

THE EFFECTS OF KINESTHETIC ACTIVITY ON  
SECONDARY SCIENCE STUDENT ACHIEVEMENT

by

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## ABSTRACT

The importance of physical activity in the classroom has been debated for decades. In this study, eleventh and twelfth grade suburban science classes were encouraged to conduct simple exercises at the beginning of class. While the overall performance, attitudes, retention of concepts and confidence of students showed no improvement, the data indicated that their in-class energy levels were more positively affected.

## INTRODUCTION AND BACKGROUND

### Project Background

I have been teaching at Cheyenne Mountain High School in Colorado Springs, Colorado for the past four years. The racial composition of the student body was 78% Caucasian, 12% Hispanic, 5% Asian, 2% African American, and less than 1% each of Native Americans and Pacific Islanders (Cheyenne Mountain High School: Did You Know?, 2011). While the Hispanic population was the second largest at Cheyenne Mountain, most of the students had advanced proficiency in English and few received extra ESL services. The students represented southern suburban Colorado Springs' socio-economic population with 11% that qualified for the free and reduced lunch program.

The 11<sup>th</sup> and 12<sup>th</sup> grade astronomy science class has been designed as a science elective for students needing a science credit, but lack the skills or prerequisites for general science classes such as chemistry and physics. As a result, the majority of students in my classes tended to be low-motivation and uninterested in science in general. For many students, the last science class they have taken before mine is freshman Introductory Physical Science and possibly sophomore Animal Biology. The curriculum was made to teach Colorado Model Content Standards including physical, life, and earth science standards. Every science was touched on in astronomy class as it brought in important aspects such as chemical compositions, nuclear reactions, possibilities for extra-terrestrial life, optics, electromagnetic spectrum, planetary geology and the laws of motion and gravity. The class was designed to be mostly inquiry-based with group

projects and individual labs. The remaining small part of the class focused on college preparation through note taking and lectures. At least once a unit, I showed videos and other visuals to demonstrate difficult astronomical concepts.

Every year, I saw students with little interest in science come into my class showing minimal motivation and confidence. They would typically skim through the minimum requirements of the class and demonstrate little higher order application of astronomy concepts at the end of the year. More often than not, they would quickly forget concepts that were covered just a week before. Overall, I saw students that had low energy and enthusiasm come into my class. Regardless of the time of day, I saw students nodding off, not participating in class discussions, and sleeping during videos. Since all of these aspects of the class were vital to student understanding of complex concepts, I wanted to find a way to help increase student alertness, confidence, and concept retention in hopes of improving overall student achievement in my class.

In this study, I researched the effects of simple physical activity on secondary student learning. Using physical activity in education has been termed kinesthetic activity, and has been used to improve learning in students for the past 50 years (Dennison & Dennison, 1994). Even in my own educational experiences, I realized that it was easier for me to recall information if I had assigned a physical motion to it. My mind remembers the information faster if it is engrained in my body or muscle memory.

I was curious to see if simple physical activities could positively impact my own students' learning and retention of concepts. I thought about getting them up and out of their chairs, moving and stretching their whole body for five short minutes before class. I

wanted to see if I could improve their memories and enthusiasm as well. Perhaps simple physical activity was the ticket.

### Focus Question

Many of the students in my astronomy classes had difficulty with motivation, confidence, and enthusiasm. As a result, many of these students struggled to succeed in my class. I was constantly experimenting with ways to increase students' attitudes, confidence and learning in science. My observations lead to the primary focus question of the study: **What impact does kinesthetic activity have on overall student achievement?** As aspects of this question, I investigated several sub questions, including the effects of physical movement on students' ability to retain concepts, attitude towards learning, energy levels, and effects on my own teaching.

### CONCEPTUAL FRAMEWORK

Dr. Paul Dennison, along with his wife Gail, developed the Brain Gym® program in the early 1980s to help facilitate whole brain learning through simple physical activity. The idea behind their work is forcing connections between the right and left centers in the brain in order to improve memory and coordination (Dennison & Dennison, 1996). This in turn automatically increases learning and reduces stress for learners of all ages. According to the Brain Gym® website ([www.braingym.org](http://www.braingym.org)), it re-establishes connections between the mind and body which can help anyone learn new skills easily

and more efficiently. Amazingly, they claim that it does not matter what the skill is nor does it matter how old the participant is. I aimed to improve student learning in my classroom, and it would have been wonderful if I could do so with simple daily exercises. I was interested to see if the reduced stress and increased mental preparedness that the program claims would help me create a better learning environment for my students. I hoped to test Dr. Dennison's ideas by using his Brain Gym® program to stimulate learning in the students in my own classroom.

Back in the 1960's, Paul Dennison was a public school teacher and reading specialist. He became interested in finding more effective ways to help students, particularly those with learning disabilities. At the time, he worked alongside Dr. Constance Amsden with the Malabar Reading Project. Their focus was investigating the growth of individual sensory perceptions in reading (auditory, visual, and tactile skills). Later, in 1975, Paul Dennison was granted a Doctorate in Education from the University of Southern California. That same year, he was awarded the Phi Delta Kappa award for Outstanding Research for his work in beginning reading achievement and its relationship to thinking skills and cognitive development. His research showed the effects of movement on learning and he developed various quick and simple exercises. In the 1980's, Paul Dennison, with the help of Gail Dennison, began marketing his brain-based learning program as Brain Gym® (Official Brain Gym Website, accessed November 13, 2011).

From previous literature, Carla Hannaford claimed that a person's body is very much a part of learning and that learning is not simply a "brain" activity. A healthy body would help encourage healthy brain activity, including learning (Hannaford, 2005).

Going all the way back to Maslow's Hierarchy of Needs, it seems logical that a person would not be able to focus on learning if their basic physiological needs are not met first (Maslow, 1943). Hannaford said, "We are all natural learners, born with a remarkable mind/body system equipped with all the elements necessary for learning. Various stressors, however, can introduce blocks that inhibit the learning process" (Hannaford, 2005, p. 109). If a person is unable to meet the needs of their body such as water, food, and exercise, then their mind would be preoccupied and would naturally be unable to absorb new information. Although my students were nearly adults (ages 16-18), I was not sure that many of them take good care of their bodies. I was unable to influence their health choices outside of school, but perhaps if I could encourage them to get up and moving in my classroom, then maybe I could positively influence how their brains were able to learn.

In my undergraduate classes, we were introduced to Howard Gardner's Theory of Multiple Intelligences. In 1983, he published *Frames of Mind*, which discussed how each person has a combination of eight possible intelligences, one of which happens to be bodily-kinesthetic. Although not every person has this type of intelligence as their strongest attribute, many of us could benefit from an educational curriculum that includes physical activity in conjunction with other teaching methods. Based on this idea, incorporating bodily-kinesthetic activities, as well as the traditional pen-to-paper methods (which tap into spatial and linguistic intelligences), should activate most students' learning centers. Gardner mentioned the possible effect of removing physical activity from schools, such as eliminating recess at the elementary level or removing physical education classes from the secondary level. He stated, "If physical education is cut from

our school, one eighth of human intelligences are eliminated” (Gardner, 1983, p. 223). If the mind/body connection is so strong, removing the opportunity for students to engage in physical fitness may also impact their mental fitness. Hannaford (1995) agreed with Gardner when she wrote, “Arts and athletics are not frills. They constitute powerful ways of thinking, and skilled ways of communicating with the world. They deserve a greater, not lesser portion of school time and budgets,” (p.88). I wanted to test the idea that improving physical exercise would also improve academic performance.

I was also interested in how Brain Gym® claims to reduce the stress in learners. People, including students, experience stress on a daily basis. Typically, once the stressor is removed, the body returns to its relaxed state. Templeton and Jensen (1996) described how this “on-off stress” can be healthy, however prolonged stress has been shown to have negative effects on the body by causing nervous cell damage in the hippocampus (or the “memory” part of the brain) which is crucial for learning. They also went on to describe how long-term stress weakens the immune system which can increase illnesses which in turn increases school absences and reduces the amount of time in which a student is actively learning. They said, “Brain Gym® activities reduce the blockages caused by stress and allow the body to function in an optimal state of learning and self-control” (Templeton & Jensen, 1996, p. 8). If Brain Gym® reduces the chronic stress in students, even if just for my class, then I believe that it would be well worth trying. This year alone, I have attended three separate meetings for student’s whose overwhelming absences are negatively affecting their grades. At each meeting, the student mentioned how hard (and stressful) it is to come back after their prolonged absence. They mentioned how they felt unprepared and that would in turn make them feel overwhelmed and

sometimes even ill. My hope was that Brain Gym® exercises would help ease my student's stress and help prepare them for a productive day of learning.

After reading an article by Spaulding, Mostert, and Beam (2010), I used their critical analysis of 4 research-based studies to help me design a research study that would hold up to their Essential Quality Indicators. These indicators fell into five categories: describing participants, implementation of the intervention and description of comparison conditions, outcome measures, data analysis, validity and reliability (pp. 24-25).

The first category, describing the participants, included a broad range of aspects, most of which do not necessarily apply to my students. Examples are proper diagnosis of each participant's disabilities, comparable relevant characteristics across all participants and teachers. The majority of my students were without learning disabilities, and I was the only teacher implementing the treatment. Both of these facts made these quality indicators irrelevant to my study. As for the third indicator, comparing relevant characteristics across all participants, my study was limited in that I only had access to the students that choose to take my classes. In order to access participants with comparable or even identical characteristics, I would have needed to spend time and money on hand-selecting participants for my study. As a schoolteacher with limited time and money, this simply was not an option.

The second category of quality indicators, implementation of the intervention and description of comparison conditions, also contained several aspects. These include clearly describing and specifying the treatment, as well as describing and assessing that the treatment was identical and reliable across different conditions. My study fit these quality indicators well. I have set aside a full day during the semester to describe my

study, basic Brain Gym® exercises and possible benefits to my students. I also have described it in following sections so that any educator can repeat my treatments. I have worked hard to do the same exercises for the same duration in each of my classes during the treatment phase.

The third category of quality indicators, outcome measures, contained various aspects. It included triangulation of data and the timing of measurements. In my study, I was careful to use a variety of data collection instruments to gain a broad perspective of my questions. I have also chosen to give the assessments and instruments at key times during the research cycle. Usually, instruments were completed in the beginning, middle and end of each step in the cycle. This helps to build a timeline of events and effects.

The fourth category of quality indicators looked for proper data analysis. This included analyzing the data so that it was appropriately assessing the key research questions. Also, it stated that the report included effect size calculations in addition to inferential statistics. My study fit these indicators. The data collection instruments were designed to measure differences that help to answer the key research questions. This made it simple to directly answer the research questions through analysis. Also, I measured of the strength of the relationships between the physical activities and my target research areas as well as drew conclusions from data that were affected by observational errors.

The final category simply listed desirable quality indicators in a research study. Many of these indicators aligned with my research, whereas some were impossible for me to include with the time that I was allowed. Examples of indicators that fit my research include data on attrition rates, valid data collection instruments, qualitative

measurements of the treatment, and presenting my results in a clear and coherent fashion. Quality indicators that my study did not have were double-blindness among the investigator and the participants, measurements of long-term effects, and including videotape observations. There are several reasons why my study failed to include these quality indicators. First, I was the only investigator as well as the only teacher in the study and therefore could not be blind to the participants. Secondly, I was limited in my time with the students and therefore could not measure long-term effects without extending my time frame. Finally, I could not include videotape observations because my district did not allow me to. Apparently, there were many legal avenues that I must have gone through to obtain permission to videotape my students in the classroom. This process takes several months to complete, and I did not have the time to obtain the required permission before beginning this study.

The only way that I would be able to meet all of the Essential Quality Indicators described was to 1) continue my research over the course of many years and 2) recruit many other teachers at my school/district to also conduct the research. This may have been too much to undertake for this particular study since it is an Action Research project.

Reading through the Essential Quality Indicators has led me to believe that I also needed to add additional data collection strategies such as field notes. I also needed to make sure that the treatments were comparable across different classes, meaning that I needed to keep a close record of each class period throughout the day. To achieve that, I used daily observation journals that described what happened each day in each class. What occurred in third period (mid-morning) was not comparable to what occurred

seventh period (mid-afternoon). Before I began the study I researched and tested various data collection techniques for the quality indicators of those methods. This was all part of establishing a baseline for comparison.

