during activity. The term metabolic equivalent (MET) represents this expenditure as a ratio of energy expended during activity in relation to the energy expended during rest. The exercise physiologist employs a MET unit to represent the intensity of an aerobic activity. Scientifically, the percentage of aerobic capacity reserve can also define aerobic intensity. The World Health

Organization (2009) defined physical activity as movement created by muscles demanding expenditure of energy. The concepts of energy expenditure, MET, and aerobic capacity reserve are difficult terms for adults to understand. How, then, might physical activity be explained to a school-aged child? The National Heart Lung and Blood Institute (NHLBI) defined physical activity as, "any body movement that works your muscles and uses more energy than you use when you're resting" (NHLBI, 2009, ¶1). This child-friendly definition accurately explains physical activity. Thus, it will be utilized as the operational definition throughout this study.

An adult can rationalize the consequences of physical inactivity. Children, on the other hand, have a difficult time conceptualizing the effects of physical inactivity on quality and quantity of life. Children use words such as 'fun' and 'friends' when describing physical activity whereas adults characterize physical activity by using phrases such as 'maintaining health' or 'preventing disease'. Effective physical activity for school-aged children should stress a variety of enjoyable lifetime activities (CDC 2008d) and the importance of being physical activity (National Institutes of Health (NIH), 2005).

Whereas quality and quantity of life may be abstract concepts for children, physical educators know children need developmentally appropriate opportunities to acquire the skills, knowledge, and attitudes to be physically active for a lifetime. Corbin and Pangrazi (1998) suggested that children should participate in at least 60 minutes of physical activity most days of the week. During this hour of accumulated activity, children should participate in aerobic, muscle, and bone strengthening activities. Aerobic activity is explained in terms of moderate and vigorous intensity. The CDC (2008e) described this intensity, "….on a scale of 0 to 10, where sitting is a 0 and the highest level of activity is a 10, moderate intensity activity is a 5 or 6….Vigorous-intensity activity is a level 7 or 8." During moderate aerobic activity, the heart will beat faster than normal, breathing will be harder than normal, and activity can be performed for longer periods of time without fatigue. Developmentally appropriate activities for children at this intensity include bicycle riding and skating. The heart will beat much faster than normal and the breath will be much harder than normal during vigorous aerobic activity. Jumping rope and playing tag are appropriate activities at this intensity level. Because vigorous activity expends more energy, it should be demonstrated at least three days a week in, "….relatively short bursts of movement (several seconds or minutes) interspersed with rest periods"(Council for Physical Education for Children (COPEC), 2003, ¶11). Likewise, muscle and bone strengthening activities should be a part of children's 60 or more minutes of physical activity at least three days a week. Muscle strengthening activities include childhood favorites like climbing on playground equipment or playing tug of war. Whereas, skipping, jumping, and hopscotch are examples of bone strengthening activities due to the force created and applied during movement.

Furthermore, physical activity should consist of multiple opportunities to move so that children are not inactive for a period greater than two hours during the day (Corbin & Pangrazi, 2004). In order to accomplish these quantitative suggestions, opportunities for physical activity will need to be available not just before and after school, but also during school hours. Administrators and school faculties need to look for and support opportunities for students to be physically active. During a typical school day, formal physical education, scheduled recess, and an integrated curriculum are appropriate avenues for physical activity.

Physical Education

With physical activity defined, the focus changes to the venues which can provide a place to acquire the skills, knowledge, and attitudes necessary to be physically active. One avenue is physical education. The curriculum of physical education offers children the opportunity to learn the skills necessary for successful participation in physical activity just as children learn how to write, read, or manipulate numbers to be successful in the classroom. Physical education instruction should promote and help children develop and maintain the skills necessary for a health-enhancing level of fitness.

Understanding and valuing physical activity are additional outcomes which can be accomplished in a quality physical education program. In addition to these outcomes, Smith and Lounsebery (2009) explained that decreasing time for physical education did not ensure better academic outcomes. Dollman, Boshoff, and Dodd (2006) confirmed this deduction in their study of 117 schools. Using results from an adapted 100 Minutes Project survey and demographics from the Department of Education and Children's Services (DECS) database, the researchers investigated the average time spent on physical education and its relationship with literacy and numeracy scores. They found a strong, positive relationship between SES and both literacy ($p < .0001$) and numeracy ($p < .0001$) achievement. Moreover, data indicated no evidence that schools with high physical education time were disadvantaging student achievement. Conversely, research has shown that the quantity of quality physical education had a positive effect on the standardized English/language arts (ELA) scores of fourth grade children (Tremarche, Robinson, & Graham, 2007). In this study, Tremarche, Robinson, and Graham used an independent samples t-test to analyze 311 students from two elementary schools in different districts. The researchers determined the physical education curricula were similar though school one had 28 clock hours of physical education while school two had 56 clock hours. The mean ELA scores for school one and two were significantly different, $t\ (309) = 1.645$, $p < .05$, indicating the quantity of physical education at school two affected the ELA scores.

Further, the norm-referenced results of 754 fourth and fifth grade students on the Metropolitan Achievement Test, Sixth Edition (MAT-6) (Psychological Testing Corporation, 1990) for reading, mathematics, language, and composite scores were not hindered by the health-related physical education project Sports, Play, and Active Recreation for Kids (SPARK) (Sallis et al., 1999). SPARK teaches health-fitness and skill-fitness activity in school and promotes physical activity outside of school. In this two year study, seven elementary schools in one school district participated. Schools were randomly assigned to a condition; two schools implemented SPARK with trained specialists, two schools implemented SPARK by training classroom teachers, and three schools implemented typical physical education taught by classroom teachers who followed no specific curriculum. The students who received specialist or trained instruction were taught three, 30 minute physical education lessons weekly. Although no gender or ethnicity differences were reported, an analysis of variance (ANOVA) analyzed with Student-Newman-Kuels adjusted pairwise comparisons indicated all achievement scores in all conditions declined indicating physical education did not adversely affect achievement. The findings of Stevens, To, Stevenson, and Locbaum (2008) also showed that physical education did not detract from the reading or mathematic achievement of 22,000 kindergarten, first, third, and fifth grade children selected from the Early Childhood Longitudinal Study-Kindergarten (ECLS-K) database. A comparative fit index and standardized root mean squared residual presentation strategy was used to analyze SES, physical activity, prior mathematics achievement, prior reading achievement, mathematics achievement, and reading achievement as well as physical education. In this study, school administrators were asked to report the frequency of physical education instruction per week. The researchers found that physical education neither improved nor detracted from reading or mathematics achievement significantly. More importantly, these results extended the findings of Coe, Pivarnik, Womack, Reeves, & Malina (2006) who had determined that students who met or exceeded the HP 2010 guidelines for vigorous physical activity outside of school had higher academic achievement unrelated to physical education enrollment. These researchers assessed 214 sixth grade students from one school who were randomly assigned to a semester of physical education. System for Observing Fitness Instruction Time (SOFIT) (McKenzie, Sallis, & Nader, 1992) was used to assess the quantity of physical activity performed during physical education while Three-Day Physical Activity Recall (3DPAR) (Weston, Petosa, & Pate, 1997) was used to report MVPA outside school. Student grades in English, mathematics, science, and world studies were changed to numeric data and totaled over two grading periods. Further, Terra Nova (California Test Bureau (CTB)/McGraw-Hill, 1996) standardized test scores were used to measure academic achievement. Shapiro-Wilk test results determined individual grades and standardized test scores were not normally distributed. To further explore achievement differences, the researchers used Kruskall-Wallis analysis and determined neither individual grades nor standardized test scores were affected by physical education enrollment. Rather, students who performed physical activity that met or exceeded the HP 2010 guidelines for vigorous physical activity outside of school had higher academic scores.

The National Association of Sport & Physical Education (NASPE), (2002) recognized the California Department of Education for matching the individual scores of 353,000 fifth, 322,000 seventh, and 279,000 ninth graders on the Stanford Achievement Test, Ninth Edition (SAT-9) (Pearson Education, 1996) with the state mandated physical fitness test, Fitnessgram (Meredith, 1999). The mean scale scores in ELA and mathematics for each component of fitness were analyzed first. Then, an ANOVA and linear regression were used to test the significance between overall fitness and achievement. The statewide findings showed a relationship between academic performance and physical fitness including:

- Higher achievement was associated with higher levels of fitness at each of the three grade levels measured.
- The relationship between academic achievement and fitness was greater in mathematics than in reading, particularly at higher fitness levels.
- Students who met minimum fitness levels in three or more physical fitness areas showed the greatest gains in academic achievement at all three grade levels.
- Females demonstrated higher achievement than males, particularly at higher fitness levels. (NASPE, 2002, ¶ 4)

Jensen (2005) said schools that do not implement an appropriate physical education program are shortchanging the potential for student academic achievement. However, the research indicates it is not so much the physical education program but the intensity of physical activity in the program that relates to academic achievement.

Scheduled Recess

Physical activity can be offered to students in a venue different from physical education. Whereas physical education is structured physical activity, recess affords children opportunities for unstructured physical activity. The national workforce is given breaks at regular intervals because employers know employees will then be alert and more attentive to their work (Jarrett, 2003; Waite-Stupianansky & Findlay, 2001). The brain of a school-aged youngster can concentrate and pay attention for less than 45 minutes before it needs a break (Parker-Pope, 2009). Recess provides a carefree opportunity for a child’s body and voice to be unleashed

(National Association for the Education of Young Children (NAEYC), 1998). More importantly, children experience meaningful physical, social, and emotional learning as they move, interact, and relieve stress (National Association of Early Childhood Specialist in State Departments of Education, 2001; NAEYC, 1998; Rivkin, 2006). Vigorous physical activity during inventive play permits children opportunities to make genuine and meaningful connections between mind and body (Breslin, Morton, & Rudisill, 2008). Further, Barros, Silver, and Stein (2009) determined that 30% of eight to nine year old public school children who had none/minimal recess were primarily black, from low socioeconomic backgrounds and lower levels of education, and lived in northeastern or southern cities. The researchers used data from the ECLS-K database and measured recess, physical education, demographics, school and classroom characteristics, and classroom behavior. Frequency analyses determined proportion of recess, cross tabulation and χ^2 analyses compared child, parent, and school characteristics with frequency of recess, and an independent t-test compared ratings of classroom behavior with frequency of recess. While elementary aged children deserve daily school time devoted to free play so their minds and bodies are healthy and primed for learning, the finding in this study is important as it matches the demographics and lack of recess made available to the school-aged participants of the current study.

Integrated Curriculum

While physical education and recess provide avenues for physical activity outside the boundaries of the classroom, learning and moving is possible inside the classroom. A classroom teacher’s priority is developing academic concepts and knowledge. When academic concepts stream together, children experience an integrated curriculum (Hastie & Martin, 2006). Lonning, DeFranco, and Weinland (1998) used the term integrated to describe the relationship between independent content areas in a balanced interdisciplinary unit. Cone, Werner, Cone, and Woods (1998) describe integration as a blending of skills and concepts where learning occurs but content area boundaries do not exist. Physical Activity Across the Curriculum (PAAC) is one such example of integration. DuBose, Mayo, Gibson, Green, Hill, Jacobsen, et al. (2008) described the rationale and design behind PAAC in their on-going three year randomized, cluster clinical trial targeting second through fifth grade students at 22 elementary schools. Intervention classroom teachers from 11 schools were taught how to incorporate moderate intensity physical activity during a six-hour inservice. These classroom teachers were asked to incorporate ~20 minutes of daily physical activity into academic instruction per school day. With a goal of 90-100 minutes of moderate physical activity per week, the intervention teachers offered additional minutes of physical activity beyond the scheduled 60 minutes of weekly physical education for their students. Control teachers from 11 schools did not alter their classroom teaching methods for their students. The researchers collected height and weight measurements of 2,000 intervention and control students to calculate body mass index (BMI) percentiles according to CDC guidelines. Baseline data were collected during the fall semester when students were in the second and third grades. Follow-up data were collected in the spring of the same academic year and the next two subsequent school years. Further, the researchers collected sub-sample data of 575 intervention and control students including waist and hip circumference, tricep and calf skinfold measurements, bioelectrical impedance, resting blood pressure, fasting blood sample, modified physical work capacity (PWC170) aerobic fitness test (Rowland, Rambusch, Stabb, Unnithan, & Siconolfi, 1993), Wechsler Individual Achievement Test 2nd edition (WAIT-II) (Wechsler, 2005), modified version of the Physical Activity Checklist Interview (PACI) (Sallis et al., 1996), and a Youth/Adolescent Nutritional Questionnaire (YAQ) (Rockett, et al., 1997). Sub-sample data were collected in the fall of the first academic year and spring of the third academic year. From the sub-sample, 132 children wore an AntiGraph accelerometer four consecutive days in the spring of each academic year to monitor physical activity. Researchers directly observed weekly physical activity in both intervention and control classrooms weekly using SOFIT while intervention teachers completed a weekly survey describing the minutes and days of integrated physical activity instruction provided. Using a modified two-sample t-test and mixed linear model, researchers hope to determine how the intervention of physical activity influenced BMI at the conclusion of their study. When traditional classroom content and physical activity are integrated as is previously described, students benefit because they gain an additional opportunity to be active and teachers benefit because interest is aroused and comprehension is strengthened (Givler, 2003; Westerhold, 2000).

Gardner (2003) identified nine intelligences to explain a learner's potential including spatial, linguistic, logical-mathematical, bodily-kinesthetic, musical, interpersonal, intrapersonal, naturalistic, and existential. Students who prefer linguistic or logical-mathematical learning thrive in traditional classrooms. Those who learn differently might benefit from an integrated environment which enables learning to occur through multiple domains and enhances the possibility of success for all students (Hruska & Clancy, 2008; Jehue & Carlisle, 2000; Nilges, 2003; Stevens-Smith, 1999). In these scenarios, a physical education teacher helps students learn academic concepts from a movement perspective. A physical educator's priority is cultivating the physical skills and concepts necessary for a lifetime of movement. However, as Mitchell and Kernodle (2004) suggested, physical activities can engage and foster multiple intelligences outside the boundaries of the traditional classroom. When integration occurs during physical education, physical activity can be used to teach academic content.