Not all of the literature that I found was in support of Brain Gym® activities as a way to improve student learning. Keith Hyatt wrote an article in 2007 addressing the drawbacks of brain-based learning research. He claimed that he was only able to find 5 resources cited by Dr. Dennison in the Brain Gym® texts that were research based, but instead were based on theory. Hyatt stated, “Although efficient connections among various parts of the brain may foster cognitive development, none of the Brain Gym® literature has provided research based, scientific evidence supporting this view of brain functioning,” (p. 118). He went on to add, “None of the Brain Gym® movements that supposedly facilitate academic learning actually include academic instruction as a component; rather, it seems that the purpose of the movements is to get the child ready to learn,” (p. 118). Finding an article that was contrary to the others that I have found intrigued me. Although I did not address the problems that Hyatt mentioned directly in his article, I did test the overall effectiveness of Brain Gym® activities on student performance.

In other countries, researchers have published information claiming that Brain Gym® and other commercial brain-based learning packages are ineffective when used in actual school settings. In the United Kingdom, two organizations published information packets warning teachers and schools about false-claims that are not supported by peer reviewed research. The popular science debunking website Sense about Science contained an article concerning Brain Gym®. It stated, “These exercises are being taught

with pseudoscientific explanations that undermine science teaching and mislead children about how their bodies work. [...] There have been a few peer reviewed scientific studies into the methods of Brain Gym®, but none of them found a significant improvement in general academic skills,” (p. 2). The Economical and Social Research Council’s Teaching and Learning Research Program mentioned that, “the pseudo-scientific terms that are used to explain how this works, let alone the concepts they express, are unrecognizable within the domain of neuroscience,” (p. 15). In an attempt to effectively communicate with educators of all grade levels, Brain Gym® created its own terms and phrases that do not agree with neuroscience vocabulary.

Regardless of apparent effectiveness of brain-based learning programs such as Brain Gym®, the good news was that researchers and educators agreed that links between neurology and education could benefit future learners. However, finding a “one size fits all” program remains elusive. Usha Goswami (2006) pointed out that two lessons could be learned from recent trends seen in neuroscience and education. First, teachers were very eager to use neuroscience to facilitate effective education of students. Secondly, neuroscientists were not well equipped to teach their craft to educators as communication rarely lines up among the groups. Regardless of if the brain-based learning packages such as Brain Gym® are immediately effective, these programs are on the right track for the future of education.

Finally, to get a complete perspective, during my research I also looked at articles describing Brain Gym® studies done with different age groups. The Brain Gym® website claims that the activities work for learners of all ages, from kindergarten all the way up to adults. One of these articles was a master’s thesis written by Valerie Pfeffer

(2009) about the effects of Brain Gym® on her kindergarten students. She found that there was no significant difference in her student's ability to retain sight words, although their focus during instruction was greatly improved (pp. 14-15). I have been unable to find articles describing studies done with older teenagers particularly, and I am eager to contribute to this previously unexplored area of research.

## METHODOLOGY

To conduct this research, the semester was divided into two equal segments of about six weeks each. For the first two weeks of the semester, no treatments were done in order to determine a "baseline" of measure. I taught my classes the way that I normally do to get to know the students. Also during this time, I sent home consent forms that were signed by both the students and the parents. If students chose not to be participants in the study, they were welcome to join in on the activities in the future, but my data analysis did not focus on those individuals.

At the beginning of the second two weeks, I started to train my students on the basics of Brain Gym®. I introduced them to the four movements of PACE (Positive, Action, Clear, and Energize) and explained to them the purpose of each exercise. The PACE activities were actually done in reverse (ECAP), starting with the "E" and moving on as each exercise prepares the learner for the next. Part of the Brain Gym® philosophy is that by making connections between the left and the right hemispheres of the brain, the student have better access to the learning centers in their own minds. Doing an activity that requires crossing one side of the body with the other side can activate this

connection, called the midline. For example, drawing a picture once with your right hand and then again with your left excites areas of the brain that may otherwise be stagnant. By awakening different centers, new connections are made between neurons, and learning new skills can become easier. Most of the Brain Gym® activities involve crossing different parts of the body.

The first exercise in PACE was designed to energize the body and mind. More of a necessity than an exercise, the students were encouraged to sip fresh water. Instead of gulping mass amounts of it, students were taught to hold each small sip in their mouth for a moment before swallowing. In addition to hydrating the students, sipping water helps the brain perform better (Hannaford, 2005, p. 145). As an electrical device, the brain requires water, the universal solvent, to conduct electrical transmissions that help us sense, think, and learn. Students were encouraged to stop by the water fountain on the way to class or to carry a water bottle with them throughout the day.

The second exercise in PACE was intended to calm the mind and body to get it ready for making midline connections. The activity was called “Brain Buttons” and was shown to increase blood flow to the brain. To do the exercise, take one hand and place it on the sternum. Place the index finger and thumb underneath the collarbone, one on either side of the sternum. The other hand is openly placed on the navel. Cross the legs at the ankle (Figure 1a). With the hand on the chest, gently massage the “brain buttons” while calmly taking deep breaths. After a minute or so, switch hands and cross the other leg. Repeat for another minute or so.

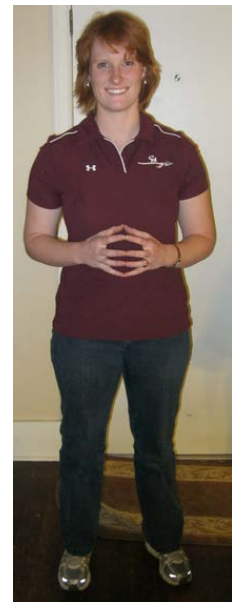
The third exercise in PACE was meant to increase overall balance and coordination while forcing connections in the midline. Called the “Cross Crawl,” it also

increased blood flow as it got the muscles of the lower and upper body moving in tempo. While sitting or standing, touch the elbow of one arm to the knee of the opposite leg. Hold for a moment and then repeat with the opposite arm and leg (Figure 1b). Continue alternating between sides for a minute or two.

The final exercise in PACE was a two part activity that was designed to calm the mind, as well as focus and organize scattered attention. Called “Hook Ups,” this exercise has two parts and can be done while sitting or standing.

Step 1: Extend your arms straight out in front of you. Cross the wrists and interlock your fingers. Fold your arms under and bring your fingers up to your chest. Cross your ankles (Figure 1c). As you inhale, press the tip of your tongue to the hard palate of your mouth, directly behind the teeth. Breathe deeply and hold for a minute or so. When you are ready, unfold your arms and uncross your legs.

Step 2: Put your fingertips together in front of your chest and continue to take deep breaths. When you inhale, press your tongue to the roof of your mouth. Hold for minute.



*Figure 1a. Brain Buttons.*

*Figure 1b. Cross Crawl.*

*Figure 1c. Hook Ups.*

Step 1 & Step 2.

After the students learned the habit of doing PACE, the entire routine took only about five minutes from the usual 50-minute class period. Students would come in to class and once the bell rings, the class would stand up and perform the exercises for five minutes. Afterwards, the students would sit down and the lesson on astronomy would begin. If the program did indeed help the students learn better, then the five minute sacrifice would make up for itself in the long run.

Finally, during the last two weeks we returned to the baseline. The class went back to normal and observations were made. When or if the students did the exercises on their own accord, they were asked about their decision later during interviews.

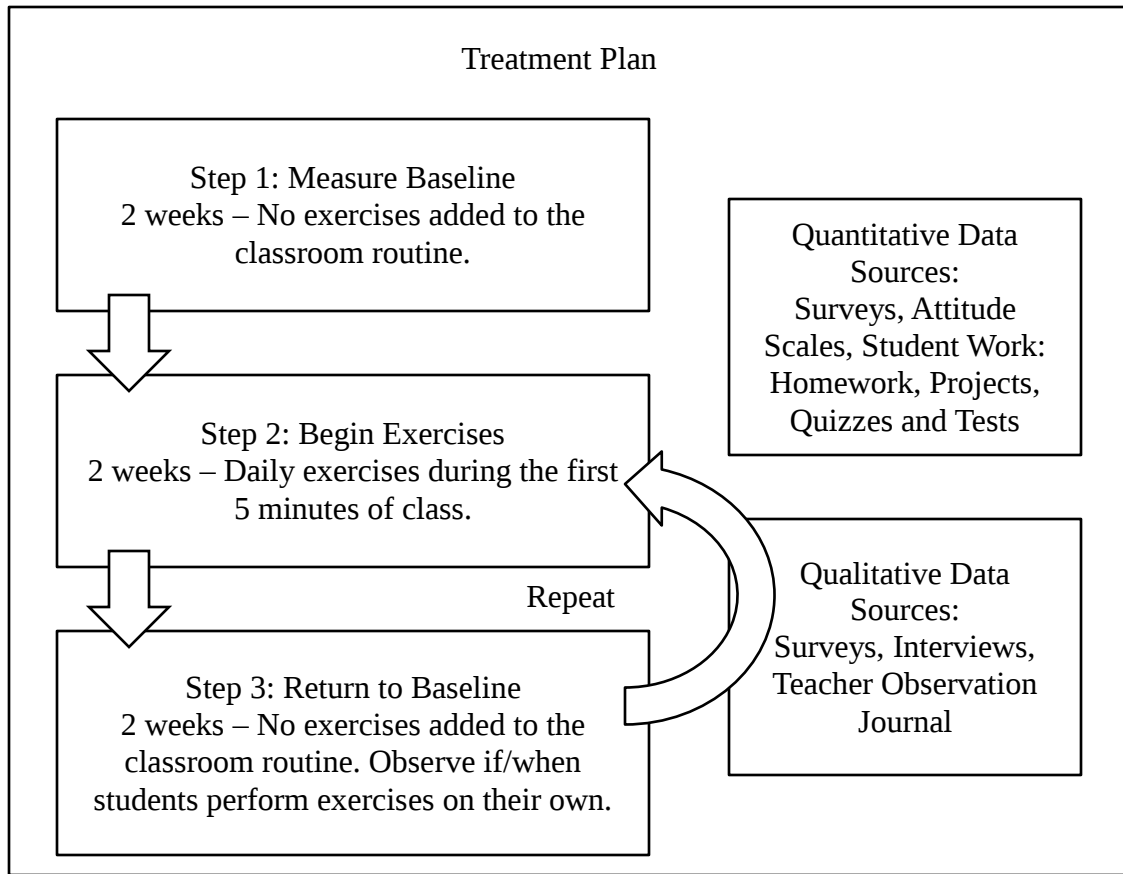


Figure 2. Concept map for action research treatment.

During the course of the study, I repeated the second and third steps to compare the effects over different units, classroom activities, and assessments. The treatment schedule is shown below.

Table 1  
*Treatment Schedule*

| Step    | Dates                    | Implementation     | Content Material                     |
|---------|--------------------------|--------------------|--------------------------------------|
| Step 1  | January 2 – 13           | Baseline           | Newton's Laws of Motion, Gravitation |
| Step 2  | January 16 – 27          | Treatment          | Kepler's Laws, Ellipses              |
| Step 3  | January 30 – February 10 | Return to baseline | Solar System, Planetary Geo          |
| *Step 2 | February 13 – 24         | Treatment          | Astrobiology, Habitable Worlds       |
| Step 3  | February 27 – March 9    | Return to baseline | Mission Design Project               |
| *Step 2 | March 12 – 23            | Treatment          | Mission Design Project               |

*\*Note.* We will skip Step 1 mid-way through the study because the baseline has already been established at the beginning of the semester.

During the study, the students were introduced to a variety of space-related topics spanning several science fields. The material required the students to use algebra-based calculations frequently. To begin the semester, students did group inquiry-based labs involving Newton's classic Laws of Motion to solve puzzle-like questions. During the second week, students used Newton's Law of gravitation to calculate the force of gravity between two objects on several solar system objects and participated in an individual computer-based lab where students' build their own solar system. During this step, students watched a video about all of Newton's Laws. When we began the first treatment step, students were using Kepler's Laws to explain and predict the motion of the planets. They also did a group lab producing ellipses and calculating various descriptive aspects of other group's ellipses. During this step, students watched a video of the inner planets. Over the beginning of the study, students took a mid-unit quiz and a unit test over the covered material.

When we returned to baseline, the students were focusing on the new accepted classification of solar system objects. Students did a group inquiry-based lab using densities of fluids to explain the accretion theory of the formation of the solar system. Afterwards, students took this concept to explain the structure of various planets and to describe the planetary geology of selected worlds. Next, students watched videos on Mars and Jupiter. When we began treatments again, the students investigated the known requirements for life and did an individual inquiry-based lab comparing the simulated environments of different worlds. Continuing into the following week, students did group-based comparisons of selected solar system bodies and chose the most likely candidate to host life. At that time, students watched videos on the remaining gas giants and the moons of the solar system. In the middle part of the study, students took a mid-unit quiz and a unit test over the covered material.

The final part of the study involved the students working on a four week project called the Mission Design Project. In this activity, students worked in groups to plan, design, and built a model of a mission to another world with the intention of finding extraterrestrial life. During the first step, the students began planning their mission, keeping track of expenses and gaining approval before moving to the next phase of the project. The teams worked together to create a mission patch that they used to describe the mission to the rest of the class. While in this step, the students watched a video about Pluto and Kuiper Belt Objects. Finally, during the last step in the study, students were finishing up their mission design projects by building a model showing their spacecraft and the surface of the world they explored. Each student also illustrated an imaginary alien and wrote a paper explaining how that organism was well adapted to its

environment. They included light-intensity and energy balance calculations showing how the organism was able to metabolize on its home. During this step, the students watched a video about the search for alien life. In the final part of the study, students took one quiz and one unit test over the covered material.

For data collection, I used a combination of artifacts, observational data and inquiry data. To help answer my primary question regarding student performance, I used teacher-made tests, standardized tests, self-assessment, and peer review. As an astronomy teacher, I already had access to assessments that I have written in previous years. In addition to these assessments I drafted pre- and post- tests to better gauge how students' knowledge grew throughout the semester. In addition to these formal assessments, I also gave the students the opportunity to rate their own performance as well as their peer's performance, especially on group work. More specifically, the students filled out a sheet rating the amount of work done by each team member as well as the quality of the work done by each teammate. These forms were used to determine a fair grade for each student in the group. For example, a student that did their fair share of work (25% of the work for a team of four) and had produced exceptional quality work would receive all of the available points, whereas as a student that did less work and produced lower quality work would receive only a portion of the score, as determined by the form filled out by the student and their teammates. These forms allowed for me to give each student a fair grade for the group work.

For the secondary question regarding retention of concepts, I periodically revisited topics from past units. I incorporated these questions into the assessments that the students completed for the current unit. By placing one or two past questions into the

current tests and quizzes, I was able to see how well the students remember the information after a certain time period has passed.

Finally, for the questions regarding student's attitude towards learning and energy levels, I used a combination of surveys, attitude scales with open ended questions, and interviews to gauge how students feel about Brain Gym® and how it impacts their learning. During interviews and throughout class, teacher observation journals and reflections described the students' general attitudes towards learning from the teacher's point of view.

Table 2  
*Research Questions and Corresponding Data Collection Methodologies*

| Action Research Questions                                                           | Data Collection Methodologies                              |         |                                                 |            |                                       |
|-------------------------------------------------------------------------------------|------------------------------------------------------------|---------|-------------------------------------------------|------------|---------------------------------------|
|                                                                                     | Student Scores<br>(homework, group<br>work, tests/quizzes) | Surveys | Attitude scales with<br>open-ended<br>questions | Interviews | Teacher observations<br>& reflections |
| What impact does kinesthetic activity have on overall student achievement?          | ✓                                                          | ✓       |                                                 | ✓          | ✓                                     |
| What impact does kinesthetic activity have on students' ability to retain concepts? | ✓                                                          |         |                                                 | ✓          | ✓                                     |
| What impact does kinesthetic activity have on students' attitude towards learning?  |                                                            | ✓       | ✓                                               | ✓          | ✓                                     |
| What impact does kinesthetic activity have on students' energy levels?              |                                                            | ✓       | ✓                                               | ✓          | ✓                                     |

In this study I used Likert surveys to gather data on student's attitudes and energy levels (Appendices A and B). I was introduced to this technique in Geoffrey Mills work *Action Research: A Guide for the Teacher Researcher* (2007). Data indicate that this

technique allowed for me to quantify all of my students' feelings and attitudes- data that might otherwise be considered to be qualitative.

To begin analyzing the data from the Likert Surveys, I correlated each answer to a corresponding number. For example, each "Strongly agree" answer was assigned a four. "Strongly disagree" was assigned a one. These questions were split into five categories to help strengthen the data analysis. These categories included students' attitudes toward the following areas: school, science class, science in general, class activities, and physical activities. I looked to see how the students answered for each of the 5 categories when I analyzed the data.

Along with Likert surveys, I also used course-related self-confidence surveys to gauge my students' attitudes towards more specific science tasks and concepts (Appendix C). I have found that they were easy to create and administer, and the data that it provided me gave me great insight into the attitudes of my students' and their learning. I continued to probe the students for more information by adding open-ended questions at the end of the survey to give the students' the opportunity to express any feeling that the scale may not have covered.

I began analyzing the data in a similar fashion as the Likert scales. I assigned a numerical score to each answer. For example, "none" was assigned a one, and "high" was given a score of four. I used the same categories that I previously used for the Likert surveys to assess how student's attitudes have changed over the course of the treatment. By using the same categories, I was able to use these confidence surveys in conjunction with the attitude surveys to paint a clear picture of the student's attitudes.

The open-ended questions were analyzed by placing student responses into categories that I chose after the fact to accurately reflect the range of responses. Once the categories were determined, the number of students that responded with each type of answer was recorded on a separate class spreadsheet. This information was shown in a table and was used to observe any relationships in data.

More specifically, I looked to see if the students' confidence increases in each topic as the semester progressed. I also looked to see if older topics become sources of lower confidence as students may have forgotten concepts from earlier in the semester. I also looked to see if the general confidence levels increased as students were exposed to the treatment of physical activities. I compared surveys from the beginning of the study to those from the middle and the end (both during treatment and non-treatment steps). This helped me to observe relationships between student confidence and physical activity.

In addition to the Likert attitude surveys and the self-confidence surveys, I interviewed individual students to gather more information about their attitudes (Appendix D). I interviewed two students from each class for a total of 10 interviewees. I interviewed the same students during the entire study. All of the students interviewed were juniors, since that grade level was the vast majority of students represented. To gain a variety of perspectives, I randomly chose these students by pulling names from a hat. If the student chose not to participate, I chose another name until I had two students from each class. The interview questions were once again designed to measure the five categories measured by the Likert surveys. This allowed for me to have a third angle on student attitude and was therefore used for data triangulation.

To address the sub questions concerning student energy levels and retention of concepts, I made daily observation and reflection journals (Appendix E). In these journals, I wrote quick notes directly after each class section throughout the day. My schedule allowed for me to take a few moments after each class to reflect on the general tone of the class, as well as any notable behaviors or questions made by the students. When this data was analyzed, the five attitude categories were looked at, as well as student energy levels, which were rated from 1 to 5 with 5 being the most energetic. Throughout lectures, I was sure to interject old questions from past units to help gauge the student's retention of concepts. I made note if the students immediately answered the question correctly, or if they needed hints to get there.

For each one of my classes, I had every student fill out the Likert attitude survey to gain as much perspective as I could from as many different individuals as possible. I used all five classes for my data pool, mostly because it was just as easy for me to survey one class as it was to survey all five. Also, I wanted to see if the time of day was an influencing factor in my research, and the only way to do that it was to collect data at different times throughout the day. Since each class period was held at the same time every day, I needed to survey all of my classes to gain this data. Also, each class had completely unique demographics, and the survey helped me assess as many types of students as possible.

I administered the survey during each step in the study, once during the treatment and once during the non-treatment. I revisited the survey and gave it to the students again during the middle and end of the study for a total of six times (Table 3). This allowed for me to compare the treatment and non-treatment stages during the beginning, middle and

end of the study. Throughout the research timeline, I collected student scores and made daily teacher observation and reflection journals.

Table 3  
*Data Collection Schedule*

| Step    | Approximate Date | Data Collection Instrument                       |                                                    |
|---------|------------------|--------------------------------------------------|----------------------------------------------------|
| Step 1  | January 6        | Interviews                                       | Student Scores, Teacher Observations & reflections |
|         | January 13       | Survey, Attitude Scale with Open-Ended Questions |                                                    |
| Step 2  | January 20       | Interviews                                       |                                                    |
|         | January 27       | Survey, Attitude Scale with Open-Ended Questions |                                                    |
| Step 3  | February 3       | Interviews                                       |                                                    |
|         | February 10      | Survey, Attitude Scale with Open-Ended Questions |                                                    |
| *Step 2 | February 17      | Interviews                                       |                                                    |
|         | February 24      | Survey, Attitude Scale with Open-Ended Questions |                                                    |
| Step 3  | March 2          | Interviews                                       |                                                    |
|         | March 9          | Survey, Attitude Scale with Open-Ended Questions |                                                    |
| *Step 2 | March 13         | Interviews                                       |                                                    |
|         | March 23         | Survey, Attitude Scale with Open-Ended Questions |                                                    |

*\*Note.* We will skip Step 1 mid-way through the study because the baseline has already been established at the beginning of the semester.

To ensure reliability, I carefully chose survey and interview items to target the information needed to answer my focus questions. Then I tested the surveys and interview questions on friends and other teachers to check for any needed changes. Once the details of each measurement tools were determined, the same survey was given to the students for each step of the study. No changes were made, however additional questions were added when appropriate. By keeping the survey and interview questions the same throughout the study, I had a better chance of having reliable data.

The measurement tools were designed to ensure external and internal validity. The survey and interview items were easily transferrable to science classes at any level or location allowing them to be used across wide study groups. With some minimal changes, the survey and interview items could also be used for measurements in any content area. The instruments were reviewed by colleagues at my school and from my graduate class, also ensuring validity. All of the data collection methods were used in conjunction with others to triangulate the findings. This gave a wide yet detailed description of factors at play in the study. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained (Appendix F).

## DATA AND ANALYSIS

Once the data was collected, analysis began. Through the use of observations, interviews, surveys, and student grades, I was able to paint a picture of how simple physical activities at the beginning of the class period affected student attitudes toward learning, retention of concepts, energy levels and overall achievement in the science classroom. I began by looking at the student attitude surveys (Figures 3, 4, 5 and 6).

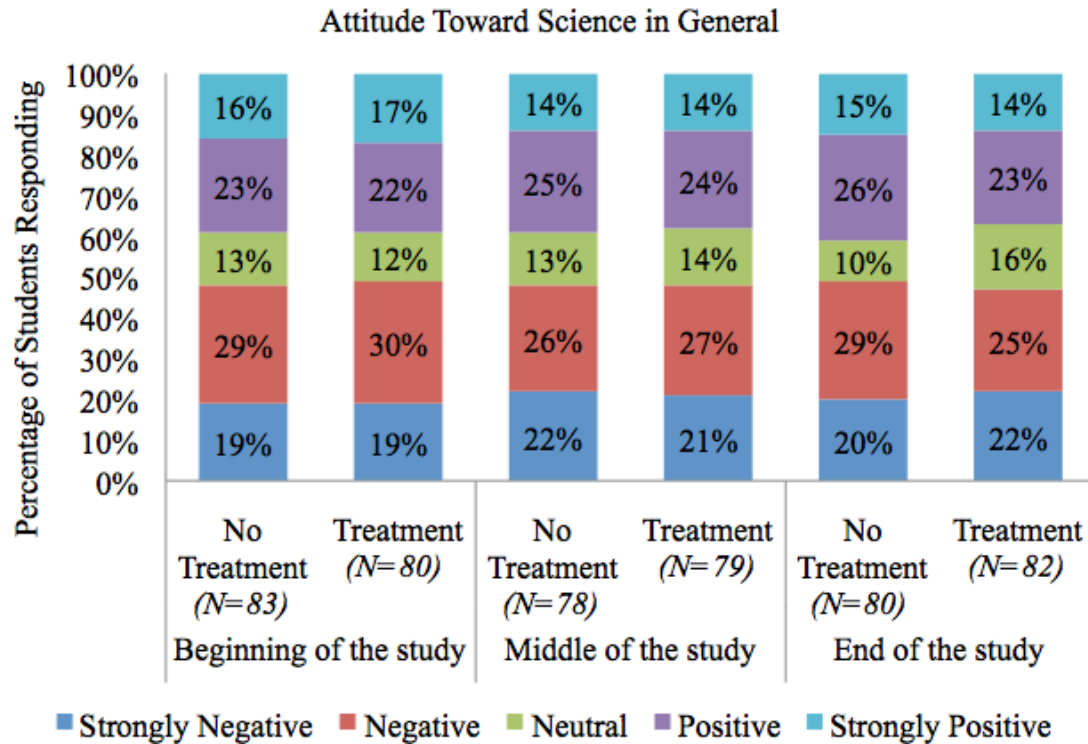


Figure 3. General science attitudes.