Whether integration occurs in a traditional classroom or gymnasium, the boundaries of seemingly dichotomous content areas are blurred and both the classroom teacher and physical educator share the responsibility of providing physical activity for children while encouraging authentic learning as students begin to see connections between content areas. Due to the mandates of NCLB, teachers feel overwhelming pressure to demonstrate their effectiveness (T.C. Martin, personal communication, December 2, 2010) and are held accountable for academic achievement in students. These pressures do not justify denying children opportunities for physical activity. Conversely, Mahar, Murphy, Rowe, Golden, Shields, and Raedeke (2006) found that, "….inclusion of 10 min[utes] of physical activity each day in the classroom will increase on-task behavior. Because improved on-task behavior is beneficial in the classroom, inclusion of 10 min[utes] physical activity will, in all likelihood, improve academic performance" (p. 2092). In this study of 243 kindergarten through fourth grade students representing 15 classes at one public school, classroom teachers received a 45 minute professional development session training them to lead Energizers. The intervention group (n = 135) received a 10 minute classroom-based activity integrated with movement, an Energizer, each school day for 12 weeks. The control group (n = 108) did not receive Energizers. Yamax pedometers assessed in-school physical activity levels for both groups while an independent t-test was used to determine average activity. Intervention classes averaged 782 more in-school steps than the control classes. The difference was statistically significant ($p < .05$) with a moderate effect size (partial eta squared = .49). In addition, a multiple baseline across classroom design was used to assess the on- and off-task behavior of 62 students 30 minutes before and 30 minutes after Energizers for two third and two fourth grade classes. At the end of a four week baseline, one third and one fourth grade class (n = 29) began the intervention. An additional third and fourth grade class (n = 33) began the intervention at the eight week mark. Observers randomly assessed one student's behavior in a 10 second interval and recorded their behavior in the next five seconds on an observation sheet. After one minute, the observer rotated to student two, three, four, five, and six following the same observation procedure. This process was repeated five times so that each student was observed a total of 20 observation intervals. Student and class scores were calculated as an average percentage. A two-way repeated measures ANOVA showed a significant on-task behavior interaction ($F(1,61) = 38.1$, $p <.05$). Fischer's least significant differences (LSD) test revealed a statistically-significant difference ($p < .017$) between the pre-Energizer and post-Energizer intervention with a moderate effect size (partial eta squared = .60) using Cohen's delta. Additionally, to examine the intervention effect on students who were on-task less than 50% of the time (n = 10), paired samples t-tests showed on-task behavior increased 20% after these students participated in Energizers.

Ahamed, Macdonald, Reed, Naylor, Liu-Ambrose, and McKay (2007) found similar results in their 16 month cluster, randomized trial of 287 fourth and fifth grade students. Action Schools! British Columbia (AS! BC) is a whole-school physical activity model targeting six action zones; school environment, extracurricular, family and community, school spirit, physical education, and the classroom. Using the AS! BC framework, classroom teachers at six intervention schools used professional development training and resource actions bins – including equipment such as balls, jump ropes, and exercise bands - to create individualized plans that ensured 15 minutes of daily classroom physical activity to compliment the currently existing 40 minutes of physical education instruction twice a week. Classroom teachers at two control schools continued their usual physical education practice. Intervention and control teachers documented and submitted classroom physical activity in weekly logs. Student height and weight data were used by researchers to calculate BMI at baseline. A modified Physical Activity Questionnaire for Children (PAQ – C) (Kowalski, Crocker, & Faulkner, 1997) was used to determine moderate-to-vigorous self-reported leisure physical activity. Control schools averaged 140 minutes of weekly MVPA while intervention schools averaged 183 minutes at baseline. Independent t-tests determined that while there were no significant physical activity differences between groups at baseline the intervention teachers provided their students with 47 additional minutes of classroom physical activity at follow-up. Additionally, researchers used the Canadian Achievement Test, Third Edition (CAT – 3) (Canadian Test Centre [CTC], 2000) language/writing, reading, and mathematics total score to determine baseline academic performance. Students at control schools had significantly higher academic total scores at baseline yet a mixed linear model helped researchers determine there were no significant academic differences between intervention and control groups at follow-up.

Life is not divided into segments. Neither should learning be divided into portions where content areas are presented separately (Douville, Pugalee, & Wallace, 2003). In their study of 53 third, fourth, and fifth grade teachers representing 45 low performing elementary schools in three metropolitan school districts, Douville, Pugalee, and Wallace used a qualitative research design to determine differences in the use of literacy, mathematics, and science integration practices. Open-ended survey responses, interviews, and artifacts provided data which were analyzed using the key-word-in-context procedure, process/outcome matrix approach, and triangulation. These researchers found teachers identified resources rather than instructional strategies during integrated planning as well as ways to reinforce basic literacy and numeracy skills during science instruction. Conceptual connections between literacy, mathematics, and science were not found to be at the core of integrated planning.

Just as a classroom teacher must be willing to weave movement into content, a physical educator must accept the responsibility of weaving traditional classroom content with physical activity to assist the academic achievement of students. For the purposes of this review, integration will be operationally defined as academic learning through movement and utilized throughout this study. The direction of this review of literature will now turn towards defining science as a discipline and reviewing the literature pertaining to science competence and the value of attitude towards science content.

Science as a Discipline

Science provides a means for children to answer questions and start to understand the natural world (National Research Council, 1996). Herrenkohl, Palincsar, Dewalter, and Kawasaki (1999) explained science as an engaging and evolving discipline. Rather than focusing on what the scientific community already accepts as fact, the Council supports a learning environment that emphasizes scientific inquiry for students (National Research Council, 2000). Duschl, Schweingruber, and Shouse (2007) explained science as inquiry that engages students as they work on problems meaningful to them. These science experiences should not only occur during the weeks of one academic year but should extend and build upon each other throughout the academic life of students (Michaels, Shouse & Schweingruber, 2008). Harlen (2001) suggested scientific inquiry creates a learning environment which develops student attitudes of curiosity, open-mindedness, reflection, and sensitivity.

The three R's – reading, writing, and arithmetic – tend to monopolize the schedule of typical elementary school days. Jones, Jones, Hardin, Chapman, Yarbrough, and Davis (1999) reported school visitors would have to look hard to see science taught. While children do need to master the basics of language arts and mathematics, science should not be considered a back burner subject (Spillane, Diamond, Walker, Halverson & Jita, 2001). These researchers conducted a four year longitudinal study of elementary school leadership. Using a theoretical sampling strategy, 13 schools were chosen and placed in one of three categories based on percentage of free and reduced lunch, student demographics, change towards improving literacy, mathematics, and science instruction, and duration of change efforts. Observation, structured and semi-structured interviews, and videotape research methods were used. Data resulting from these methods supplemented survey data from the Consortium on Chicago School Research. The non-numerical unstructured data indexing, searching, and theorizing (NUDIST) qualitative coding program was used. The researchers found the personnel supporting science instruction and financial resources supporting science was three times less than that of literacy and mathematics. Further, their findings indicated teachers identified the influence of school administrators on language arts instruction twice as often as they did for science.

In order for students to demonstrate NCLB requirements, educators must go beyond transferring informational facts and instead nurture scientific thinking and reasoning (Marx & Harris, 2006). Nelson and Landel (2007) suggested that teachers with specialized skills in science work collaboratively with teams of teachers to provide such instruction. The integration of language arts and science offers students and teachers a potential alternative (Bybee & Scotter, 2007; Hapgood & Palincsar, 2007). James, Eijkelhof, Gaskell, Olson, Raizen, and Sáez (1997) presented an international case study of science integration with mathematics and technology, as well as integration between scientific fields. Of value to this review of literature is their repeated mention of integration as a method of instruction which created an authentic learning environment for students. Rather than seeing science as a collection of memorized facts, teachers need to implement strategies leading to investigative science learning (Harlen, 1997). Harlen conducted a two year, four phase study. During phase one, 514 primary teachers responded to a questionnaire about background and confidence in teaching. A confidence index was computed for each curriculum area by multiplying the percentage in each of four categories and summing the product. The teachers felt most confident teaching English and mathematics; confidence index score of 370 for both curriculum areas. Science ranked eighth of 11 subjects; confidence index score of 252. Further, teachers were more confident with biological and earth sciences and least confident with physical science; confidence index scores of 282, 284, and 234 respectively. As a subset of phase one, interviews of 57 teachers were analyzed and coded for evidence of scientific understanding and change in understanding during phase two. These teachers were presented with three "events" related to phase one survey questions. Using either equipment or photographs, the researcher would ask teachers to explain each event. On average, 36% of teachers understood events from the start and 44 % developed understanding as a result of the interview, yet 19% were unable to understand events. Phase three isolated 33 primary teachers who had no science background, low teaching confidence, and little understanding of science concepts. These teachers recorded their actual science teaching in an instructional journal and discussed their classroom work via phone interview. A series of six strategies used by low confidence teachers were discovered. These included:

1. avoidance
2. keeping to a confident topic - like biological rather physical science

3. stressing process rather than conceptual development outcomes
4. relying on the textbook
5. emphasizing direct instruction rather than questioning and discussion
6. avoiding all but the simplest practical work.

Alarmingly, the researcher discovered less confident teachers were not concerned with student understanding when evaluating their teaching success.

Kato and Van Meetern (2008) described how the constructivist theory encouraged physical science learning in early childhood classrooms by integrating content in meaningful ways. This theoretical consideration was confirmed by Kinchin's (2004) study of 349 middle school students. In his two school study, participants were asked view and identify which concept cartoon portraying conversation between teacher and pupil they would rather be a student – objectivist or constructivist - and why. Written dialogue between the cartoon teacher and student triggered conversation among the participants. As a result, 11.2% of respondents indicated they preferred objectivist learning. Boys were two times as likely to identify the environment as an easier and more secure place to learn. The remaining 88.8% of students cited the constructivist environment as more interesting, effective, and meaningful place to learn.

The integration of science and physical education has been utilized to help students link and better understand scientific principles (Buchanan et. al., 2002; Hill & Sharland, 2001; Hamrich, Richardson, Green, & Livingston, 2001). While the first two sources described practical applications for physical educators, the final citation - Sisters in Sport Science (SISS) - was a two year, ten sport program which taught elementary aged girls abstract scientific principles and mathematics naturally embedded in sport. Hamrich, Richardson, Green, and Livingston (2001) reported preliminary findings based on interviews of 20 students. Eighty percent of respondents could recall a scientific fact learned during tennis while 14 of 20 girls indicated program sessions reinforced school science instruction. These examples support statements by the National Research Council that students need to have an environment which builds, extends, and applies knowledge to help students best learn science.

Science Competence

Competence is defined as the state or quality of being competent (The American Heritage College Dictionary, 2007). Whereas NCLB has set the current standard for student competence in school subjects, a review of literature reflects an understanding of perceived competence. For example, Marsh, Craven, and Debus (1991) reported that young children perceived their own self –concept more accurately than previously thought. In their research, 501 kindergarten, first, and second grade students responded individually to the Self Description Questionaire I (SDQ-I) (Marsh, 1988). SDQ-I assesses reading, mathematics, and general school academic self concept, non-academic self concept in physical ability, physical appearance, peer and parent relationships, and general self-concept. Further, the SDQ-I was administered to 269 first and second grade students from the previous pool of participants using the group administration procedures. Separate factor analyses were conducted on responses by each age group and the total group using linear structural relations (LISREL). Multivariate and univariate ANOVAs were used to determine gender and age effects. Confirmatory factor analyses were conducted on item-pair scores. Results showed the eight factor, a priori model fit the individually administered responses better than the group administered responses. Factor correlations were larger (M = .682) for first grade responses than second grade responses (M = .425) and mean correlations were larger (M = .671) for first grade individually administered responses than second grade individually administered responses (*M* = .478). The researchers summarized that decreasing factor correlations with increasing age indicated younger children better differentiated perceived self-concept than previously theorized. Further, the effects of gender, age, and their interaction accounted for 2% of the variance in any SDQ-I scores.

Butler (2005) concurred that the ability to accurately perceive competence improved during the concrete operational period. Children begin to be able to make more truthful self-appraisals based on their school experiences. Specifically, by the end of first grade, children will be able to differentiate competence between themselves and others when specific skills are demonstrated with varying degrees of proficiency. Eccles, Wigfield, Harold, and Blumenfeld (1993) found first, second, and fourth grade students were able to demonstrate perceived competence in activities; boys perceived greater competence in math (*M* = 5.67, *SD* = 1.04) and general sports (*M* = 6.14, *SD* = 1.03) whereas girls perceived greater competence in reading (*M* = 5.81, *SD* = 1.06) and instrumental music (*M* = 5.15, *SD* = 1.43). During this four year longitudinal study, 865 first, second, and fourth graders representing 10 elementary schools in four semi-urban school districts participated. Study one and two reported findings of the second year of data collection. During study one, participants completed a likert-type questionnaire regarding their beliefs about reading, mathematics, instrumental music, and sport. Exploratory factor analyses were done on items assessing belief across the domains. Cattell's scree test selected items greater than .40 within each factor and were presented with varimax rotation. These analyses found first, second, and fourth grade children distinguished perceived competence differences between reading, mathematics, instrumental music, and sport. Likewise, confirmatory factor analyses found children's perceptions of competence across grades were differentiated. The participants and methods were the same during study two. However, a gender by grade level analyses of variance was performed. As a result of study two, the researchers determined competence perceptions decreased significantly across grades in reading, math, and instrumental music. The sport domain did not have a significant grade level effect.