During the beginning of the study, student responses to survey questions relating to science attitudes showed that 48% of students had negative attitudes toward science ( $N=83$ ). This percentage did not show significant changes over the middle and final portions of the study. During the times when students were doing the physical activities before class, the percentage of students with negative attitudes only changed by 1 to 3 percentage points. Comparing non-treatment survey responses from the beginning to the end of the study showed a slight decrease in negative student attitudes of 1% ( $N=80$ ). Within the attitude surveys, questions were specifically gauged to measure students' attitudes towards science in general as opposed to science class specifically. Students' responses concerning attitudes towards science class specifically were similar to student responses about science in general (Figure 4).

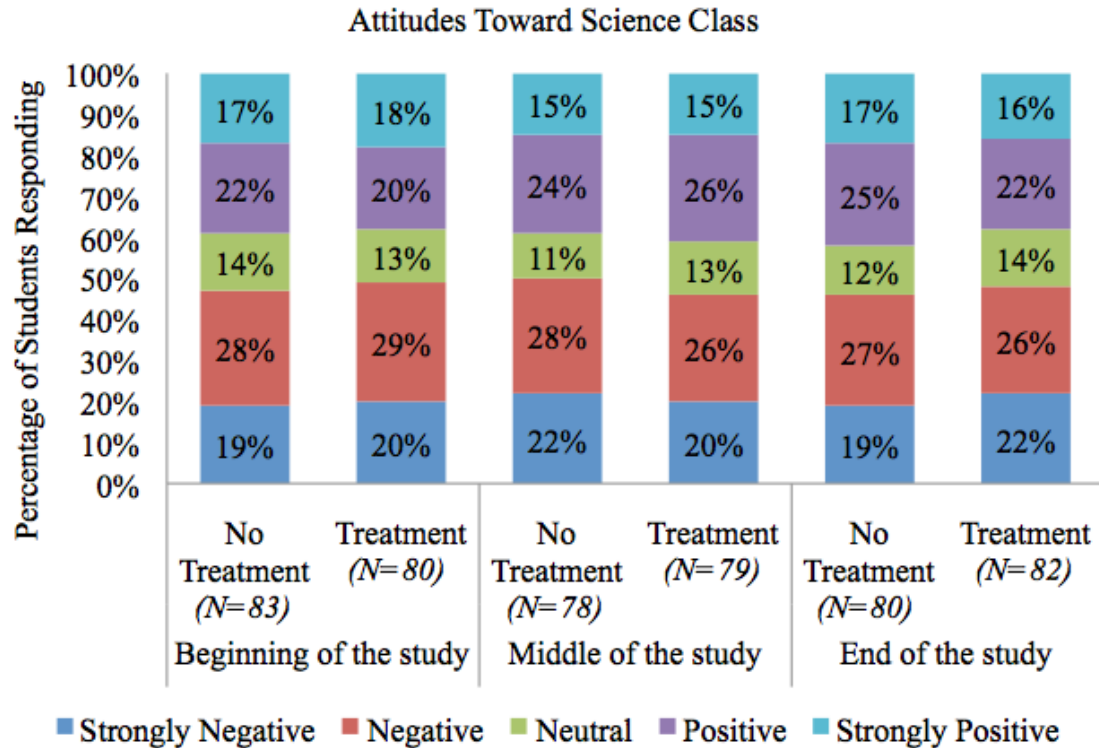


Figure 4. Science class attitudes.

As was seen with the students' attitudes toward science in general, student responses to the survey questions showed that 47% of students had negative attitudes towards science class specifically ( $N=83$ ). This percentage did not show significant changes over the middle and final stages of the study. During the times when students were doing the physical activities before class, the percentage of students with negative attitudes only changed by 1 to 2%. Negative student attitudes changed by just 1% from the beginning to the end of the study ( $N=80$ ).

Overall, the observation journals noted that the classes' attitudes varied little over the study. Class periods that began the semester with an innate curiosity in science continued to have the same curiosity throughout the end of data collection. Likewise, class periods with less interest in science continued that trend through to the end. During

interviews, about 50% of students said that they did not like science because it is “dry” or “boring”. Throughout the study, neutral student responses slightly varied between 10 and 16%. Positive student responses remained mostly steady throughout the study with ranges between 38 and 41%. These students told me that science is “interesting” and that “it explains things that happen in real life.”

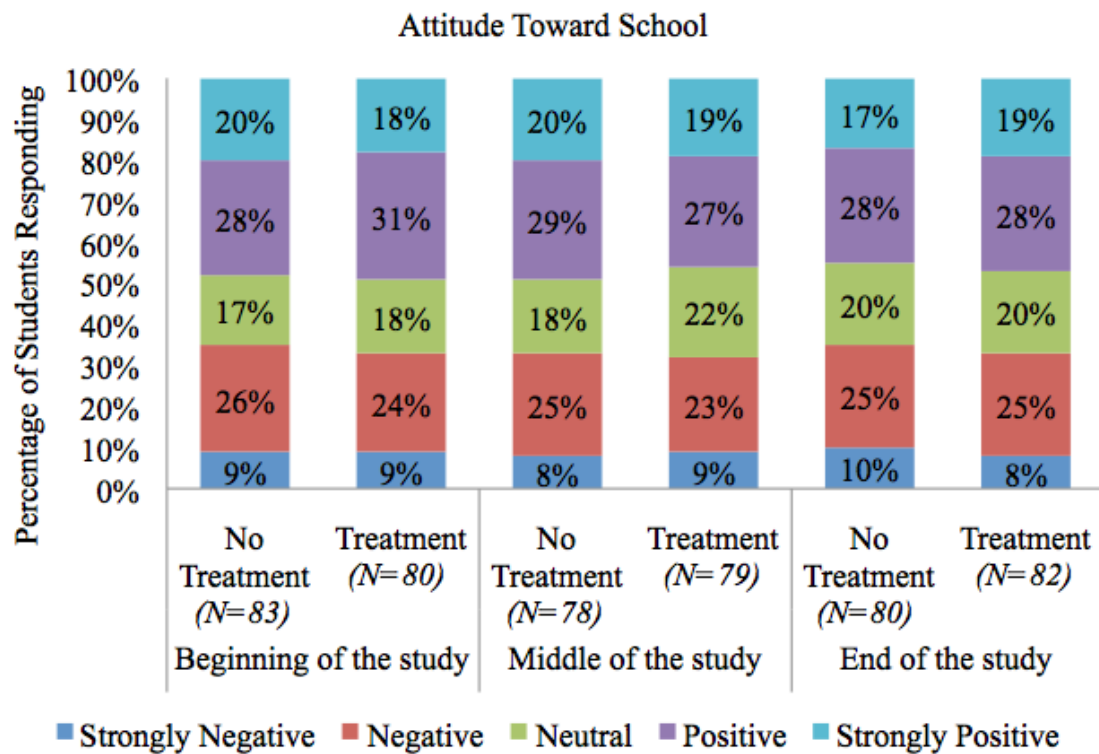


Figure 5. School attitudes.

Comparatively, students’ attitudes about school in general differed from students’ attitudes about science. Whereas the average negative responses for science attitudes varied from 47 to 49%, negative attitudes for school ranged from 32 to 35% (Figure 3). Not surprisingly, most students with positive attitudes about school mentioned “hanging out with friends” as their favorite aspect of school. During interviews, students would tell me that their favorite classes were those that allowed for socializing such as art and

physical education. However, comparing times of physical activity to times without the exercises showed no significant change in students' negative responses with differences between 1 to 2%. Neutral responses ranged from 17 to 22%. One of these students told me that "school is boring but I go to see my friends every day." Thankfully, more students responded to having positive attitudes about school than those with negative attitudes; however the difference was less than 10% on average. This meant that the majority of students had one or more aspects of school that they enjoyed every day and kept them coming back. There were two students that told me that they looked forward to doing the exercises each day. These students did typically like science class, but their attitudes changed when we began doing the exercises. One of these students asked me each day that we did not perform the exercises if we could do so. I would allow this student to do the exercises during baselines and asked him why he did them during an interview. He told me, "They're fun, and it's like a little break. After sitting all day, it's good to move around a little bit." This particular student's responses to the attitude survey improved when we were doing the exercises. However, his grades showed no measureable improvement.

Throughout the study, students' attitude towards general class activities was gauged through student surveys. These general class activities included all learning activities done in class, including hands-on labs, learning games, and projects. Student responses are displayed below (Figure 6).

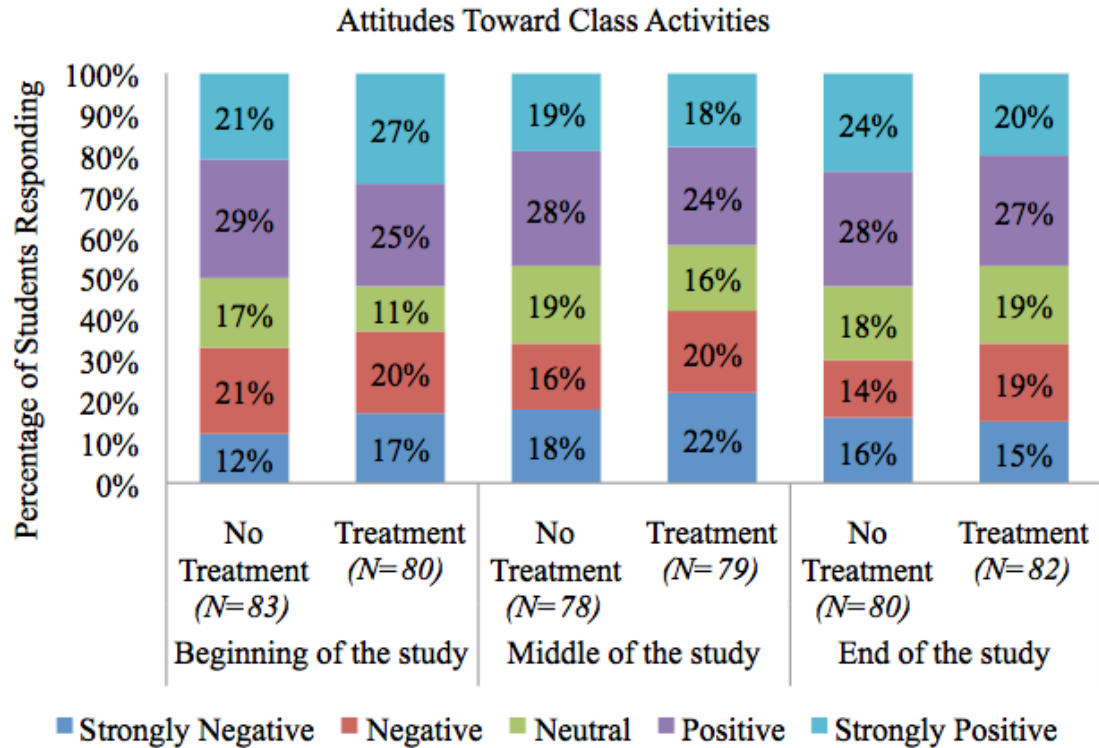


Figure 6. Attitude toward class activities.

Over the course of the study, students' attitudes towards general learning activities showed no relation to performing the exercises. During the beginning of the study, 33% of students responded negatively ( $N=83$ ). These negative responses increased slightly towards the end of the study by 1% ( $N=80$ ). Comparing times of treatment to those of non-treatment, random changes occurred in student responses showing no relationship with performing the exercises. From the interviews, several students mentioned that hands on activities were the most helpful for them, which was reflected in the data. The majority of positive student responses came from the times when the students did the hands on ellipse lab and again when they began the mission design group project.

Over the course of the study, overall student grades were recorded for each two week segment. These assessments included homework, quizzes and test scores. Each unit of the class lasted approximately four weeks, so each treatment and non-treatment cycle covered one unit (Figure 7).

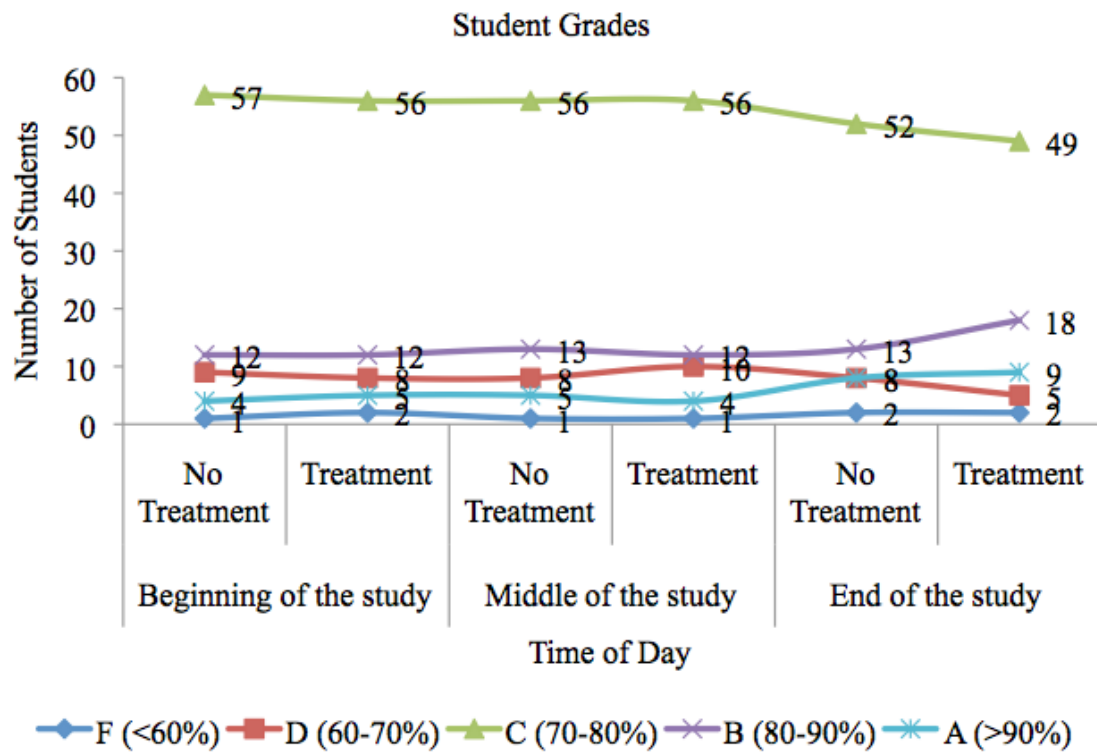


Figure 7. Student grades, ( $N=83$ ).

During the beginning of the study, student scores were mostly average with the greatest number of students having grades in the C range (between 70 and 80%) ( $N=83$ ). Fewer students had exceptional grades (B or better) and poor grades (D and below). Student scores remained mostly unchanged during the middle of the study. Towards the end of the study, student grades improved with 27 students (32.5%) earning scores of B or better compared to the 17 students (20%) during the middle and beginning. These same students had average or poor scores (D or C grade) in the middle and beginning of

the study. There was no significant increase between treatment and non-treatment phases of the study. During interviews in the final portion of the study, students whose grades improved told me “the unit on the solar system was interesting because we talked about aliens.” Increased student interest could have contributed to the nearly 10% increase in student scores.

As far as individual students outside twice the standard deviation (an average grade percentage of 10%) were concerned, some students’ grades were affected positively from the treatment, while others were negatively impacted. During the beginning of the study, three students’ grades were impacted by the exercises. Two of these students’ grades improved by a letter grade while the other student’s score dropped. This suggests that the treatment played a role in improving two of the students’ scores because they participated in the exercises each day. The other student never participated, possibly causing his grade to drop. During the middle of the study, five students’ grades dropped by a letter grade. All but one of these students were absent for portions of the unit, causing them to do poorly on the assessments. When they were present, each one of these students participated in the exercises. These same students later improved their scores significantly during the final portion of the study, after they made up the missing materials and retook the test. The other student whose grades decreased was an interview subject, and he commented that the math was too difficult for him, causing him to lose valuable points on the test and quiz, despite being a frequent participant in the exercises. Finally, during the end of the study, eight students improved their grades by one letter. Four of those students were the same students that lost points due to absences in the middle of the study. They continued to participate in the exercises and were present in

class for the remainder of the study. These students' grades improved from the middle of the study, but returned to the grades that they had at the beginning before their extended absences. The other three students whose grades improved during the final portion did not participate in the exercises regularly, but worked together in a group for the mission design project. Their scores probably improved due to the group dynamics instead of the effect of the exercises.

Throughout the study, students were given tests and quizzes for each unit. In these assessments, four questions were added from previous units. These questions allowed for me to see how much of older material the students would recall (Figure 8).

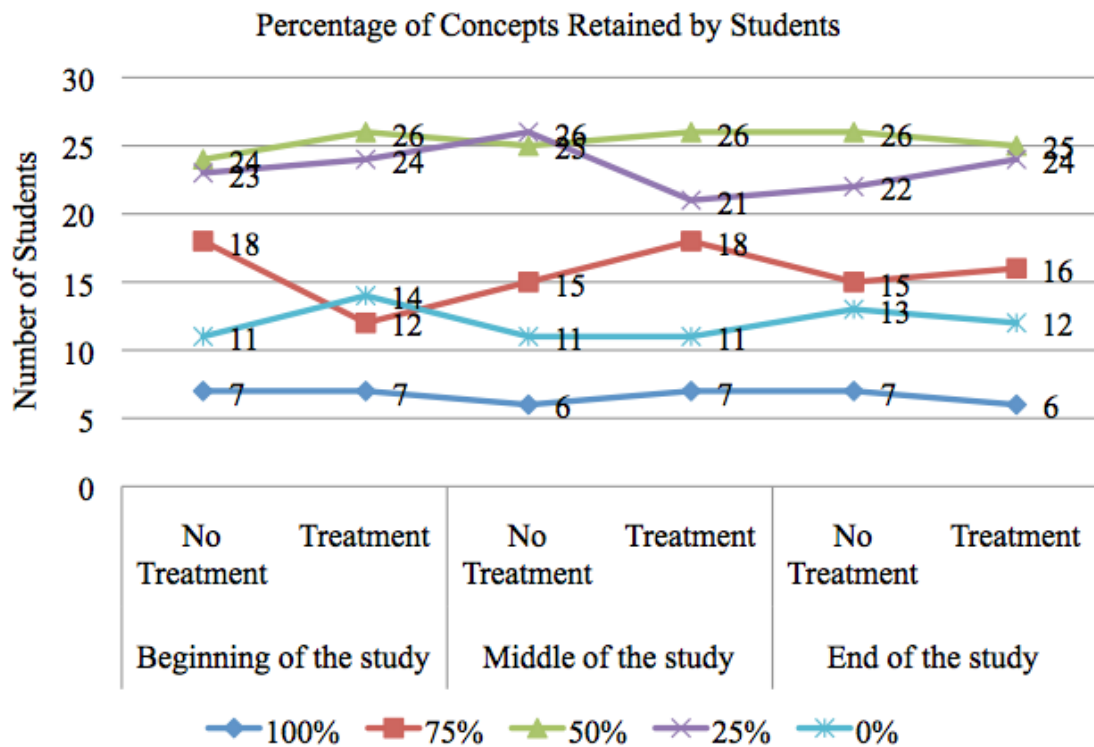


Figure 8. Percentage of concepts retained by students, ( $N=83$ ).

The majority of students had difficulty remembering past concepts, and the exercises did not appear to make a difference. Most students remembered 25 to 50% of

the old material throughout the study. The fewest number of students remembered 100% of the material, and the same 6 students received the same high score from the beginning to the end of the study. Twice as many students remembered none of the material compared to those that recalled everything. Unfortunately, the treatments made no consistent change in the ability of the students to recall past content.

With regard to student confidence, students rated survey questions addressing current and past concepts. Throughout the study, student confidence levels bounced up and down, however there were no consistent changes between treatment and non-treatment phases (Figure 9).

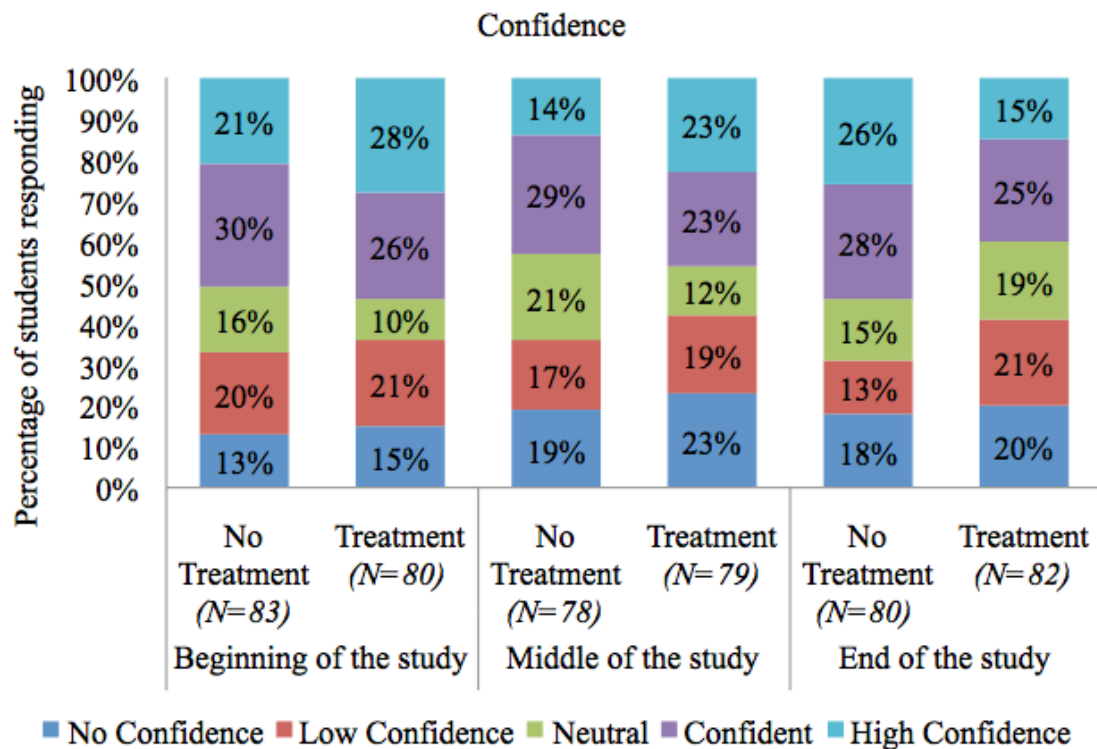


Figure 9. Student confidence.

Students with positive confidence levels ranged between 40 to 52%. The highest number of students with positive confidence levels was during the non-treatment phase of

the final portion of the study. Students told me that the content matter was the biggest factor in their confidence level, with time to practice each type of question being a close second. Interestingly, students with consistently low confidence listed questions involving math to be their biggest struggle. Students with consistently high confidence listed math-related problems as being the easiest. I think that the students' previous experiences with math, whether good or bad, may have given students preconceived notions about how easy or hard math calculations are.