Andre, Whigham, Hendrickson, and Chambers (1999) enlisted 194 kindergarten through third grade students, 243 fourth through sixth grade students, and 347 parents for their study of perceived competence of science and other school subjects. Younger students (K – 3rd grade) completed a 12 item likert-type questionnaire assessing their competence, degree of liking, and their perception of gender dominance in jobs for mathematics, reading, life sciences, and physical sciences. Older students (4th – 6th grade) completed a 102-item, 5 point scale survey assessing their competence, degree of liking, and their perception of gender dominance in jobs for mathematics, reading, life science, physical sciences, social studies, language arts, computer skills, music, art, team sports, dance/gymnastics, and social skills. In addition, students were asked how hard they believed they worked, their expected grade, and perceived importance of each subject. Using the same subjects from the older children's survey, parents completed a five attitude survey assessing parents' perception of their child's competence, parents' perception of subject matter importance, parents' perceived competence in each subject, parents' perceived daily usage of each subject, and how parents expected their child to perform in each subject. Questionnaire and survey data were collected prior to the intervention of the Family Math and Science project. Gender-by-grade level ANOVAs were done on combined data as well as gender ANOVAs for each variable to analyze results. The researchers discovered boys perceived math competence (M = 2.58) as better than their reading (M = 2.42) or physical science (M = 2.37) competence and perceived their life science (M= 2.55) and reading competence equal to or better than their physical science competence. In this same study, girls perceived reading (M = 2.62) and math (*M*= 2.63) competence better than life and physical science and perceived higher life science (*M* = 2.47) than physical science (*M* = 2.20) competence. They also found parents expected older elementary-aged boys to perform better in science ($F(1,320) = 6.17$, $p = .05$). These findings are of particular value to this study because they report student perceptions of physical science competence.

Students with a strong sense of personal competence approach in-class assignments, homework, quizzes, and tests as challenges to be mastered rather than as tasks to be avoided. Furthermore, when pupils realized effort and persistence result in competence in an academic domain, they may be willing to make similar efforts in another domain (Schunk & Pajares, 2005). While the previous findings of competence are tightly woven with student perceptions, for the purposes of this study, the researcher is interested in competence as it pertains to a measure of quantitative achievement. Thus, competence will be defined as objective ability or the capability to produce standards-based outcomes.

Attitude towards Science

Andre, Whigham, Hendrickson, and Chambers (1999) defined attitude as, "…the degree of liking or positive affect for a subject matter" (p. 724). Liking a content area implies a student finds interest in, sees value in, and enjoys learning. The Longitudinal Study of American Youth (LSAY) was a national study of middle and high school students funded by the National Science Foundation (NSF). George (2000) used latent variable growth modeling to determine change in science attitude related to student background and social psychological variables from 7^{th} to 11^{th} grades (n = 444) participating in LSAY. Exploratory factor analyses were conducted on the attitude variables using Statistical Analysis System (SAS) software and the LISREL program.

The researcher discovered three important findings. First, mean attitudes toward science declined as students aged from M_7 = 11.26, M_8 = 11.10, M_9 = 10.76, M_{10} = 10.77 to M_{11} = 10.63. Second, students indicated positive science self-concept variables ranging from 0.422 – 0.585 which can be associated with positive attitude towards science. Finally, teachers who were perceived as encouraging had students who reported positive attitude towards science.

Patrick, Mantzicopoulos, Samarapungavan, and French (2008) confirmed students' attitude towards science is directly related to the role of the teacher in the classroom. In their study, data were collected on 62 kindergarteners from one school and 48 kindergarteners from a second school experiencing integrated science activities as part of the Science Literacy Project (SLP) being conducted in a suburban public school district. SLP advocates that early scientific literacy is created through everyday interactive experiences. A professional development workshop taught the kindergarten teachers how to employ inquiry-based science activities in their classrooms. Following a pre-inquiry stage where students asked questions and made predictions about science themes, their teachers presented lessons which integrated language, math, and science skills to their children. The children, then, conducted and reported on their investigations. In addition to inquiry experiences, teachers presented informational science books to children. Prior to the intervention of inquiry-based instruction in this study, the kindergarten teachers assessed academic achievement using two subtests of the Dynamic Indicators of Basic Early Literacy Skills (DIBELS) (Good & Kaminski, 2002) while the researchers used two subtests of the Woodcock-Johnson III Tests of Achievement (WJ-III) (Woodcock, McGrew, & Mather, 2001) at mid-year. Puppet Interview Scales of Competence in and Enjoyment of Science (PISCES) (Mantzicopoulos, Patrick, & Samarapungavan, 2008) measured attitude towards science at the conclusion of the study. A cluster analysis using Ward's linkage method classified kindergarteners into three groups - high motivation, low competence but high liking, and low liking with moderate competence. Further, an adapted teacher-child relationship scale was used by researchers to measure each child's perception of their teacher during science. A MANOVA indicated the teacher-child relationships differed significantly ($F(4,204) = 2.81$, $p < .05$, partial eta squared = 0.05). A LSD post-hoc test showed children with the low liking profile reported significantly less teacher support ($M = 1.43$, $SD = 0.51$) than did children with high motivation ($M = 1.70$, $SD = 0.37$). Researchers transcribed and coded 16 videotaped science lessons from the second school's kindergarten classrooms to analyze teacher-child interactions. Children in the high motivation group averaged seven teacher interactions per science lesson compared to four interactions between the teacher and low competence students and six interactions with the low liking group. The researchers concluded the role of the teacher correlated with positive attitude towards science.

Çokador and Külçe (2008) conducted a study of 503 middle school students who completed a questionnaire consisting of fixed response questions to compile demographic and psychosocial characteristics and open-ended likert-type questions to determine science attitude. Open-ended questions had three sub-dimensions; perceptions of subject, perceptions of instruction, and perceptions of science. A comparative research method using inferential statistics analyzed data. While the researchers did not find significant change in attitude with regards to gender, they did find higher SES significantly changed perception of subject and perception of instruction with mean scores of 3.78 and 3.28 respectively. The students' perception of science mean scores (3.73) was highest while their perception of instruction had the lowest mean score (3.16) indicating the students did not favor traditional methods of teaching science. In their discussion, the authors recommended using alternative teaching methods as a way to improve student attitudes toward science. Murphy, Ambusaidi, and Beggs (2006) discovered students preferred experiments and practical work in science to "textbook" learning. In their study of 396 nine - ten year old children and 548 11 – 12 year old children (n = 944) from 45 schools, these researchers ask children to complete a three – part questionnaire. Part one was comprised of 18 attitude questions where students indicated yes, no, or not sure. Part two was compromised on 16 topic questions where students indicated like or don't like. Part three was a free-response question where students were asked what they expected future science instruction to be. Further, teachers informally discussed science with 15 males and 15 females representing 12 of the 45 schools. The researchers provided questions to explore feelings about science in and out of school as well as expected science learning in future grades. Teachers dictated and submitted student responses. Results of part one indicated younger students enjoyed solving science problems (M = 2.67) more than older students (M = 2.59) while older students indicated "science is about discovering and investigating new ideas" (M = 2.77) more than younger students (M = 2.70). In addition, girls liked science experiments (M = 2.56) more than boys (M = 2.37) whereas boys enjoyed problem solving (M = 2.65) more than girls (M = 2.56). Results of part two indicated statistically significant differences (α = 0.05% or lower) for the topics of rusting and solids, liquids, and gases for younger students and the topic of plants for older students. In addition, statistically significant gender differences (α = 0.05% or lower) existed for the topic of plants for girls and forces and friction for boys. Part three discussions revealed student preferred hands-on teaching methods. Rather than factual recall, it is student's preference to non-traditional methods of teaching science that is important to this review of literature.

Interest is also interrelated with a positive attitude toward science for elementary and middle school students. Jones, Howe, and Rua (2000) investigated the science attitudes of 437 sixth grade students. Data were collected from subtests of the Science and Scientist survey (Sjoberg, Mehta, & Mulemwa, 1995). One subtest, Out of School Experiences: What Have I Done, determined student background differences. Chi-square analyses showed boys tended to have out-of-school experiences in physical sciences while girls had out-of-school experiences with biological science. Things to Learn About, another subtest, inventoried interesting science curriculum items. Chi- square analyses showed boys were more interested in physical sciences while girls had more interest in biological sciences. Finally, the Science in Action subtest investigated attitudes and contributions of science. Frequency and chi-square analyses showed 51% of females reported science was difficult to understand. Jarvis and Pell (2005) determined different findings of interest when they conducted a repeated, longitudinal study of 293, 10 and 11 year old students from 10 classes at four schools. Quantitative data were collected to measure attitude one month prior to, three – seven days after, two months after, and four – five months after students visited the UK National Space Centre. Each student completed five attitude scales, totaling 74 statements, using a likert-type scale during each phase of data collection. A MANOVA was used to investigate significant change over time. In addition, researchers used a t-test to determine gender differences between subjects. Qualitative data were collected as students were observed in the main exhibition area, during the Centre introduction, and through staff reports of children's responses during flight simulation. Using a grounded theory approach, a sampling of students was chosen for interviews two months and four – five months after the visit. Teacher interviews were also conducted at these times. The researchers discovered a statistically significant effect on interest in space ($F = 5.09$, $p < 0.01$) as a result of the Centre visit. Moreover, the impact for girls was significantly higher ($F = 4.80$, $p < 0.01$). There was a statistically significant effect on the value of science ($F = 3.35$, $p < 0.05$) as a result of the Centre visit. Specifically, boys' mean scores remained elevated five months after the visit. Finally, as a result of the visit, the researchers determined 20% of students positively changed their interest in becoming a scientist. The pattern of change was stronger for boys, with girls having consistently lower scores.

According to Mantzicopoulos, Patrick, and Samarapungavan (2008), science content which develops competence and enjoyment, should be presented to students early in their academic careers. In their study of 113 kindergarteners from two suburban schools in the same district, teachers presented life science units through a series of 60 minute lessons. The lessons were taught twice a week and were videotaped. The kindergarteners attending the first school spent five weeks learning about living things and the life cycle of a butterfly. In the second school, kindergarteners spent four weeks learning about living things in their environment and six additional weeks learning about marine life cycles and reproduction by observing organisms in their classroom saltwater aquariums. Chi-square analyses determined there were no statistically significant differences between the schools based on pre-intervention assessments using Initial Sound Fluency (ISF) and Letter-Naming Fluency (LNF) DIBELS subtests as well as school data obtained from the state's Department of Education website. School-by-Gender MANOVA with DIBELS data indicated group ($F(2,99) = 3.93$, $p = .01$) and gender ($F(2,99) = 4.83$, $p = .02$) effects were significant though their interactions were not significant. ANOVA results indicated school 2 ($M_{\text{ISF}} = 12.85$) had significantly higher means than school one ($M_{\text{ISF}} = 9.03$). Regardless of group, girls outperformed boys on DIBELS subtests.

PISCES was created by these researchers as a way to measure young children's motivational beliefs about science. PISCES administration format begins by asking a child to choose and name one of five ethnically diverse puppets which best represents themselves. The examiner uses an ethnically identical puppet to talk about and present questions exploring likes and dislikes. The child identifies which puppet thinks the same as them. To control for order effects, negative statements made by each puppet are counterbalanced and order of presentation varied so new items are not always presented by the same puppet. The examiner recorded the child's response and any other spontaneous statements on an answer sheet. Total administration time was approximately 15 minutes.

For Mantzicopoulos, Patrick, and Samarapungavan's 2008 study, PISCES protocol was piloted post-intervention as children were asked two open-ended practice items related to science experiences before the researchers used the puppets to ask 30 dichotomous questions aimed at discovering competence beliefs. The detailed narrative responses from the PISCES practice questions of school one children provided the information necessary to create a five category coding scheme which was applied to school two verbatim-recorded student responses. Further, the researchers conducted common factor analysis with squared multiple correlations on the 30 items with promax rotation. Cluster analyses retained 17 items with factor loadings > or =.35 creating a three factor structure. Seven items loaded on factor one which was named science competence, six items loaded on factor two which was named science liking, and four items loaded on factor three which was named ease of science learning. Internal consistency for the three subscales and the full scale were computed; Cronbach's α were .79, .79, .64, and .84 respectively. The children were also assessed using the Passage Comprehension, Applied Problems, and Science Knowledge subtests of the WJ-III. Correlations between post-intervention assessments provided PISCES validity evidence. Multivariate analysis of covariance (MANCOVA) using DIBELS subscales as covariates and PISCES subscales as dependent variables revealed a small (r =.21, p<.05) but significant correlation between LNF and science competence. Further, group two children had significantly higher perceptions of science competence (M_{adj} = .91) and science liking (M_{adj} = .92) than group one children (M_{adj} = .71 and M_{adj} = .80 respectively). This final finding is all the more relevant because research shows that as students age their attitude towards science declines. Jarvis and Pell (2002) summarized that, "as, pupils get older, their enthusiasm for science falls. At the same time they find it less difficult and demanding" (p. 52). Implementing rigorous and relevant instruction may retain student interest in and liking of science.

Summary

This review of literature has demonstrated those qualities characteristic of physical activity which benefits a child's health and develops positive attitude. Opportunities for physical activity may be made available to students during structured physical education, unstructured recess, or weaved into classroom instruction through integration. Conversely, this review has shown a lack of literature regarding objective science competence and limited research pertaining to elementary-aged student's attitude towards physical science. Furthermore, the integration of physical activity with science instruction is not present in the literature.

Just as children need reading and numerical literacy, they also need to understand and be able to apply science concepts for everyday living and possess the physical skills necessary for a lifetime of movement. These observations suggest that combining opportunities for physical activity with an emphasis on increasing positive attitude towards and competence in science would lead to beneficial outcomes. Thus, the purpose of this study is to examine the effects of physical activity on science competence and the effects of physical activity on attitude towards the content of science.

Drawing on public school teaching experience with elementary school children, several hypotheses were made:

1. Children in the intervention group will demonstrate greater MVPA compared to the control group after the instructional period as measured by SOFIT.
2. Children in the physical activity intervention group and children in the control group will not differ significantly on the physical science competence pre-test.
3. Children in the physical activity intervention group will improve significantly from pre-test to post-test on the physical science competence test and will improve significantly better than the control group after the instructional period.
4. Children in the physical activity intervention group and children in the control group will not differ significantly on the modified What I Really Think of Science attitude scale pre-test.
5. Children exposed to the physical activity intervention will demonstrate positive affect from pre-test to post-test on the modified What I Really Think of Science attitude scale and will demonstrate greater positive affect than the control group after the instructional period.

Possible Limitations

Intervening variables. As much as was possible, variables like prior knowledge were controlled for by the quasi-experimental design. Adherence to a global planning schedule utilizing shared instructional resources further ensured consistent physical science instruction for the control and intervention groups.