During the study, classroom energy levels were the most affected by the exercises performed. Energy levels were subjectively evaluated by the teacher and recorded as part of the teacher observation journal on a scale of 1 to 5 (1 being the lowest energy level and 5 being the highest). When students asked more questions or were more talkative, the class was given a higher score than when students seemed sluggish or sleepy (Figure 10).

Every two weeks, one or two days of classes were devoted to showing astronomy videos, and the teacher would watch for students that appeared to be nodding off or sleeping. During times when students would do exercises before class, the number of students sleeping during videos or passively sitting during lectures decreased dramatically. Students mentioned during interviews that the exercises helped them stay focused on the videos and would "wake them up" before class notes. During treatment phases, more students would ask questions and socialize with classmates. Also, students made comments during the exercises that I found interesting. They would say things like, "Whew. Feel the burn!" and sometimes students would create a rhythmic beat for the students to move to. In the middle of the treatment, one of my classes spontaneously broke out singing "Single Ladies" by Beyoncé as they were doing the Cross Crawl.

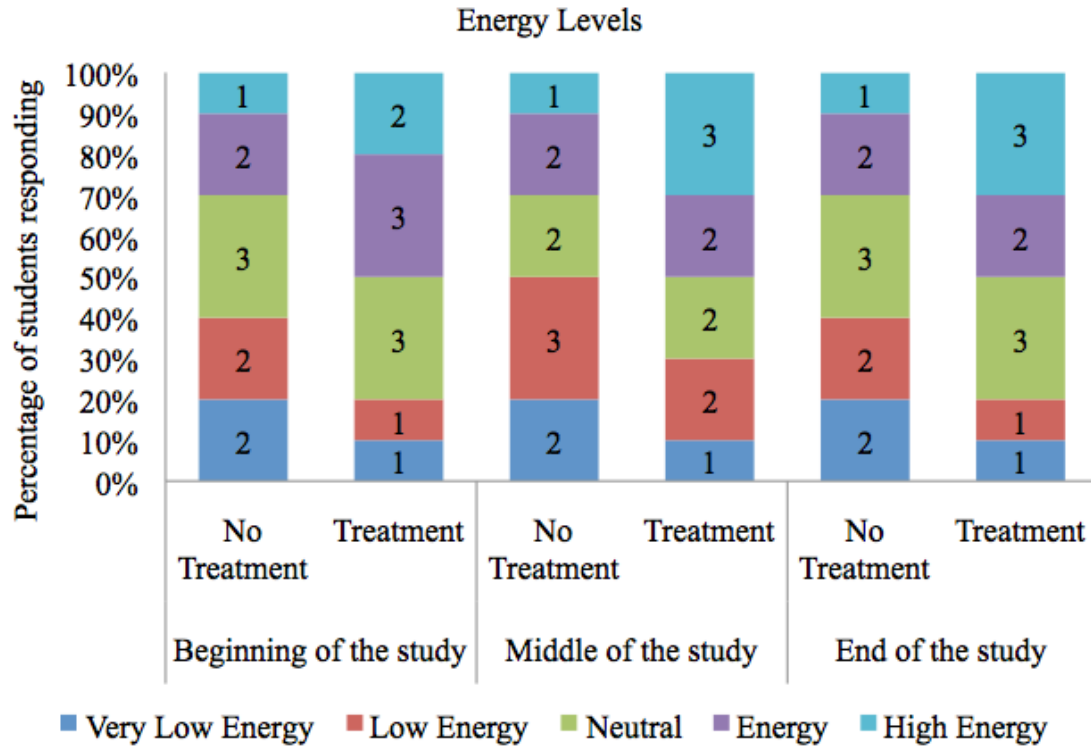
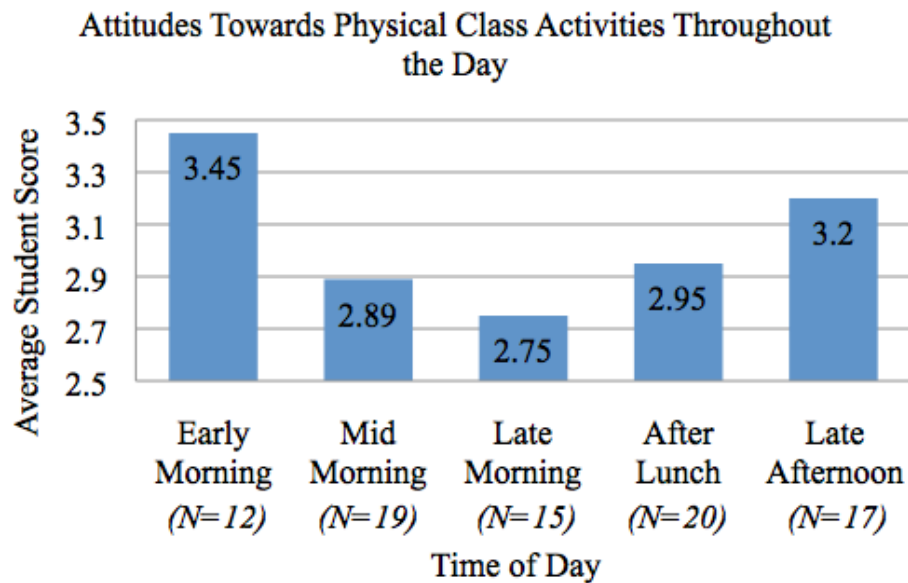


Figure 10. Average student energy levels across all class periods. Each bar represents two weeks (10 school days), ( $N=83$ ).

Obviously the students were having fun with the activities. In the interviews, one student told me that she wished her other teachers would do the exercises because “it’s a good way to spend time in class. I hate it when teachers start the class with a pop quiz or something. This is so much better!” As seen in the observation and reflection journals, the classes’ energy levels increased for each treatment step by 9%. When the class would return to the baseline of not performing physical activities before class, more students would slip into old habits of nodding off in class or would not ask as many questions. Overall, the classroom would be quieter when there was no physical activity. Although the increased energy levels did not translate to better grades, the overall environment of the classroom became more enjoyable for everyone.

From the surveys, it became apparent that attitudes towards school, science, and confidence towards science remain largely the same throughout the day. However, students' attitude towards class activities jumps one-quarter point during the time immediately after lunch. Also, students' attitude towards physical activity creates a dramatic parabolic shape as the day continues, dropping before lunch and gradually rising afterwards (Figure 11). Interestingly, average energy levels from observation journals showed a similar pattern (Figure 12).



*Figure 11.* Student attitudes towards physical class activities throughout the day.

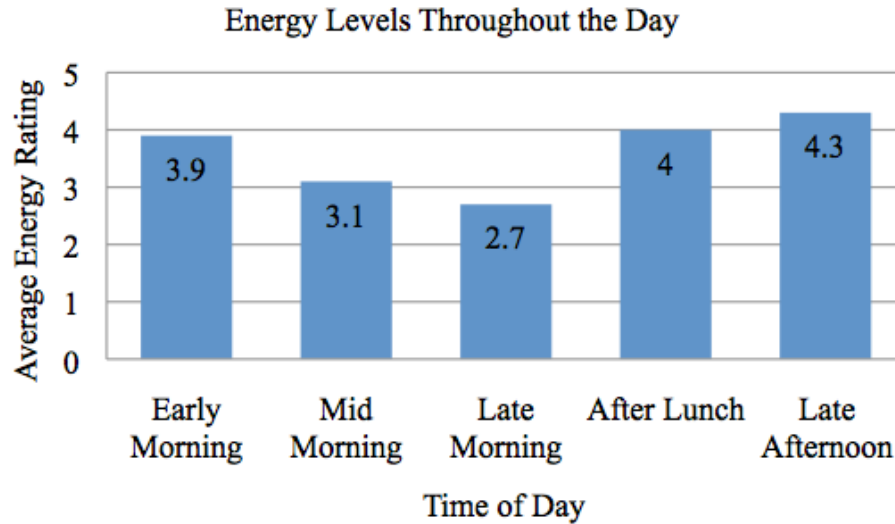


Figure 12. Average energy levels over the course of a day, ( $N=83$ ).

I suspect student attitude toward physical activity and energy levels varied throughout the day as a result of lunchtime breaks. Students are probably losing energy as the morning progresses, eat lunch, and then regain energy as the body finishes digesting toward the end of the school day.

The observation and reflection journal provided insight into the daily changes seen through treatment and non-treatment steps. During times of non-treatment, the students were more withdrawn and less likely to participate in class discussions. Treatment steps gave the students more energy in class, and this was seen through more active participation in discussions and more questions asked by the students. Also, they were more social with each other by talking more and working together in groups more effectively. Students arrived at answers more quickly and with less prompting. During interviews, students mentioned that they knew what was going on in class more often than they did when we were in non-treatment steps. One student specifically said, "I feel like the instructions are clearer and I know what I am supposed to do." Through the

journals, I noticed that fewer students fell asleep while we were watching videos if the exercises were done before class. Interestingly, two students would fall asleep regardless of doing the exercises. This could be due to these particular students staying up too late at night and not getting enough sleep. One of these students told me, “I am always tired because I have to wake up early every day to take my little sister to daycare before coming to school.” Unfortunately, this student never adapted to this schedule by going to sleep a little bit earlier the previous evening. During the final part of the study, while doing the group work, the exercises appeared to give the students more energy to work as a team and the general volume in the classroom was louder during treatment steps.

The observation journals also gave me insight into changes in my own teaching. I noticed that after doing the exercises, I became more energetic in the classroom as well. In the past, I would sit on a stool at the front of the classroom frequently. This would allow me to see the students while being close to the overhead screen and white boards. I would get up from the stool only when needed. After doing the exercises, I would be up and moving throughout the classroom more frequently. For three whole days during the second treatment cycle, I didn’t sit on the stool once! The only time that it was used during those days was when I needed it to reach the buttons to turn on the TV. The rest of the time, I was walking around the room while teaching and telling more stories to emphasize points. At the end of these days, my arms were more tired because I would use them to gesture as I spoke. This is very different from what I would normally do during times without the exercises. The students picked up on the change as well. During my fourth period class after doing the exercises, someone in class asked me, “Did you break

your stool? You never use it anymore.” Obviously, the energy I put toward teaching had changed dramatically.

As a whole, the exercises appeared to affect the students’ energy levels in class, but did not affect their retention of concepts, attitudes, or overall grades in class. The students became better participants in class after performing the exercises, but did not do any better or worse on class work, quizzes, and tests. Also, my style of teaching changed as my own energy increased.

## INTERPRETATION AND CONCLUSION

Simple physical activities done in class offer teachers and students several challenges and benefits. By providing a time to be physically active, the students get blood moving throughout the body and gets students out of the typical routine of passively sitting and minimally participating in class. The data from this study began to uncover valuable aspects in kinesthetic activity in their affects on energy levels and participation of students. Most of the data was inconclusive while some of it showed that the physical activities were providing some of the desired results.

Did physical activity help students’ attitudes towards science and school? Based on student surveys, interviews, and teacher observations, it is most likely that the kinesthetic exercises made no significant change in the student’s attitude as a whole. However, students that were already interested in science became more interested and those with no science interests remained uninterested. For example, one student arrived the first day of class bursting to tell me all about his own theories on gravity and

cosmology. As the semester continued, this student displayed an obvious love of astronomy and science in general. He frequently participated in the exercises, and told me on several occasions that the physical activity helped him concentrate in class. He even told me about times that he used them to help him focus before taking tests in his Spanish class. After the study, I looked at this particular student's grades and they improved significantly. From the middle of the study to the end, his grade went from a high C to an A. Each time the class did the exercises, this student's grade would improve, little by little. From my observations, I noticed that he would complete in-class assignments after doing the exercises. When we did not do treatments, he would use the time in class to socialize and would tell me that he would "get it done later" when I asked him about the homework that was just assigned. Often times, he would come in the next day without the assignment and would tell me that he forgot about it. Using class time more wisely to get assignments completed helped to improve his scores. He also was one of the few students that were able to retain information from past units, each time averaging 75 to 100% of the information throughout the study. Unfortunately, the exercises did not seem to affect the memory of this student. He appeared to have a very good memory despite the treatments. This student came by my office after the study ended and we spoke about the results that I was seeing. He offered his own interpretation, saying "I think [the exercises] help out if you allow them to. If you breathe and drink water and move around, your brain will probably be happier."

As for school attitudes, the vast majority of students listed one or more aspects of school that keep them coming back every day. Most of my students were very social and enjoyed being with friends, whether they were in classes or sports together or simply saw

each other in the halls or during lunch. Few students simply didn't enjoy school, and the reasons for that could have been varied. The physical exercises had no effect on these attitudes. Few students simply do not enjoy school at all, with various reasons, and the exercises made no measured change in these students' attitudes.

To answer the sub question of how the kinesthetic exercises affected the long term retention of concepts in students, the data suggests that there was no difference in memory between times of no activity compared to times with the physical exercises. Although students were more willing to ask questions during class time, when it came to remembering information that was presented a week or more beforehand, students had difficulty recalling those concepts. Quiz and test scores on old questions remained unchanged throughout the study. Apparently, movement in class does not affect the long-term retention of concepts in students.

As far as the sub question concerning the affect of movement on students' confidence in their skills, student surveys and interviews revealed that student confidence remained unchanged throughout the study. Data showed that students had a dramatic split among those that were very confident and those that had little to no confidence. This split involved the students' perceived math abilities, and this split remained unchanged by the physical activities. The students' previous experiences with math, whether good or bad, gave students preconceived notions about how easy or hard math calculations are. I came to the conclusion that kinesthetic exercises had no effect on student confidence; however, previous math experience and practice could potentially play a large role in improving or decreasing students' perceived ability in mathematics.

To answer the sub question about how student energy levels were affected by daily physical movement, the data showed a measureable difference between times without exercises and times with the kinesthetic activities. Regardless of the content material presented, students were more active in their questions, and needed less prompting to arrive at questions posed to the class. They were more talkative with the general volume of the class increasing after physical activities were completed before class. Students worked better with peers and were more productive in group work. Also, fewer students nodded off or slept during in-class videos. Perhaps the students were learning more, but the assessments were unable to reveal it. I came to the conclusion that those five minutes of simple in-class movement increases the overall energy levels of students in class. This could mean that the students were learning more, however the assessments did not indicate that there was any significant change in the amount of learning do to the exercises.

Time of day also appears to play a large role in the energy levels of students. In general, students begin the day with energy to burn, but that energy level decreases as lunch time approaches. After lunch, while the students are digesting, the energy levels slowly begin to increase until the end of the school day. In the late afternoon, students had the same amounts of energy as they did when they began their school day. The data suggests that students are more likely to want to complete physical exercises early in the morning or late in the afternoon, but not before or after lunch. This leads me to conclude that the time of day contributes to the students' motivation to participate in the physical exercises.

Did the physical exercises affect the overall achievement of students? Over the course of the study, data showed no measureable changes in student grades, with the exception of the final part where the students worked in teams to design missions. During this part, student grades improved slightly. This could have been due to the change in the structure of the class. During the final four weeks of the study, the students were working on group projects. As many of my students were very social, allowing them to work with others may have helped to increase student achievement. I concluded that the physical activities improved the students' energy levels helping them to be more engaged in the class and more willing to socialize and work within a group. Giving the students the opportunity to work with others and allowing them to complete physical exercises before class allowed for them to use newly-found energy towards completing the project. As a result, the students' grades increased during the final portion of the study.

After looking at individual outliers, it appeared that several students' grades were possibly impacted by the exercises. Students that were frequent participants in the treatments improved their scores by one letter grade. Some of these same students only improved their grades during the time when they were working in groups and doing the exercises, leading me to believe that the group dynamics improved with the introduction of the exercises. Unfortunately, some student's grades dropped during times of treatment, but the majority of these students had extended absences. After they returned to class at the end of the study and did the exercises regularly, their grades returned to their original score from the beginning of the study. I conclude that the absences negatively impacted these student's grades and regularly attending classes improved these scores, despite the

participation or non-participation in the exercises. Keep in mind, however, that the possible impact only appeared in a small number of the overall population of students.

Overall, only one aspect of the study was affected by daily physical activity. Although students' attitudes, confidence, retention of concepts, and achievement were unaffected, the students' energy levels in class were dramatically improved with daily exercises. Simple kinesthetic activity allowed for the students to be more active in class discussions, stay more alert during videos, become more social with classmates, and work more effectively in groups.

## VALUE

This study has provided valuable insight into how light physical activity can positively influence the environment in the classroom. Although not all learning outcomes were affected, I think that the value of increasing student energy in the classroom should not be underestimated. Particularly in my own teaching, I noticed dramatic impacts.

Normally, I feel like my teaching style is direct and to the point. I will ask direct questions to the students, and if they falter, I give them hints to get them thinking along the right track. Rarely do I allow myself to get on tangents and spend time telling stories that are related to course material. In this way, I now consider my old teaching habits as coming across as dry to some students. However, during the study I participated in all of the exercises that I asked my students to do. This means that I was doing the movements 5 times each day. From this experience, I noticed that my teaching became more light-

hearted and in some cases, more relatable to students. My examples became more creative, and I spent more time telling stories to help illustrate difficult concepts. I also noticed that I would move around the room much more while teaching classes which I relate directly to the added energy that I gained from the exercises. In the past, I often times would sit on a stool in front of the projector screen or white board, only getting up when needed. Since performing the exercises, I would rarely use the stool during classes. In turn, I think that the classroom environment became more enjoyable for both the students and me as their teacher. I became more enthusiastic about my subject, and this energy was met by the students as well.

During the course of this study, I also faced a challenge. The difficulty I ran into was convincing my students to give brain-based learning a try during the beginning of the study. Many of the students resisted participating because they saw it as “pointless.” One student told me that she would “rather be learning than wasting time with exercises.” Other students found the whole concept of the study interesting and would participate to help me “get data for the research.” Not surprisingly, these were the same students that had positive attitudes about science and were inherently interested in discovery. A few of these students would ask me why we weren’t doing the exercises when we were in periods of non-treatment, and I had to remind them that revisiting the baseline was important for comparison. As for the majority of students, during the beginning of the study they would begrudgingly go through the motions of the exercises, but would sigh or grumble when they got out of their seats to do so. Towards the middle and the end of the study, I observed that these students would do the exercises out of keeping a routine, but only if their friends in the class did the exercises too. When the majority of students

in a class would participate, the whole class would benefit from the increase in energy in the learning environment. After data collection was complete, I was surprised to hear a couple of my originally-resistant students asking if we could do the exercises again. Just before a group lab or activity, I would agree and we spent a few minutes revisiting the kinesthetic movements. In the future, I would be very interested in repeating this study after spending more time training the students to help them become more invested in the process. What I would do differently, however, is to use more of the Brain Gym® exercises to investigate if these specific activities improve student performance as opposed to just the PACE exercises.

I plan to continue encouraging my students to remain active as I teach different sets of students from year to year. To help address the challenge I met with this study, I plan on sharing my observations and data with future classes. I hope that by seeing the evidence that physical activities can make the classroom environment more enjoyable for teacher and student alike, that my upcoming students will be more willing to give it a try. However, I will probably reserve days when we do the exercises to lessons that require more energy and enthusiasm from students such as group projects.

This study filled a void in current brain-based learning research. Studies on younger students, those with learning disabilities, and adults are common. However, this is the only action research to date on how physical activity affects the learning in junior and senior science students in an American suburban public high school. The data from this study agrees with previous research that brain-based learning programs in public school settings with average students are not effective at improving overall performance.

My findings also agree that students become more energized in class after some light physical movement.

This study allowed for me to consider additional questions. One of the questions that came up was “How might the other exercises of Brain Gym® or similar brain-based learning programs effect student learning?” In the future, researchers may be interested to investigate if the amount of time performing exercises effects how well students learn. Could brain-based learning programs be more effective in different subjects such as reading, arts, or foreign languages? Would this type of program be more effective for freshman or sophomore learners? What if the students developed their own movements? How might that affect their learning? All of these questions are areas where future research may be headed in order to learn more about how brain based learning works in the classroom.

For other educators that are interested in integrating brain-based learning into their classroom, I recommend that they try it with reserve. This program should definitely be used for increasing student energy in the classroom. However, it is unlikely that teacher expectations of improving student grades, retention of concepts, attitude and confidence will be met. I only used the PACE portion of Brain Gym® in this study, so I cannot comment on the effectiveness of the entire program. With that said, I can confidently say that daily physical activity dramatically changes the students’ day-to-day energy and social dynamics, and can make the classroom environment more fun to teach in.

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## APPENDICES

APPENDIX A

PRE-TREATMENT LIKERT STUDENT ATTITUDE SURVEY

**Astronomy Student Survey**

Name: \_\_\_\_\_

For each statement, indicate if you agree or disagree by circling one of the choices. Participation is voluntary, and you can choose to not answer any question that you do not want to answer, and you can stop at anytime. Your participation or non-participation will not affect your grade or class standing.

| <b>Statement and Questions</b>                                                                               | <b>Circle one of the choices.</b><br><b>For the questions, write your answers in the space provided.</b> |          |         |       |                |  |
|--------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|----------|---------|-------|----------------|--|
| I like school.                                                                                               | Strongly disagree                                                                                        | Disagree | Neutral | Agree | Strongly agree |  |
| What do you like most about school?                                                                          |                                                                                                          |          |         |       |                |  |
| I get good grades in school.                                                                                 | Strongly disagree                                                                                        | Disagree | Neutral | Agree | Strongly agree |  |
| I like science class.                                                                                        | Strongly disagree                                                                                        | Disagree | Neutral | Agree | Strongly agree |  |
| What do you like most about science class?                                                                   |                                                                                                          |          |         |       |                |  |
| I get good grades in science class                                                                           | Strongly disagree                                                                                        | Disagree | Neutral | Agree | Strongly agree |  |
| I always try my best in school.                                                                              | Strongly disagree                                                                                        | Disagree | Neutral | Agree | Strongly agree |  |
| Have you always done this or was there a time (please explain if there was) you didn't always try your best? |                                                                                                          |          |         |       |                |  |
| I always try my best in science class.                                                                       | Strongly disagree                                                                                        | Disagree | Neutral | Agree | Strongly agree |  |
| I would enjoy being a scientist.                                                                             | Strongly disagree                                                                                        | Disagree | Neutral | Agree | Strongly agree |  |
| I plan on continuing my education after high school.                                                         | Strongly disagree                                                                                        | Disagree | Neutral | Agree | Strongly agree |  |
| Science is boring.                                                                                           | Strongly disagree                                                                                        | Disagree | Neutral | Agree | Strongly agree |  |
| What makes it most boring for you?                                                                           |                                                                                                          |          |         |       |                |  |
| I do not like any part of science class.                                                                     | Strongly disagree                                                                                        | Disagree | Neutral | Agree | Strongly agree |  |

| Statement and Questions                                                   | <p align="center"><b>Circle one of the choices.</b></p> <p align="center"><b>For the questions, write your answers in the space provided.</b></p> |
|---------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| The activities we do in science class help me learn.                      | Strongly disagree   Disagree   Neutral   Agree   Strongly agree                                                                                   |
| Which type of activities helps you the most?                              |                                                                                                                                                   |
| The activities we do are fun.                                             | Strongly disagree   Disagree   Neutral   Agree   Strongly agree                                                                                   |
| Name the most fun science activity you can remember.                      |                                                                                                                                                   |
| How often do you exercise or are you physically active outside of school? | Never   1-2 times/week   3-4 times/week   4-5 times/week   6+ times/week                                                                          |
| Please give an example of exercises or physical activities that you do.   |                                                                                                                                                   |
| I feel like I know what is going on in science class.                     | Strongly disagree   Disagree   Neutral   Agree   Strongly agree                                                                                   |
| I am confused in science class.                                           | Strongly disagree   Disagree   Neutral   Agree   Strongly agree                                                                                   |
| What makes it most confusing for you?                                     |                                                                                                                                                   |
| I learn in science class.                                                 | Strongly disagree   Disagree   Neutral   Agree   Strongly agree                                                                                   |