Novelty of Treatment. The intervention of physical activity during science instruction created a unique learning environment. Participant responses to the attitude scale may have been different as a result of this novelty.

Sample size. Fifty-four of the possible 64 third grade students participated in this study. Obtaining verbal assent from four children and securing parental consent for six additional students would have created a greater sample size.

Setting. The participants receiving science instruction integrated with physical activity were taught in a classroom void of furniture other than a permanent closet, permanent counter, and two bookshelves bolted to the floors. Although the ratio of students to teacher (32:1) was greater, students experiencing the intervention of physical activity did not have to navigate around desks, tables, and chairs when moving. In classrooms two and three, the student-to-teacher ratio was 16:1. This figure was lower than the normal ratio of 23:1 and 22:1, respectively, but the children had more limited space to move as kidney-shaped tables, computer work stations, children’s personal belongings, and other miscellaneous furniture occupied square footage on the floor. These classroom obstacles could have restricted MVPA or the presentation of such activity by teachers Two or Three.

Teaching experience and style. The teaching style of the classroom teachers and researcher must be considered a possible limitation. The researcher acted as a participant in the study. The researcher was unfamiliar with the specific educational needs of many students in the study whereas the classroom teachers were very familiar with the unique learning styles of their own students. They, too, were unfamiliar with the specific requirements of third graders from another classroom. Lack of familiarity and personal style of teaching may have impacted the interactions between classroom teacher, researcher, and students in each learning environment.

Treatment assignment. Purposive assignment was utilized to determine class roles during the study. Classroom two was composed of six students from the teacher's roster and five students from classroom one. Five additional students remained in their homeroom class – classroom two - to receive science instruction though they were not members of control group because parental consent was not attained. Classroom three was composed of seven students from the teacher's roster and four students from classroom one. Five additional learners remained in their homeroom class - classroom three – to receive science instruction though they were not members of the control group because four students declined verbal assent and one student's parent did not authorize study participation. To facilitate smooth management practice, classroom teacher One and the researcher escorted 32 students to the intervention classroom. Purposive rather than random assignment could have limited the study. In addition, purposive assignment to control and intervention learning environments could have affected the novelty of the treatment.

Treatment structure. Students were not accustomed to receiving daily science instruction. Rather, their typical experience with science content was on alternating afternoons when reading, language arts, and mathematics instruction was complete. Twelve consecutive days of physical science instruction could have resulted in physical or mental tiredness.

CHAPTER III

METHODOLOGY

A review of research literature has shown that physical activity can benefit children's physical and mental health (AASA, 2007). Further, a relationship between physical activity, reading, and mathematics academic achievement has been shown (ACSM, 2006). The driving force behind this investigation was to demonstrate the possibility of integration as a possible solution to both a child's need for physical activity and instructional science minutes. The purposes of this study were to examine the effects of physical activity on science competence and to examine the effects of physical activity on attitude towards science.

Setting

Data were collected at one elementary school (PreK – 5) located in the southeastern United States. The school was selected for participation as a result of a previous professional relationship. In the academic year prior to the study, the researcher consulted the physical educators in this setting as they integrated mathematics into their existing program. The school principal recognized the necessity of establishing this relationship towards obtaining AYP in mathematics. The school successfully achieved AYP during the 2009 – 2010 school year.

This school is rural and enrolls approximately 385 students from predominantly lower socioeconomic homes. The percentage of students receiving free or reduced lunch was 94%. The school population was predominantly African American (91%) with the rest of the population consisting of Caucasian (7 %) and other (2%) children.

Participants

Human subjects approval was obtained from the Institutional Review Board (IRB) for Research Involving Human Subjects. Independent research approval was obtained from the school system Federal Programs school improvement specialist and the school system superintendent. The third grade was specifically chosen because of the cooperation of the principal and classroom teachers. From the 2009 – 2010 academic year, results of Otis-Lennon School Ability Test (Otis & Lennon, 2009) indicate this particular grade level's performance was below average with a stanine score of three. However, this same group of children achieved total reading and total mathematics scores in the middle category of the SAT - 9 with performances in the 67% and 51% respectively. This grade level included three classrooms.

Students. The researcher explained that she was a student just as they were students. Further, the researcher explained that she wanted to learn the answers to important questions about science. She explained that, just as the school had to have parent/guardian permission for them to go on a field trip, she needed the permission of two important groups of people; the students and their parent/guardian. The researcher continued the child-friendly explanation of the study by describing how permission would be obtained. The students were told they could show the researcher a "thumbs up" if they wanted to participate and a "thumbs down" if they did not want to participate. The researcher assured the children that their decision would not be taken personally but would be used to determine who would receive a parent permission form. The researcher explained that, just as they had to return a signed permission form to go on a field trip, those who had given a "thumbs up" would have to return a signed permission form to participate in the study. Four students declined verbal assent. Six parents declined to allow their child's data to be used in the study. Informed consent (See Appendix A) was obtained from the remaining third grade students (n = 54) at the school. Student data remained anonymous by coding data with numbers. During the study, no intervention student opted out of the science instruction with physical activity though procedures were in place to swap an intervention student with a control student of the same gender if necessary. The percentage of participating third grade students receiving free or reduced lunch was 94%. The percentage of participating third grade students was 94% African American with the rest of the population consisting of 6 % Caucasian and 2% other children.

Classroom Teachers. Classroom teacher One was a Caucasian female who had 27 years of teaching experience. As a career second grade teacher, this was her first year at the third grade level. Classroom teacher One assisted the researcher with management of students and equipment throughout the intervention. Classroom teacher Two was a Caucasian female who had two years of third grade teaching experience. Classroom teacher Three was an African American male who had eight years of teaching experience at the third grade level. Traditional science instruction was presented to the control learners by classroom teachers Two and Three.

Researcher. The researcher acted as a participant in the study. She had 16 years of physical education teaching experience in grades kindergarten through fifth grade as well as four and a half years of experience instructing university pre-service elementary classroom and physical education teachers. In the academic year prior to the study, the researcher consulted the physical educators in this setting as they infused mathematics into their existing physical education program with second through fifth grade students. Prior to the onset of the study, the researcher further developed rapport with the school and specifically the third grade level as a weekly volunteer in each third grade classroom during the fall semester. This role allowed the researcher to interact with parents as an office greeter, interact with school faculty and staff during principal walk-throughs and grade-level meetings, and interact with third grade students as they performed DIBELS Fresh Reads for Differentiated Test Practice, Oral Reading Fluency Progress Monitoring, and Word Use Fluency Progress Monitoring.

Duration of Study

Students in this grade level followed a traditional morning schedule of uninterrupted ELA and mathematics instruction. Learners typically received 30 minutes of afternoon science or social studies instruction on an alternating schedule. As an example, if science was taught on Monday, social studies would be taught on Tuesday. For the purposes of this study, the control students received 12, 30 minute physical science lessons as it would have been traditionally presented. The intervention students received 12, 30 minute physical science lessons integrated with physical activity. Science instruction of force, motion, work, and simple machines for both the control and intervention groups was provided on consecutive school days (See Figure 1).

Monday	Tuesday	Wednesday	Thursday	Friday
22 What I Really Think About Science Pre-Test	23 Science Unit Pre-Test	24 Thanksgiving	25 Holidays	26 -------------------

29 Day 1 Instruction Establish Learning Environment	30 Day 2 Instruction Motion	1 Day 3 Instruction Motion	2 Day 4 Instruction Force	3 Day 5 Instruction Force
6 Day 6 Instruction Waves	7 Day 7 Instruction Work	8 Day 8 Instruction Work	9 Day 9 Instruction Simple Machines	10 Day 10 Instruction Simple Machines
13 Day 11 Instruction Simple Machines	14 Day 12 Instruction Simple Machines	15 Science Unit Post-Test	16 What I Really Think About Science Post- Test	17 Celebration

Figure 1. Global Science Planning November – December 2010

Procedures

Anonymous data were gathered through a pre and post physical science competence assessment and an attitude scale. Student data remained anonymous by coding data with numbers. Further, participant confidentiality was ensured because the researcher did not discuss the results of the data collection instruments with the classroom teachers. Videotaped data were gathered for 11 consecutive school days and coded following SOFIT protocol at the conclusion of the study.

The control students, representing one half of the school's third grade population, received 12 consecutive days of science instruction as it would be traditionally presented by the classroom teachers in rooms two and three. Classroom two was composed of 11 students from the teacher's roster and five students from classroom one. The classroom demographics were predominantly African American (86%) with the rest of the population consisting of Caucasian (12%) children. Data from five students on the teacher's roster were not collected as parental consent was not secured. Classroom three was composed of 12 students from the teacher's roster and four students from classroom one. The classroom demographics were predominantly African American (94%) with the rest of the population consisting of a Caucasian (6%) child. Data from five students on the teacher's roster were not collected as a result of four children who declined verbal assent and one child whose parental consent was not secured.

Thirty-two intervention students, representing the remaining one half of the school's third grade population, received 12 consecutive days of science instruction taught by the researcher. This included 10 students from classroom one, 12 students from classroom two, and 10 students from classroom three. The intervention group demographics were predominantly African American (94%) with the rest of the population consisting of a Caucasian (3%) child and a child (3%) classified as "other." The treatment instruction integrated physical activity with science and was presented in an empty classroom on an adjoining hall of the school building.

The student textbook, teacher's edition textbook, and publishers' ancillary resources adopted by the school system were used in all classrooms. Although the content of force, motion, work, and simple machines may have been presented differently, adherence to state science standards regulated consistent, rigorous instruction.

At the conclusion of the instructional period, all students completed the same competence assessment and modified attitude scale. Any absent student completed the pre or post attitude scale or competence assessment the next school day if student assent and parent consent had been obtained. Collected data were removed from the school campus daily and transported to a secure filing cabinet in the faculty advisor's office. The confidential code list was destroyed on June 28, 2011. The videotaped files were digital files which were also destroyed on June 28, 2011. The anonymous data (competence pre and post test, attitude pre and post test, and SOFIT coding sheets) will be retained in a locked filing cabinet in the faculty advisor's office until December 13, 2013. All anonymous data will be destroyed on December 14, 2013.

Data Analysis

The purposes of this study were to examine the effects of physical activity on science competence and to examine the effects of physical activity on attitude towards science. A quasi-experimental design was used because subjects were randomly assigned to the intervention group and control groups.

Physical Activity. The independent variable for this study was physical activity. A one-way ANOVA was used to analyze physical activity data. SOFIT was utilized to measure the proportion of participant's time spent in MVPA (McKenzie, 2006) in both the control and intervention learning environments. Video cameras recorded simultaneous science instruction in three separate locations so that each of the 11, 30 minute lessons could be analyzed. Learning environments were established during the first day of the study and, therefore, were not videotaped. Throughout the study, three independent video cameras recorded lessons presented to students. The video cameras were secured to a tripod and positioned on a waist-high counter located in the right corner of each classroom. SOFIT was used to discover if there were differences in the intensity of student physical activity during each videotaped lesson. The level of physical activity for each pre-selected student was coded either 1 = lying down, 2 = sitting, 3 = standing, 4 = walking, or 5 = very active. Code level five (very active) was used when activity required expenditure of energy greater than that used during ordinary walking (McKenzie, 2006, p. 8). SOFIT protocol required the target student to be observed for a 10 second interval followed by a 10 second record interval. Student one was observed for four consecutive minutes (12 observations) before rotating to student two. Students one, two, three, and four were observed in a rotating sequence until the lesson ended. The researcher coded the events occurring on each lesson following SOFIT protocols. To determine interobserver agreement (IOA), a second observer trained in SOFIT was used. IOA reliability checks were conducted on four, 8 minute portions of science instruction (1 from each control teacher and 2 intervention lessons). A percentage of IOA was calculated using the following formula: [#agreements/ (#agreements + #disagreements)] X 100. Mean IOA agreement was 94.7%. This interobserver reliability exceeds the recommended level of 90% agreement (van der Mars, 1989, p. 71) suggested.

Competence. A pretest – posttest quasi-experimental design assessed the difference between groups as a result of physical activity. The first dependent variable was science competence. One-way ANOVA was used to analyze physical science competence data. Differences in the student's competence were measured using a modified version of the school system adopted teacher's edition chapter and unit assessment pertaining to force, motion, work, and simple machines (Bell, DiSpezio, Frank, Krockover, McLeod, ten Brink, et. al, 2006). Four matching vocabulary terms from the Chapter 15 assessment and four matching vocabulary terms from the Chapter 16 assessment were paired with eight multiple choice questions from the Unit F assessment to create a sixteen question physical science competence pre and post test assessment (See Appendix B). The researcher displayed the assessment using an overhead projector and read each assessment question. Test administration took no longer than 30 minutes. One school day prior to the onset of the study, students were asked to complete the physical science competence test.

Attitude towards Science. The second dependent variable was attitude as shown by the modified What I really think of science attitude scale. Based on attitude scales developed during the 1980's and 1990's, Pell and Jarvis (2001) designed and pilot tested an attitudinal instrument for elementary school students age five to eleven. AstraZeneca Science Teaching Trust funding allowed the authors to collect baseline data for their three-part attitude scale; Being in School, Science Experiments, and What I really think of science.

Developed as a measurement of liking school, Being in School was a 12 item likert-type scale with an overall reliability between 0.69 and 0.77. Science Experiments, the second part of the attitude scale, was created to assess feelings towards experimentation. This 10 item likert-type scale demonstrated an overall reliability between 0.68 and 0.73. What I really think of science was produced to rate feelings about science as a school subject and science in a real world application. This third part of the attitude scale was composed of 21 likert-type items where students responded by coloring in a smiley face to agree, an unhappy face to disagree, or a straight face if they were unsure. Additionally, respondents were asked to complete two open-ended qualitative statements; A good thing about science is….. and A bad thing about science is…..

This final part of the attitude scale was further divided into three sub-scales for the purposes of reporting reliability; Science Enthusiasm, Social Context, and Science as a Difficult Subject. Science Enthusiasm included item number one, five, six, thirteen, fourteen, sixteen, seventeen, and twenty-one. Administered on five separate occasions – January 1999, September 1999, January 2000, and twice in July 2000, overall reliability was reported as 0.72, 0.78, 0.78, 0.76, and 0.76 respectively. Item number two, three, eight, nine, ten, eleven, fifteen, and nineteen comprised Social Context. Again, five administrations resulted in overall reliability of 0.66, 0.71, 0.69, 0.69, and 0.70. Science as a Difficult Subject included the remaining 5 items including statements four, seven, twelve, eighteen, and twenty. Administered on five separate occasions, overall reliability was published as January 1999 = 0.65, September 1999 = 0.70, January 2000 = 0.65, July 2000(1) = 0.69, and July 2000(2) = 0.71. These three sub-scales plus the two open-ended statements were combined to form the complete What I really think of science attitude scale (See Appendix C).

For the purposes of this study, only the third part of the author's attitude scale, What I really think of science, was utilized. The permission of the author was secured to modify the British English statements of the original scale into complete American English sentences. In April 2009, this modified version of the attitude scale was pilot tested in two third grade classrooms from the researcher's previous employer. This administration was conducted to check on the wording of the sentences and to better understand the method of administration. The pilot test revealed the attitude scale should be displayed using an overhead projector, read to the participants, and would take no longer than 30 minutes to administer from beginning to end. Two school days before the study began, students were asked to complete a 21- item What I Really Think of Science attitude scale with two open-ended qualitative statements; A good thing about science is….. and A bad thing about science is….. (See Appendix D).

Following data collection, an exploratory factor analysis with principal component extraction method was conducted on the 21 items of the attitude scale with varimax rotation. In this particular study, these methods would maximize correlation between the 21 items of the attitude scale and better explain each independent factor. An initial analysis was run to obtain eigenvalues for each component in the data. Seven components had eigenvalues over Kaiser's criterion of 1 and, in combination, explained 69.96% of the variance. Further examination indicated this retained too many factors whereas plotting eigenvalues better explained the data.

Given the convergence of the scree plot, three components were retained for the final analysis (See Figure 2).

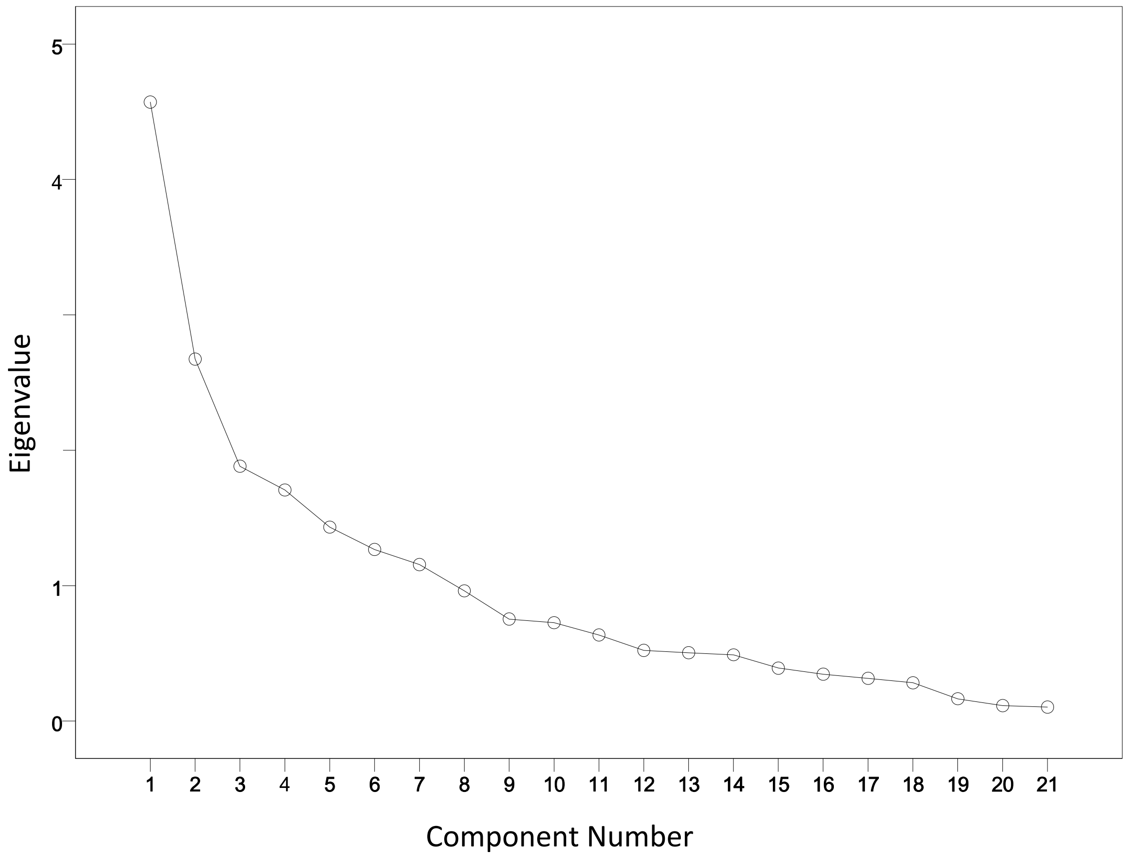

Figure 2. Scree Plot

The three retained components (15 items) combined to explain 43.47% of the variance. Table 1 shows the factor loadings after rotation.

Table 1
Summary of Analysis Results for What I Really Think of Science

Item	Context of a Difficult Subject	Enthusiasm	Social Context
Science can make chemicals we need from rocks.	.832		
Science has made us better and safer medicines.	.671		

Science makes me think.	.654		
You have to be clever to do science.	.605		
I would like to be given a science kit as a present.	.414		
I like to watch science programs on TV.		.875	
I am always reading science stories		.689	
I would like to be a scientist.		.633	
I often do science experiments at home.		.529	
One day, I would like to go to the moon.		.421	
Our food is safer thanks to science.		.359	
Science is good for everybody.			.832
TV, telephones, and radio have all needed science.			.618
I think more money should be spent on science.			.488
I like science more than any other school work.			.403
Internal consistency Cronbach's α	.703	.740	.620

Factor 1 was renamed Context of a Difficult Subject and included the first five table items.

Factor 2 was renamed Enthusiasm and included the next six table items.

Factor 3 was renamed Science Context and included the final four table items.

Originally, students responded to likert-type items by coloring in faces; ☺ to agree, ☹ to disagree, or a 😐 if they were unsure. Faces were subsequently transformed to numerical values for the purposes of analysis. A smiley face was converted to a numerical value of 3, a straight face was converted to a numerical value of 2, and an unhappy face was converted to a numerical value of 1. Gelin, Beasley, and Zumbo (2003) confirmed the validity of a three point scale in exploratory factor analysis by explaining, "…it is debatable whether children can distinguish between 5 to 9 levels of agreement." (p. 22). The neighboring method was used to determine the value of four pre- and six post- statements which were not answered by participants.

The What I Really Think of Science attitude scale concluded with two open-ended qualitative statements. Students were asked to complete the sentence, "A good thing about science is….." To code each student's written answer, the researcher re-wrote a legible response word-for-word with its anonymous coding number. A student's written response that was unlike a previous answer became a new entry with its unidentifiable coding number. A duplicated response was indicated by a tally mark and the corresponding coding number. Four illegible or unanswered sentences occurred during the pre-test. This coding process was replicated to account for each student's response to the incomplete sentence, "A bad thing about science is….." Again, four illegible or unanswered sentences occurred during the pre-test.

Post-test, the same coding process was replicated for student responses to the What I Really Think of Science incomplete qualitative sentence, "A good thing about science is….." The researcher copied a legible answer word-for-word with its anonymous coding number. A student's written reply that did not match a preceding response became another listing with its unidentifiable coding number. A repeated answer was indicated by a tally mark and the corresponding coding number. Ten illegible or unanswered responses occurred after the instructional period. To complete the coding and account for each student's response to the incomplete sentence, "A bad thing about science is….." the process was replicated once more. Seven illegible or unanswered responses occurred during the post-test.

A series of one-way ANOVAs and a one-way MANOVA were used to analyze the pretest and posttest attitude data. All data analysis was conducted using Statistical Package for Social Sciences (SPSS) statistical software, version 19.

CHAPTER IV

RESULTS

The purposes of this study were to examine the effects of physical activity on science competence and to examine the effects of physical activity on attitude towards science. Prior to the onset of this study, the following hypotheses were made:

1. Children in the intervention group will demonstrate greater MVPA compared to the control group after the instructional period as measured by SOFIT.
2. Children in the physical activity intervention group and children in the control group will not differ significantly on the physical science competence pre-test.
3. Children in the physical activity intervention group will improve significantly from pre-test to post-test on the physical science competence test and will improve significantly better than the control group after the instructional period.
4. Children in the physical activity intervention group and children in the control group will not differ significantly on the modified What I Really Think of Science attitude scale pre-test.
5. Children exposed to the physical activity intervention will demonstrate positive affect from pre-test to post-test on the modified What I Really Think of Science attitude scale and will demonstrate greater positive affect than the control group after the instructional period.

A presentation and analysis of each hypothesis is given below. A detailed discussion interpreting these results in terms of the research questions for this study are presented in Chapter 5.

Physical Activity

Figure 3 shows the MVPA mean scores for the control and intervention groups.

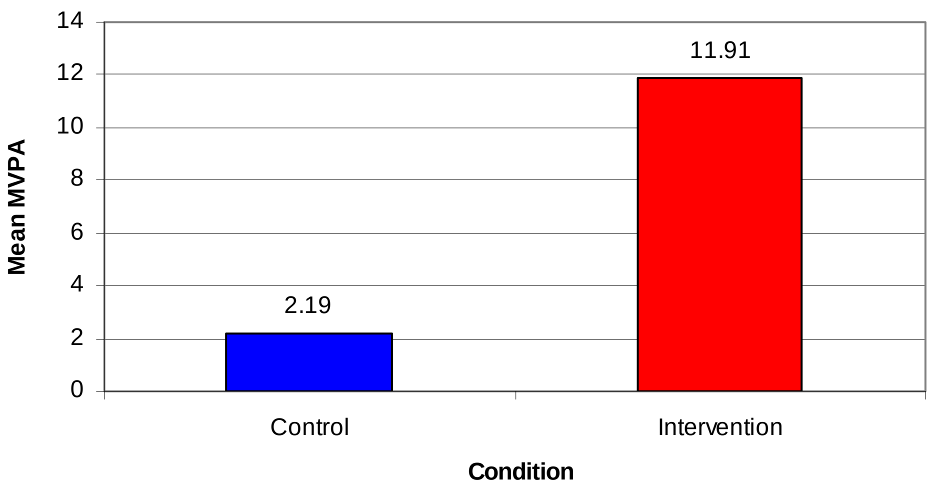

Figure 3. Mean Scores of Moderate-to-Vigorous Physical Activity (MVPA)

On average, intervention participants experienced greater MVPA (*M* = 11.91, *SD* = 4.48) than control participants (*M* = 2.19, *SD* = 2.48). This difference was statistically significant ($F(1,30) = 63.10$, $p = .001$), with partial eta squared = .68 demonstrating a large effect size. This finding supports the hypothesis that children in the intervention group would demonstrate greater MVPA compared to the control group after the instructional period.

Physical Science Competence

Figure 4 shows the competence mean scores for the control and intervention groups pre- and post-intervention.

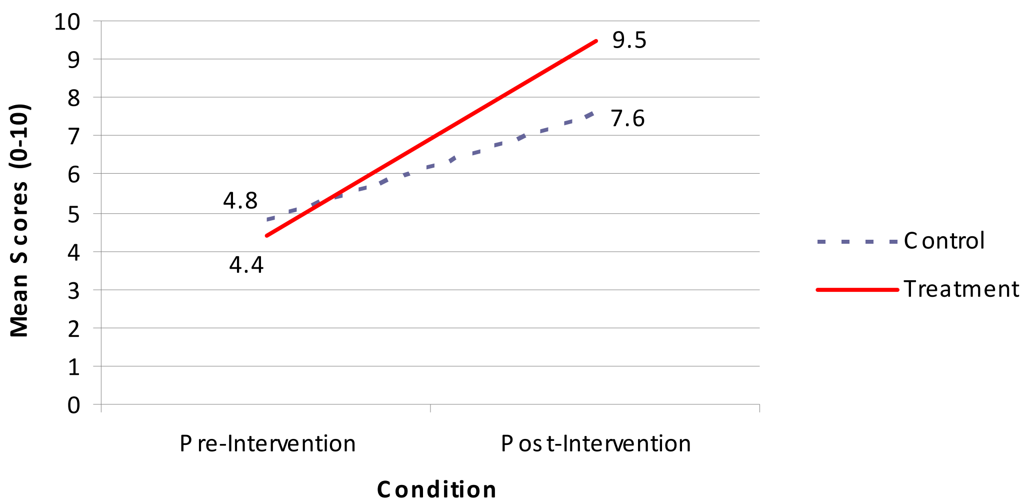

Figure 4. Mean Score of Physical Science Competence

Summary statistics for physical science competence showed the intervention group (n = 31) averaged 4.4 points (*SD* = 2.3) on the cognitive pre-assessment with a post-assessment average of 9.5 points (*SD* = 4.3). The control group (n = 22) averaged 4.8 points (*SD* = 1.7) on the cognitive pre-assessment with a post-assessment average of 7.6 points (*SD* = 3.3). On average, intervention participants post – pre competence increased ($M = 5.1$, $SD = 3.56$) which was greater than control participants ($M = 2.86$, $SD = 3.51$).

Pre-test, Levene's test showed that the variance was equal between the intervention and control groups, $p = 0.282$. Further, there was no difference between the intervention and control groups' physical science pre-test, ($F(1,51) = 0.523$, $p = 0.473$). This finding supports the hypothesis that children in the physical activity intervention group and children in the control group would not differ significantly on the physical science competence pre-test.

Post-test, Levene's test showed that the equal variance assumption could be assumed, p = 0.935. Further, there was a statistically significant difference between the intervention and control groups' competence post-test, ($F(1,51) = 5.119$, $p = .028$), with a moderate to large effect size (partial eta squared = .091). This finding supports the hypothesis that children in the physical activity intervention group improved significantly from pre-test to post-test on the physical science competence test and improved significantly better than the control group after the instructional period.