APPENDIX B

POST-TREATMENT LIKERT STUDENT ATTITUDE SURVEY

**Astronomy Student Survey**

Name: \_\_\_\_\_

For each statement, indicate if you agree or disagree by circling one of the choices. Participation is voluntary, and you can choose to not answer any question that you do not want to answer, and you can stop at anytime. Your participation or non-participation will not affect your grade or class standing.

| <b>Statement and Questions</b>                                                                               | <b>Circle one of the choices.</b><br><b>For the questions, write your answers in the space provided.</b> |          |         |       |                |  |
|--------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|----------|---------|-------|----------------|--|
| I like school.                                                                                               | Strongly disagree                                                                                        | Disagree | Neutral | Agree | Strongly agree |  |
| What do you like most about school?                                                                          |                                                                                                          |          |         |       |                |  |
| I get good grades in school.                                                                                 | Strongly disagree                                                                                        | Disagree | Neutral | Agree | Strongly agree |  |
| I like science class.                                                                                        | Strongly disagree                                                                                        | Disagree | Neutral | Agree | Strongly agree |  |
| What do you like most about science class?                                                                   |                                                                                                          |          |         |       |                |  |
| I get good grades in science class                                                                           | Strongly disagree                                                                                        | Disagree | Neutral | Agree | Strongly agree |  |
| I always try my best in school.                                                                              | Strongly disagree                                                                                        | Disagree | Neutral | Agree | Strongly agree |  |
| Have you always done this or was there a time (please explain if there was) you didn't always try your best? |                                                                                                          |          |         |       |                |  |
| I always try my best in science class.                                                                       | Strongly disagree                                                                                        | Disagree | Neutral | Agree | Strongly agree |  |
| I would enjoy being a scientist.                                                                             | Strongly disagree                                                                                        | Disagree | Neutral | Agree | Strongly agree |  |
| I plan on continuing my education after high school.                                                         | Strongly disagree                                                                                        | Disagree | Neutral | Agree | Strongly agree |  |
| Science is boring.                                                                                           | Strongly disagree                                                                                        | Disagree | Neutral | Agree | Strongly agree |  |
| What makes it most boring for you?                                                                           |                                                                                                          |          |         |       |                |  |
| I do not like any part of science class.                                                                     | Strongly disagree                                                                                        | Disagree | Neutral | Agree | Strongly agree |  |

| Statement and Questions                                                   | <p align="center"><b>Circle one of the choices.</b></p> <p align="center"><b>For the questions, write your answers in the space provided.</b></p> |
|---------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| The activities we do in science class help me learn.                      | Strongly disagree   Disagree   Neutral   Agree   Strongly agree                                                                                   |
| Which type of activities helps you the most?                              |                                                                                                                                                   |
| The activities we do are fun.                                             | Strongly disagree   Disagree   Neutral   Agree   Strongly agree                                                                                   |
| Name the most fun science activity you can remember.                      |                                                                                                                                                   |
| How often do you exercise or are you physically active outside of school? | Never   1-2 times/week   3-4 times/week   4-5 times/week   6+ times/week                                                                          |
| Please give an example of exercises or physical activities that you do.   |                                                                                                                                                   |
| How often do you participate in the physical exercises in class?          | Never   25% of the time   50% of the time   75 % of the time   All the time                                                                       |
| Why do you participate as often as you do?                                |                                                                                                                                                   |
| I feel like I know what is going on in science class.                     | Strongly disagree   Disagree   Neutral   Agree   Strongly agree                                                                                   |
| I am confused in science class.                                           | Strongly disagree   Disagree   Neutral   Agree   Strongly agree                                                                                   |
| What makes it most confusing for you?                                     |                                                                                                                                                   |
| I learn in science class.                                                 | Strongly disagree   Disagree   Neutral   Agree   Strongly agree                                                                                   |

APPENDIX C

ASTRONOMY SELF-CONFIDENCE SURVEY

Astronomy Self-Confidence Survey      Name: \_\_\_\_\_

This survey is to help both of us understand your level of confidence in your science skills. Rather than thinking about your science skills in general, please indicate how confident you feel about your ability to do the various kinds of problems listed below. (Circle the most accurate response for each.) Participation is voluntary, and you can choose to not answer any question that you do not want to answer, and you can stop at anytime. Your participation or non-participation will not affect your grade or class standing.

| Kinds of Problems                         | Self Confidence in Your Ability to Do Them |     |        |      |
|-------------------------------------------|--------------------------------------------|-----|--------|------|
| 1. Scientific Notation                    | None                                       | Low | Medium | High |
| 2. Significant Figures                    | None                                       | Low | Medium | High |
| 3. Calculating distances                  | None                                       | Low | Medium | High |
| 4. Calculating orbital period             | None                                       | Low | Medium | High |
| 5. Calculating absolute magnitude         | None                                       | Low | Medium | High |
| 6. Determining spectral class             | None                                       | Low | Medium | High |
| 7. Determining luminosity class           | None                                       | Low | Medium | High |
| 8. Identifying types of nuclear reactions | None                                       | Low | Medium | High |
| 9. Calculating nuclear energy release     | None                                       | Low | Medium | High |
| 10. Classifying galaxies                  | None                                       | Low | Medium | High |

At this point, which of the above areas do you feel most confident in?

What makes you feel most confident about performing that type of problem (that you mentioned above)? Can you give me an example?

At this point, which of the above areas do you feel least confident in?

What makes you feel less confident about performing that type of problem (that you mentioned above)? Can you give me an example?

APPENDIX D

INTERVIEW QUESTIONS

Participation is voluntary, and you can choose to not answer any question that you do not want to answer, and you can stop at anytime. Your participation or non-participation will not affect your grade or class standing.

1. How is your year going?
  - a. Probe – Why do you say that?
2. Do you like school?
  - a. What about school do you like or dislike?
3. If you could choose 2 words to describe science, what would they be?
4. Do you like science class?
  - a. What about science class do you like or dislike?
5. What part of science class do you look forward to?
  - a. Why do you look forward to that part?
6. What part of science are you least comfortable with or do you like the least?
  - a. What do you not like about that part?
7. Do you see yourself taking extra science classes next year (as a senior in high school or as a freshman in college)?
  - a. Why or why not?
8. Do you find science interesting?
  - a. What do you find the most interesting about science?
  - b. Why do you not find science interesting?
9. What are some things in class that you like?
  - a. Why did you like this activity?
10. Did this activity also help you learn?
  - a. How did this activity help you learn?
11. Do you feel like you know what is going on in science class?
  - a. What are some things we do in class that help you in knowing what is going on?
  - b. Can you give me an example of when you knew what was or was not going on?
12. Do you feel you are able to successfully complete the activities we do in science class?
  - a. Why do you say that?
  - b. How do you know if you are successful or not?
13. Do you feel like you are learning in science class?
  - a. How do you know if you are or are not learning?
  - b. What activities are the hardest for you?
  - c. What activities do you do that help you learn?
14. Do you enjoy the physical exercises we do in science class?
  - a. What about it do you enjoy or not enjoy?
  - b. Which exercise is your favorite? Why?
  - c. Which exercise is your least favorite? Why?
15. After you do the exercises, do you feel like you can learn easier?
  - a. Do you feel like you can remember information easier?
  - b. What makes you say that?
16. Is there anything else you would like me to know?

APPENDIX E

TEACHER JOURNAL AND REFLECTION OUTLINE

## Observation and Reflection Journal

Date/Period: \_\_\_\_\_ % of class participating: \_\_\_\_\_ Energy rating: \_\_\_\_\_

Today's activity/lesson:

General observations:

Specific student examples:

Quality of teaching:

APPENDIX F

IRB EXEMPTION FORM



**INSTITUTIONAL REVIEW BOARD**  
**For the Protection of Human Subjects**  
**FWA 00000165**

960 Technology Blvd. Room 127  
 Immunology & Infectious Diseases  
 Montana State University  
 Bozeman, MT 59718  
 Telephone: 406-994-6783  
 FAX: 406-994-4303  
 E-mail: cherylj@montana.edu

*Chair:* Mark Quinn  
 406-994-4707  
 mquinn@montana.edu  
*Administrator:*  
 Cheryl Johnson  
 406-994-4706 or 6783  
 cherylj@montana.edu

**MEMORANDUM**  
 .....

**TO:** Killian Gilbreth

**FROM:** Mark Quinn, Ph.D. Chair *Mark Quinn Ch.*  
 Institutional Review Board for the Protection of Human Subjects

**DATE:** November 1, 2011

**SUBJECT:** "The Effects of Kinesthetic Activity on Secondary Science Student Achievement" [KG110111-EX]

The above research, described in your submission of November 1, 2011, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal Regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- ☒ (b)(1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- ☒ (b)(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- ☐ (b)(3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- ☐ (b)(4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- ☐ (b)(5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- ☐ (b)(6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

**Montana State University Institutional Review Board  
Consent to Participate in Research**

**The effects of kinesthetic activity on secondary science student achievement**

**Parental Consent Form**

We invite you and your student to participate in a research study conducted by Kellina Gilbreth for Montana State University. Walter Woodbaugh is the Montana State University faculty advisor for this study. Your participation in this study is voluntary. You should read the information below and ask questions about anything you do not understand before deciding whether or not to participate.

**Purpose of the Study:**

Past research suggests that gentle movements of the body help increase mental focus and concentration. This study compares the effects of these physical exercises on secondary student performance in earth and space science classes. Effectiveness will be evaluated by the use of school documents (homework scores, tests, quizzes), as well as surveys and interviews.

**Duration and Location:**

You student's participation in this study is during normal school hours from mid-November 2011 to mid-April 2012 at Cheyenne Mountain High School.

**Procedure:**

During the first 5 minutes of each 50 minute class period, students will be encouraged to participate in 3 simple physical exercises. These activities can be done while standing or sitting in a chair. Afterwards, class will resume as normal. Data will be collected through student surveys, interviews, regular school documents (homework, quizzes, and tests), and teacher observations.

**Potential Risks and Discomforts:**

Risks involved with this study are minimal but include the possibility of losing balance and falling over while standing during the exercises. To minimize this risk, all of the exercises can be completed while sitting in a chair. We will be asking students throughout the study how they feel during the exercises. If at any time the student feels uncomfortable, they are free to rest or to stop participating in the study.

**Benefits of the Study:**

The possibility of improving student learning through simple physical activity.

**APPROVED  
MSU IRB**  
11/01/2011  
Date approved  
NA  
Expiration date

**Alternatives to Participation:**

All students have the right to choose not to participate in this study. You or your student may also choose to withdraw from the study at any time without penalty.

**Confidentiality:**

When the results of the research are published or discussed in conferences, no information will be included that would reveal your identity.

Your information will be kept confidential and secure by locking forms in a file box. All subjects will be identified by a code number. The list of code numbers with the subject names will be kept in a separate lock box in a different location. All data entered into computers will be password protected. This information will be stored until July 2012 and will be destroyed at that time.

**Participation and Withdrawal:**

Your participation in this research is voluntary. If you choose not to participate, that will not affect your relationship with the instructor or Cheyenne Mountain High School. If you decide to participate, you are free to withdraw your consent and discontinue participation at any time without prejudice.

**Rights of Research Subjects:**

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your student's rights as a research subject, you may contact Kellina Gilbreth, investigator, 719-475-6110 ext 158, [kellina@cmsd12.org](mailto:kellina@cmsd12.org).

APPROVED  
MSU IRB  
11/01/2011  
Date approved  
NA  
Expiration date

**Signature of Research Subject and Parent/Guardian:**

*I have read the information provided above. I have been given an opportunity to ask questions and all of my questions have been answered to my satisfaction. I have been given a copy of this form.*

---

Name of Subject

---

Signature of Subject

---

Date**Signature of Parent/Guardian:**

*I have read the information provided above. I have been given an opportunity to ask questions and all of my questions have been answered to my satisfaction. I have been given a copy of this form.*

---

Name of Parent/Guardian

---

Signature of Parent/Guardian

---

Date**Signature of Investigator:**

---

Signature of Investigator

---

Date

APPROVED  
MSU IRB  
11/01/2011  
Date approved  
NA  
Expiration date