Attitude towards Science

Exploratory factor analysis of What I Really Think of Science revealed three retained components which included a total of 15 attitude scale items. Figure 5 shows the first factor mean scores for the control and intervention groups pre- and post-intervention.

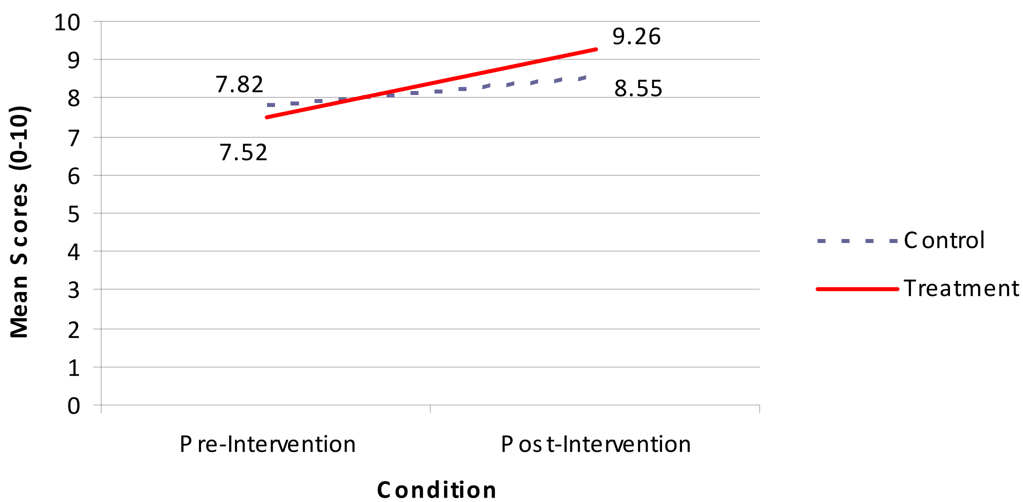

Figure 5. Mean Scores for Context of a Difficult Subject

Factor one was renamed Context of a Difficult Subject and included five items with a possible total point range from five to fifteen for each item. Summary statistics for science in the Context of a Difficult Subject showed the intervention group (n = 31) averaged 7.52 points (*SD* = 2.01) on each attitude pre-assessment item with a post-assessment average of 9.26 points (*SD* = 2.61) per item. The control group (n = 22) averaged 7.82 points (*SD* = 2.61) on each attitude pre-assessment item with a post-assessment average of 8.55 (*SD* = 2.81) per item.

Context of a Difficult Subject factor loading retained the following items: (1) Science can make chemicals we need from rocks. (2) Science has made us better and safer medicines. (3) Science makes me think. (4) You have to be clever to do science. (5) I would like to be given a science kit as a present. Results indicate the percentage of disagreement on all five items increased for the intervention group following the instructional period. Conversely, the percentage of agreement on all five items decreased for the intervention group following the intervention. Likewise, the results indicate the percentage of disagreement on all five items increased for the control group following the instructional period. The percentage of agreement on items one, three, and four decreased for the control group whereas responses increased on items two and five following the intervention. Table 2 shows the number of individual responses for both intervention and control students and the resulting percentage for each factor item.

Table 2. Context of a Difficult Subject Factor

	Intervention						Control					
	Pre			Post			Pre			Post		
Item	D	U	A	D	U	A	D	U	A	D	U	A
1	13% (4)	48% (15)	39% (12)	32% (10)	35% (11)	32% (10)	14% (3)	36% (8)	50% (11)	23% (5)	36% (8)	41% (9)
2	10% (3)	35% (11)	55% (17)	29% (9)	19% (6)	52% (16)	9% (2)	50% (11)	41% (9)	18% (4)	27% (6)	55% (12)
3	6% (2)	13% (4)	81% (25)	19% (6)	19% (6)	61% (19)	5% (1)	23% (5)	73% (16)	9% (2)	32% (7)	59% (13)
4	6% (2)	19% (6)	74% (23)	29% (9)	16% (5)	55% (17)	9% (2)	14% (3)	77% (17)	18% (4)	23% (5)	59% (13)
5	19% (6)	26% (8)	55% (17)	42% (13)	32% (10)	26% (8)	27% (6)	32% (7)	41% (9)	45% (10)	9% (2)	45% (10)

Note. D = Disagree U = Unsure A = Agree
Item text:

1) Science can make chemicals we need from rocks.
2) Science has made us better and safer medicines.
3) Science makes me think.
4) You have to be clever to do science.
5) I would like to be given a science kit as a present.

( ) = number of student responses.
The intervention percentage is based on (n = 31). The control percentage is based on (n = 22).

Figure 6 shows the second factor mean scores for the control and intervention groups pre- and post-intervention.

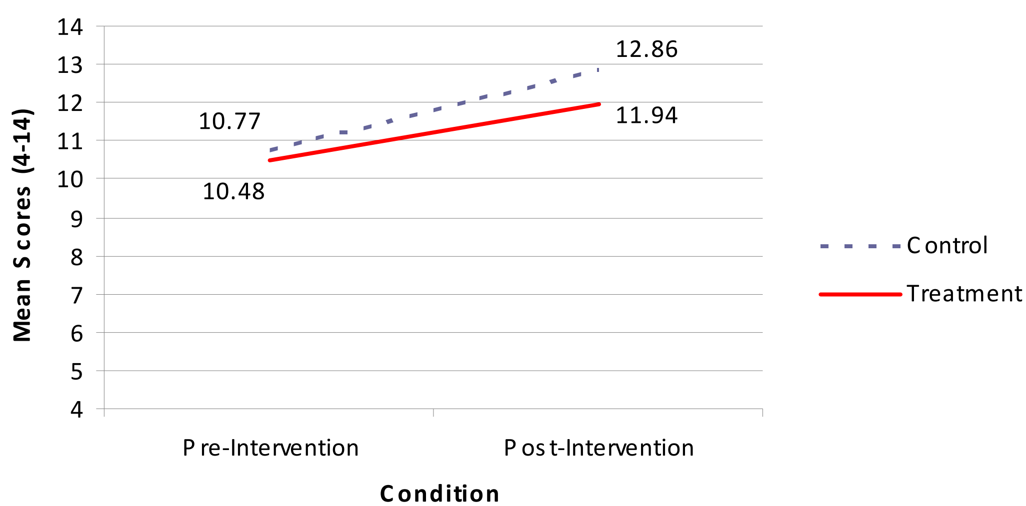

Figure 6. Mean Scores of Enthusiasm

Factor two was renamed Enthusiasm and included six items with a possible total point range from five to fifteen for each item. Summary statistics for Enthusiasm showed the intervention group (n = 31) averaged 10.48 points (*SD* = 3.38) on each attitude pre-assessment item with a post-assessment average of 11.94 (*SD* = 3.71) per item. The control group (n = 22) averaged 10.77 points (*SD* = 3.50) on each attitude pre-assessment item with a post-assessment average of 12.86 points (*SD* = 3.51) per item.

Enthusiasm factor loading retained the following items: (1) I like to watch science programs on TV. (2) I am always reading science stories. (3) I would like to be a scientist. (4) I often do science experiments at home. (5) One day, I would like to go to the moon. (6) Our food is safer thanks to science. Results indicate the percentage of disagreement on items one, two, three, five, and six increased for the intervention group following the instructional period. Conversely, the percentage of agreement on these same items decreased for the intervention group following the instructional period. Intervention responses to the fourth item were reversed; an increase of 9% disagreement and a decrease of 9% agreement following the intervention. Results indicate the percentage of disagreement on all six items increased for the control group following the instructional period whereas the percentage of agreement on all six items decreased for the control group following the instructional period. Table 3 shows the number of individual responses for both intervention and control students and the resulting percentage for each factor item.

Table 3. Enthusiasm Factor

Item	Intervention						Control					
	Pre			Post			Pre			Post		
	D	U	A	D	U	A	D	U	A	D	U	A
1	29% (9)	10% (3)	61% (19)	52% (16)	10% (3)	39% (12)	45% (10)	9% (2)	45% (10)	64% (14)	9% (2)	27% (6)
2	29% (9)	19% (6)	52% (16)	35% (11)	29% (9)	35% (11)	32% (7)	9% (2)	59% (13)	64% (14)	14% (3)	23% (5)
3	19% (6)	19% (6)	61% (19)	39% (12)	23% (7)	39% (12)	23% (5)	18% (4)	59% (13)	32% (7)	18% (4)	50% (11)
4	48% (15)	26% (8)	26% (8)	39% (12)	26% (8)	35% (11)	41% (9)	23% (5)	36% (8)	50% (11)	18% (4)	32% (7)
5	26% (8)	10% (3)	65% (20)	39% (12)	16% (5)	45% (14)	23% (5)	9% (2)	68% (15)	27% (6)	14% (3)	59% (13)
6	16% (5)	29% (9)	55% (17)	26% (8)	35% (11)	39% (12)	14% (3)	41% (9)	45% (10)	59% (13)	18% (4)	23% (5)

Note. D = Disagree U = Unsure A = Agree
Item text:
1) I like to watch science programs on TV.
2) I am always reading science stories.
3) I would like to be a scientist.
4) I often do science experiments at home.
5) One day, I would like to go to the moon.
6) Our food is safer thanks to science.

( ) = number of student responses.
The intervention percentage is based on (n = 31). The control percentage is based on (n = 22).

Figure 7 shows the third factor mean scores for the control and intervention groups pre- and post-intervention.

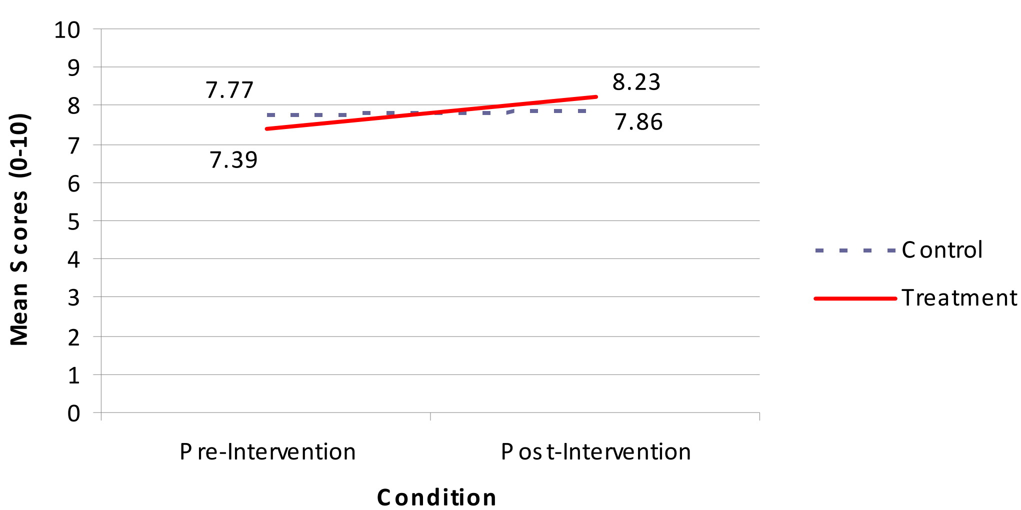

Figure 7. Mean Scores of Science Context

Factor three was renamed Science Context and included four items with a possible total point range from five to fifteen for each item. Summary statistics for Science Context showed the intervention group (n = 31) averaged 7.39 points (*SD* = 2.01) on each attitude pre-assessment item with a post-assessment average of 8.23 points (*SD* = 1.99). The control group (n = 22) averaged 7.77 points (*SD* = 2.35) on each attitude pre-assessment item with a post-assessment average of 7.86 points (*SD* = 2.44).

Science Context factor loading retained the following items: (1) Science is good for everybody. (2) TV, telephones, and radio have all needed science. (3) I think more money should be spent on science. (4) I like science more than any other school subject. Results indicate the percentage of disagreement on all four items increased for the intervention group following the instructional period. Conversely, the percentage of agreement on all four items decreased for the intervention group following the instructional period. Results indicate the percentage of disagreement on the first, second, and third items increased for the control group whereas the fourth item decreased following the instructional period. The percentage of agreement on items one and three decreased for the control group whereas responses increased on items two and four following the instructional period. Table 4 shows the number of individual responses for both intervention and control students and the resulting percentage for each factor item.

Table 4. Science Context Factor

	Intervention						Control					
	Pre			Post			Pre			Post		
Item	D	U	A	D	U	A	D	U	A	D	U	A
1	13% (4)	29% (9)	58% (18)	16% (5)	35% (11)	48% (15)	9% (2)	27% (6)	64% (14)	14% (3)	41% (9)	45% (10)
2	19% (6)	52% (16)	29% (9)	26% (8)	55% (17)	19% (6)	23% (5)	50% (11)	27% (6)	36% (8)	27% (6)	36% (8)
3	45% (14)	23% (7)	32% (10)	48% (15)	39% (12)	13% (4)	36% (8)	36% (8)	27% (6)	64% (14)	14% (3)	23% (5)
4	32% (10)	16% (5)	52% (16)	48% (15)	19% (6)	32% (10)	50% (11)	27% (6)	23% (5)	32% (7)	18% (4)	50% (11)

Note. D = Disagree U = Unsure A = Agree
Item text:
1) Science is good for everybody.
2) TV, telephones, and radio have all needed science.
3) I think more money should be spent on science.
4) I like science more than any other school work.
( ) = number of student responses.
The intervention percentage is based on (n = 31). The control percentage is based on (n = 22).

Overall results indicate the percentage of disagreement on each factor of What I Really Think of Science increased for the intervention group following the instructional period. Specifically, there was an eight percent increase on the total results. Conversely, overall results indicate the percentage of agreement on each factor decreased for the intervention group. There was a 15% decrease on the total results. Likewise, overall results indicate the percentage of disagreement on each factor of What I Really Think of Science increased for the control group following the instructional period. Specifically, there was a 13% increase on the total results. The percentage of agreement on factors one and two decreased for the control group whereas the percentage of agreement increased on factor three following the instructional period. There was a 7% decrease on the total results. Table 5 shows the overall attitude factor results for both intervention and control students and the resulting percentage for each factor.

Table 5. Overall Attitude Factor Results

	Intervention						Control					
	Pre			Post			Pre			Post		
Factor	D	U	A	D	U	A	D	U	A	D	U	A
1	11% (17)	28% (44)	61% (94)	30% (47)	25% (38)	45% (70)	13% (14)	31% (34)	56% (62)	23% (25)	25% (28)	52% (57)
2	28% (52)	19% (35)	53% (99)	38% (71)	23% (43)	39% (72)	30% (39)	18% (24)	52% (69)	49% (65)	15% (20)	36% (47)
3	27% (34)	30% (37)	43% (53)	35% (43)	37% (46)	28% (35)	30% (26)	35% (31)	35% (31)	36% (32)	25% (22)	39% (34)
Total	27% (103)	25% (116)	53% (246)	35% (161)	27% (127)	38% (177)	24% (79)	27% (89)	49% (162)	37% (122)	21% (70)	42% (138)

Note. D = Disagree U = Unsure A = Agree
Factor text:
1) Context of a Difficult Subject
2) Enthusiasm
3) Science Context

( ) = number of student responses.
The intervention percentage is based on (n = 31). The control percentage is based on (n = 22).

Pre-test, Levene's test showed that the variance was equal between the intervention and control groups, $p = 0.107$. Further, there was no difference between the intervention and control groups attitude towards science pre-test, ($F(1,51) = 0.314$, $p = 0.578$). This finding supports the hypothesis that children in the physical activity intervention group and children in the control group would not differ significantly on the modified What I Really Think of Science attitude scale pre-test.

Post-test, Levene's test showed that the equal variance assumption could be assumed, $p = 0.267$. Yet, there was no statistically significant difference between the intervention and control groups post-test, ($F(1,51) = .375$, $p = .543$). This finding does not support the hypothesis that children exposed to the physical activity intervention demonstrated positive affect from pre-test to post-test on the modified What I Really Think of Science attitude scale. Likewise, this finding does not support the hypothesis that children exposed to the physical activity intervention demonstrated greater positive affect than the control group after the instructional period.

To further explore attitude towards science, the post – pre differences between the attitude factors of Context of a Difficult Subject, Enthusiasm, and Science Context were investigated using a one-way MANOVA. Rather than using three ANOVAs, a one-way MANOVA improved the likelihood of discovering significant attitude differences related to physical activity. Box's M test showed that the equality of variance - co-variance matrices could be assumed, $p = 0.377$. Wilks' Lambda = .91, ($F(3, 49) = 1.594$, $p = .203$) indicated there was no statistical difference in factors between the intervention and control groups.

What I Really Think of Science attitude scale concluded with two open-ended qualitative statements. Students were asked to complete the sentence, "A good thing about science is….." In addition, students were asked to complete the sentence, "A bad thing about science is….." Table 6 presents a comprehensive list of qualitative responses when participants were asked to complete the sentence, "A good thing about science is…..." 21 (10 intervention and 11 control) third graders indicated learning was a pre-study benefit. Post-study responses to the same qualitative statement found 16 (seven intervention and nine control) students, including 21% of the same respondents, continued to believe a good thing about science was learning. In addition, nine (six intervention and three control) children identified "fun" as a good thing about post-study science.

Table 7 presents a comprehensive list of qualitative responses when participants were asked to complete the sentence, "A bad thing about science is….." Six (three intervention and three control) third graders indicated nothing was a pre-study transgression. Post-study responses to the same qualitative statement found 10 (five intervention and five control) students, including 40% of the same respondents, continued to believe nothing was wrong with science.

Table 6
A Good Thing About Science Is…

Student Responses	Intervention		Control	
	Pre	Post	Pre	Post
Learning	40% (10)	28% (7)	50% (11)	41% (9)
Experiments	12% (3)	8% (2)	4.5% (1)	14% (3)
Looking up words	4% (1)	--	4.5% (1)	4.5% (1)
Helping make things better	8% (2)	12% (3)	--	--
Reading	8% (2)	--	--	--
It is cool	4% (1)	--	4.5% (1)	--
It is easy	8% (2)	--	--	--
You need to think hard	--	--	9% (2)	--
We don't do a lot of work	--	--	4.5% (1)	--
Activities	--	--	4.5% (1)	--
Fun	--	24% (6)	4.5% (1)	14% (3)
Making something	4% (1)	--	--	--
My parents know about it	4% (1)	--	--	--
Nothing	4% (1)	8% (2)	--	4.5% (1)
Pictures	4% (1)	--	--	--
Plants	--	--	4.5% (1)	--
The lesson	--	--	4.5% (1)	--
Things can be true	--	--	4.5% (1)	--
We get to do it everyday	--	8% (2)	--	--
Doing stuff you don't do at home	--	--	--	4.5% (1)
I like it	--	4% (1)	--	--
It doesn't cost to do it at home	--	4% (1)	--	--
Listening	--	--	--	4.5% (1)
Not writing	--	--	--	4.5% (1)
They teach us	--	--	--	4.5% (1)
We don't do nothing wrong	--	--	--	4.5% (1)
Writing	--	4% (1)	--	--
Total	100% (25)	100% (25)	100% (22)	100% (22)

Note. ( ) = number of student responses. The percentage has been determined by dividing the number of responses by the total number of responses to the prompt. -- (double dash) = represents an unmatched response.

Table 7
A Bad Thing About Science Is…

Student Responses	Intervention		Control	
	Pre	Post	Pre	Post
Nothing	16% (3)	22% (5)	14% (3)	23% (5)
Danger	11% (2)	8.7% (2)	14% (3)	4.5% (1)
The work	5% (1)	22% (5)	14% (3)	14% (3)
I don't like it	11% (2)	4.3% (1)	--	--
You don't write to much	16% (3)	4.3% (1)	--	--
You need to listen	5% (1)	4.3% (1)	9% (2)	4.5% (1)
We do a lot of it	5% (1)	--	9% (2)	4.5% (1)
A mistake	5% (1)	4.3% (1)	4.5% (1)	9% (2)
Not following directions	5% (1)	--	4.5% (1)	--
Bad grades	5% (1)	--	4.5% (1)	--
Getting mad	--	--	4.5% (1)	--
It is hard to become a scientist	5% (1)	--	--	--
It is long	--	--	4.5% (1)	--
Looking up words	5% (1)	--	--	--
Not sure	5% (1)	4.3% (1)	--	--
Reading	--	4.3% (1)	4.5% (1)	9% (2)
They play	--	--	9% (2)	--
We don't do that much work	--	--	4.5% (1)	--
It is hard to learn	--	4.3% (1)	--	--
Not helping	--	--	--	4.5% (1)
Not learning	--	--	--	4.5% (1)
People don't like it	--	--	--	4.5% (1)
Thinking of a good idea	--	4.3% (1)	--	--
We do it everyday	--	--	--	4.5% (1)
We don't do it at home	--	4.3% (1)	--	--
We don't do it that much	--	--	--	4.5% (1)
We don't have fun	--	4.3% (1)	--	4.5% (1)
You do not do bad stuff	--	4.3% (1)	--	--
You don't know it	--	--	--	4.5% (1)
Total	100% (19)	100% (23)	100% (22)	100% (22)

Note. ( ) = number of student responses. The percentage has been determined by dividing the number of responses by the total number of responses to the prompt. -- (double dash) = represents an unmatched response.

Summary

In conclusion, the analyzed data revealed three major findings. First, the results of this study found children in the intervention group demonstrated greater MVPA compared to the control group after the instructional period. Second, with regards to physical science competence, the results found intervention and control groups did not differ significantly on the physical science competence pre-test but that children in the physical activity intervention group improved significantly from pre-test to post-test on the physical science competence test and improved significantly better than the control group after the instructional period. Finally, the results of this study found attitude towards science for the intervention and control groups did not differ significantly prior to or following physical science instruction with the intervention of physical activity.

CHAPTER V

DISCUSSION

The purposes of this study were to examine the effect of physical activity on science competence and to examine the effect of physical activity on student attitude towards science. Three classes of third grade students learned about force, motion, work, and simple machines. Two groups received science instruction in a traditional classroom setting. The other group received science instruction integrated with physical activity. Data were gathered pre and post study to determine the difference in science competence and attitude towards science. In addition, videotaped data were collected to ascertain the amount of MVPA during science instruction. The following hypotheses were proposed: (1) children in the intervention group would demonstrate greater MVPA compared to the control group after the instructional period as measured by SOFIT, (2) children in the physical activity intervention group and children in the control group would not differ significantly on the physical science competence pre-test, (3) children in the physical activity intervention group would improve significantly from pre-test to post-test on the physical science competence test and would improve significantly better than the control group after the instructional period, (4) children in the physical activity intervention group and children in the control group would not differ significantly on the What I Really Think of Science attitude scale pre-test, and (5) children exposed to the physical activity intervention would demonstrate positive affect from pre-test to post-test on the What I Really Think of Science attitude scale and would demonstrate greater positive affect than the control group after the instructional period.

This chapter offers discussion of the results of the study in terms of the developed hypotheses and the existing literature. Data pertaining to the hypotheses are reviewed and discussed. In addition, the contributing link between these new research findings and the literature is addressed. The limitations and implications for further research are presented at the conclusion of the chapter.

Summary Results

The results of this study showed intervention participants averaged greater time moving with moderate-to-vigorous physical intensity ($M = 11.91$, SD= 4.48) than control participants ($M = 2.19$, SD = 2.48) during the physical science instructional period. This difference was statistically significant ($F(1,30) = 63.10$, $p = .001$), with partial eta squared = .68 demonstrating a large effect size. This result supports the researcher’s first hypothesis.

While the intervention and control groups did not differ significantly on the physical science pre-test ($F(1,51) = 0.523$, $p = 0.473$), the finding of this research indicates intervention students demonstrated an average gain of five points on physical science competence related to force, motion, work, and simple machines whereas the gain for control students was half that average after the instructional period (see Figure 4). There was a statistically significant difference between the intervention and control groups post-test, ($F(1,51) = 5.119$, $p = .028$), with a moderate to large effect size (partial eta squared = .091). This final result supports the third hypothesis that children in the physical activity intervention group improved significantly better on the physical science competence test than the control group after the instructional period. Further, these findings support previous conclusions that academic achievement is not hindered but is improved by opportunities for physical activity (DuBose et al, 2008; Mahar, Murphy, Rowe, Golden, Shields, & Raedke, 2006; Stevens, To, Stevenson, & Lochbaum, 2008).

Sallis et al (1999) suggested academic performance was maintained or even enhanced by physical activity. In that study, physical activity was taught by trained specialists and classroom teachers. The intervention of physical activity was presented by the researcher through integrated science instruction in this study. The competence results of this research support the value of integration as an instructional approach (Gilver, 2003; Westerhold, 2000) because it not only increased the accumulated daily minutes of MVPA for children but also successfully presented science content. Douville, Pugalee, and Wallace (2003) suggested integration helped students make relevant curricular connections. Making meaning through kinesthetic learning was a result of this study and a connecting avenue in educating the whole child as discussed by Hamrich, Richardson, Green, & Livingston (2001).

Intervention and control group attitude towards science did not differ significantly prior to the instructional period on the likert-type sentences of the What I Really Think of Science attitude scale ($F(1,51) = 0.314$, $p = 0.578$). This finding supports the fourth hypothesis. The final hypothesis that children exposed to the physical activity intervention would demonstrate positive affect from pre-test to post-test on the What I Really Think of Science attitude scale and would demonstrate greater positive affect than the control group after the instructional period was not supported by this research. Quantitatively, there was no statistically significant difference between the intervention and control groups post-test, ($F(1,51) = .375$, $p = .543$). However, after the instructional period, 24 % of the intervention group and 14% of the control group identified a good thing about science was, “fun” after the instructional period. This qualitative post test result supports Andre, Whigham, Hendrickson, and Chambers (1999) definition of attitude and previous research findings (Jones, Howe, & Rua, 2000; Kinchin 2004).

Significance of the Results

Corbin and Pangrazi (1998, 2004) recommended children should participate in at least 60 minutes of physical activity most days of the week so that their bodies were not inactive for a period greater than two hours during the day. Students in this study followed a traditional morning schedule of uninterrupted English/language arts and mathematics instruction prior to 40 minutes of daily physical education instruction. They received 30 minutes of afternoon science instruction on alternating school days. Unfortunately, these students did not have scheduled recess. Ahamed, Macdonald, Reed, Naylor, Liu-Ambrose, and McKay (2007) found that additional minutes of classroom physical activity can enhance and complement the existing physical education program without compromising academic achievement. In this study, the children in the intervention group received 12, 30 minute physical science lessons integrated with movement on consecutive school days averaging three and one-half additional minutes of MVPA daily. For example, intervention students experienced force as they pushed and pulled themselves on scooters, demonstrated motion while galloping, skipping, and sliding to change positions, and learned about the function of a class three lever as they passed an object to a partner with a foam-tipped hockey stick.

During the instructional period of this study, the children in the control group also received 12, 30 minute physical science lessons on consecutive school days. Yet, those students averaged 40 additional seconds of MVPA daily. Classroom teacher Three maintained a traditional classroom environment where students' moderate physical activity was a result of walking to retrieve instructional materials or to travel to and from science trade book reading groups. While classroom teacher Two also maintained a traditional classroom environment, her students demonstrated greater moderate physical activity as they participated in various hands-on experiments and trivia review games which required walking in the classroom. These results carry great significance to educators as the intervention of integrated movement not only contributed precious minutes of activity towards Corbin and Pangrazi's suggested 60 minute standard but, more importantly, the integration of science content rendered valuable minutes of health-enhancing physical activity without compromising science competence.

Although considerably stretched, these classroom teachers have the resources available to plan and present more vigorously active science lessons similar to those presented by the researcher to the intervention students in this study. Likewise, the physical educators previously integrated mathematics concepts in a school-wide effort to successful achieve AYP. They, too, have an equipment room full of resources which could be used to plan and present science-enriched physical education lessons.

Although a few physical activity studies (Coe, Pivarnik, Womack, Reeves, & Malina, 2006; ACSM 2006) have explored the effect of physical activity on academic achievement, little empirical data exists in the literature explaining how science competence has been affected. The current study showed that student's physical science competence as it pertained to force, motion, work, and simple machines rather than performance on standardized tests, as found by Sallis et al (1999) and NASPE (2002), could be positively affected.

Previously, research involving attitude towards science had been conducted to explore the role of the teacher (George, 2000), examine instructional approach (Jarvis & Pell, 2002), or investigate the role of parents (Jarvis & Pell, 2005; Jones, Howe, & Rua, 2000). This study determined there were no statistically significant differences between the attitude factors of context of a difficult subject, enthusiasm, or science context for either the intervention or control groups. However, the small sample size in this study did not offer the researcher adequate power to detect differences. These third graders elevated agreement towards likert-type statements prior to the instructional period could have been limited by their previous experiences on alternating school days when instructional time away from ELA and mathematics was available (Marx & Harris, 2006). When the participants were asked to complete the sentence, "A bad thing about science is….." post-test, 22% of the intervention group and 23% of the control group specified, "nothing" was bad indicating a 6% and 9% increase respectively. These qualitative results might suggest these third graders appreciated the opportunity to learn about force, work, motion, and simple machines through daily science instruction.

Limitations of the Study

There are several elements of this study that limit the generalizability of the findings. Readers should consider the following limitations that may have impacted the internal and external validity of these results when attempting to apply these findings across other populations and learning situations.

While the classroom teachers were familiar with the state course of study, science content, and adopted science textbook and ancillary materials, the researcher was not a content expert. The researcher had not taught an entire science unit but did have previous experience integrating traditional classroom content with movement including science concepts. Therefore, she had to gain specific physical science knowledge through self study. Planning and preparation issues such as instructional pacing and developing appropriate science lesson plans challenged the researcher whereas previous teaching experience aided presentation of engaging content and classroom management.

The sample size of this particular study is another limiting factor. Fifty-three of the possible 64 third grade students participated in this study. Obtaining verbal assent from four children, securing parental consent for six additional students, and retaining one participant lost to in-school suspension would have created a greater sample size.

This study was conducted during the fifteen school days between Thanksgiving and Christmas on the academic calendar (see Table 1). Numerous seasonal events distracted the student's attention from academic learning. Timing is imperative to successful teaching and the excitement of the season did not make this the best time to be conducting an empirical study.

Technical problems limited the study. The video cameras were secured to a tripod and positioned on a waist-high counter located in the right corner of each classroom. While this arrangement was identical in all three classrooms, the angle of the camera lens did not permit full classroom coverage. Those students who were unable to participate in the study could be positioned so that they were not recorded but were present for science instruction in classrooms two and three. However, when children moved throughout intervention or control classrooms, physical activity could not be completely captured continuously.

Finally, utilizing a modified version of the "What I really think of science" attitude scale may have limited student responses in this particular setting. The original attitude scale was found to be reliable with elementary school students age five to eleven in Great Britain. However, the results of this study might imply the need to not only alter British English statements to complete American English statements but to create a scale more specific to the grade level and/or unit of instruction.

Implications and Future Research

There are several implications of the research findings in this study. Researchers and educators should consider the previously mentioned limitations and items discussed below when implementing the methodology of this particular study across other populations or learning situations.

Future researchers should consider other science instruction which could be enhanced by physical activity. During an informal planning period discussion on December 2nd, the third grade teachers and I chatted about the direct connections the physical science content of force, motion, work, and simple machines had with physical activity. For example, participants understood light and strong force as it applied to moving a ball. Although anatomical levers had not been identified previously, the physical movement of various body parts helped students comprehend the relationship of various simple machines within their body. This discovery implies other third grade content standards like life science instruction of habitats or earth science instruction pertaining to natural resources would be more challenging to teach through physical activity but, nonetheless, should be attempted.

Previous physical education studies focused on the effect of physical activity on language arts (Tremarche, Robinson, & Graham, 2007) and mathematics (NASPE, 2002) standardized test scores. Pre and post study assessment of physical science competence in this study demonstrates the potential for classroom teachers to integrate physical activity into future science instruction. Likewise, social studies instruction integrated with physical activity should be considered as another opportunity for students to be active learners.

In order to more accurately examine the potential of physical activity's effect on positive change in attitude towards science, further research needs to explore physical activity integrated with more consistent and rigorous science instruction. A consistent pattern of increased disagreement and decreased agreement on attitude responses from pre to post study (see Tables 2, 3, 4, and 5) by intervention and control groups might reflect the novelty of 30 minutes of daily science instruction for all students and/or the originality of integrating physical activity with science learning for the intervention group. To further explore change in attitude towards science, researchers need to conduct a study which reflects an alternating schedule of afternoon instruction for one unit of study or investigate change in attitude across multiple units of study.

Conclusion

At a time when children are inundated with the screens of multi-media technology and schools are pressured to meet the rigorous standards of federal legislation, it seems like a missed opportunity if educators do not continue to explore the contribution of integrated learning as a way to help children achieve academically and physically. This study provides evidence that it is the reciprocal responsibility of classroom teachers to integrate physical activity as it is the obligation of physical educators to integrate academic content towards developing a "whole child" (ASCD, 2009). Hopefully, additional science integration research will bring classroom teachers and physical educators closer together in an effort to help students achieve. The results of this study demonstrate integrating physical activity with physical science is one way educators can work collaboratively to teach the whole child. The mission of education is to enhance academic learning. Rigorous, standards-based science instruction was the foundation of this study. Students were able to make meaning of physical science content and demonstrate their comprehension of its relevance. This study offers evidence that physical activity can not only contribute to the health of children but to the success of competent learners.

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APPENDICES

APPENDIX A

INFORMED CONSENT

INFORMED CONSENT
FOR RESEARCH STUDY ENTITLED
The Effect of Physical Activity on Science Competence and
Attitude toward Science Content

Your child is invited, along with his/her classmates, to participate in a study at Eastside Elementary School. The study is designed to examine the effect of physical activity on learning and liking science. This study is being conducted by Ann Klinkenborg under the supervision of Dr. Sheri Brock and Dr. Peter Hastie of the Department of Kinesiology at Auburn University.

While Ms. Klinkenborg is not your child's classroom teacher, Eastside Elementary School students have been invited to participate in this study because they are familiar with Ms. Klinkenborg. The school was selected for participation because of the cooperation of the teachers and principal.

If you allow your child to participate, data will be collected during videotaped classroom instruction. They will complete a written pre-assessment and attitude scale before science instruction is given. They will complete the same written assessment and attitude scale after learning about force, motion, work, and machines. Please know your child will continue to receive classroom instruction meeting the high standards of the Chambers County School District. Your child may or may not have the addition of physical activity to their classroom instruction.

There are no risks or discomforts associated with participation in this study. Reasonable benefits to participation will include an opportunity to be physically active, learn science content, and like the content of science. We can not promise that your child will receive any or all of the benefits described.

Any information obtained in connection with this study and that can be identified with your child will remain confidential. Data will be kept confidential by the use of student numbers. Competence, attitude, and physical activity information collected through your child's participation may be used for publication in a professional journal and/or presented at a professional meeting. If so, no identifiable information will be included. Confidential data will be retained and destroyed according to Institutional Review Board policy. Your decision to participate is voluntary and your child may withdraw from participation in this study at any time, without penalty. Your decision whether or not to allow your child to participate will not jeopardize your future relations with Auburn University or Eastside Elementary School.

If you have any questions, we invite you ask them now. If you have questions later, please contact Ann Klinkenborg @ 706 569 – 2699 (klinkam@auburn.edu) or Dr. Sheri Brock @ 334 844 – 1464 (brocksj@auburn.edu) and we will be happy to answer them.

Page 1 of 2 Parent/Guardian's Initials ______

You will be provided a copy of this form to keep.

For more information regarding your child's rights as a research participant, you may contact the Auburn University Institutional Review Board for Research Involving Human Subjects by phone 334 844 – 5966 or e-mail hsubjec@auburn.edu .

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE WHETHER OR NOT YOU WISH TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO PARTICIPATE.

______________________________	______________________________
Parent's Signature Date	Investigator's Signature Date
	Ann Klinkenborg
______________________________	______________________________
Print Name	Print Name
	______________________________
	Co - Investigator's Signature Date
	Sheri J. Brock
	______________________________
	Print Name

APPENDIX B

COMPETENCE TEST

Name ______________________ Date ______________________

Vocabulary

Match each item in column B with its meaning in Column A.

	Column A	Column B
_____	1. Force that pulls two objects toward each other	A. fulcrum
_____	2. The fixed point on a lever	B. force
_____	3. Change in position	C. lever
_____	4. Using force to move an object	D. gravity
_____	5. Distance an object moves in a certain period of time	E. simple machine
_____	6. A bar that turns on a fixed point	F. speed
_____	7. Any kind of push or pull	G. work
_____	8. A machine that needs only one force to make it work	H. motion

Write the letter of the best choice.

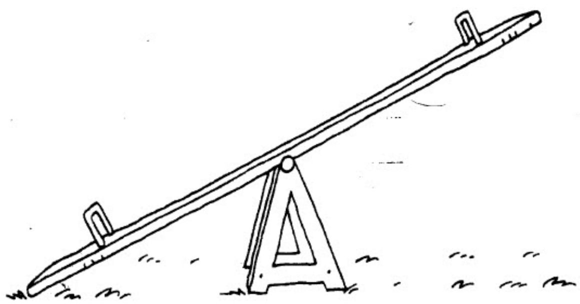
_____ 9. Two tug-of-war teams are pulling in opposite directions on a rope. The rope does not move. Why?

A. There are no forces acting on the rope.
B. The net force is zero.
C. The rope has too much mass.
D. Gravity is too strong.

_____10. Why does the same force move a baseball farther than a bowling ball?

F. The baseball is softer.
G. The baseball has a rougher surface.
H. The baseball has less volume.
J. The baseball has less mass.

______11. What type of simple machine is a seesaw?



A. lever
B. pulley
C. wheel-and-axle
D. all of the above

______12. A dog pushes a bone across the floor. The bone moves to the left. In which direction did the dog probably push the bone?

F. right
G. left
H. down
J. up

______13. Which simple machine would best help movers put boxes in the back of a tall truck?

A. inclined plane
B. screw
C. wedge
D. wheel-and-axle

______14. Which statement about force is false?

F. Forces always start objects moving.
G. A moving object will keep moving until a force stops it.
H. The stronger the force, the greater the change in motion.
J. An object moves in the direction of the force pushing or pulling it.

______15. What is the main purpose of a machine?

A. to change the speed of an object
B. to change the way work is done
C. to turn an object
D. to eliminate work

______16. Tyrese pulls a chair across the floor. Which two things would he need to measure to find the amount of work he has done?

F. distance and time
G. time and wavelength
H. time and force
J. force and distance

APPENDIX C

ORIGINAL ATTITUDE SCALE

What I really think of science

Here are some views about science and its place in the world.

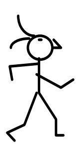
Do you agree disagree or are you not sure ?

			Agree	Not sure	Disagree
1.	I should like to be a scientist	1			
2.	Science is good for everybody	2			
3.	Lots more money should be spent on science	3			
4.	You have to be clever to do science	4			
5.	I like science more than any other school work	5			
6.	I often do science experiments at home	6			
7.	Science is just too difficult	7			
8.	It is easy to find out new things in science lessons	8			
9.	Science has made us better and safer medicines	9			
10.	TV, telephones and radio have all needed science	10			
11.	Our food is safer thanks to science	11			
12.	We have to do too much work in science	12			

Just a few more ....on you go ....

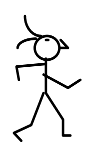
			Agree	Not sure	Disagree
13.	I like to watch science programmes on TV	13			
14.	School science clubs are a good idea	14			
15.	Science makes me think	15			
16.	I am always reading science stories	16			
17.	I should like to be given a science kit as a present	17			
18.	We do too much science at school	18			
19.	Science can make chemicals we need from rocks	19			
20.	We have to do too much writing in science	20			
21.	One day, I should like to go to the Moon	21			

Fill in the boxes, if you can, before Science Runner passes..

....  ....

A good thing about science
....
A bad thing about science
....

Did you answer every one ? You did ? Then, you have finished !

Science Runner says Thank you very much ☺ and good luck ! .... 

APPENDIX D

MODIFIED ATTITUDE SCALE

What I Really Think of Science

Here are some views about science and its place in the world.

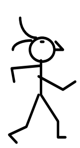
Do you agree ☺ disagree ☹ or are you not sure 😐 ?

			Agree	Not sure	Disagree
1.	I would like to be a scientist.	1	☺	😐	☹
2.	Science is good for everybody.	2	☺	😐	☹
3.	I think more money should be spent on science.	3	☺	😐	☹
4.	You have to be clever to do science.	4	☺	😐	☹
5.	I like science more than any other school work.	5	☺	😐	☹
6.	I often do science experiments at home.	6	☺	😐	☹
7.	Science is difficult.	7	☺	😐	☹
8.	It is easy to find out new things in science lessons.	8	☺	😐	☹
9.	Science has made us better and safer medicines.	9	☺	😐	☹
10.	TV, telephones, and radio have all needed science.	10	☺	😐	☹
11.	Our food is safer thanks to science.	11	☺	😐	☹
12.	We have to do too much work in science.	12	☺	😐	☹

Just a few more ....on you go ....

			Agree	Not sure	Disagree
13.	I like to watch science programs on TV.	13	☺	😐	☹
14.	School science clubs are a good idea.	14	☺	😐	☹
15.	Science makes me think.	15	☺	😐	☹
16.	I am always reading science stories.	16	☺	😐	☹
17.	I would like to be given a science kit as a present.	17	☺	😐	☹
18.	We do too much science at school.	18	☺	😐	☹
19.	Science can make chemicals we need from rocks.	19	☺	😐	☹
20.	We have to do too much writing in science.	20	☺	😐	☹
21.	One day, I would like to go to the Moon.	21	☺	😐	☹

Fill in the boxes, if you can, before Science Runner passes.

....  ....

A good thing about science is ....
A bad thing about science is ....

Did you answer every one? You did? Then, you have finished!

Science Runner says Thank you very much ☺ and good luck ! ....