The Mathematical Benefits of Exercise

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This curriculum unit is recommended for:
6th Grade Math (or 5th Grade Honors Math)

Keywords: mean, median, box plot, dot plot, histogram, 6th grade math, exercise, BDNF, brain, research, CTI, exercise and the brain.

Teaching Standards: See Appendix 1 for teaching standards addressed in this unit.

Synopsis: At the completion of this unit, students will use authentic class data to learn how to calculate the mean and median of a set of data, as well as display that data as a histogram, dot plot and box plot. Perhaps more importantly, the students will learn about the benefits of regular exercise, and how it may relate to their own success in school. In this unit, students will take part in an experiment to see if regular exercise before studying for a timed multiplication and division test has any benefit on their test scores. Some classes will serve as the control, and therefore will not exercise before studying and taking their tests. Other classes will be the experimental group, and they will exercise before studying and taking their tests. After four weeks of testing and data collection, students will analyze the data to see if the exercise group had better gains on their tests that the control group. Hopefully, exercise group will show better growth on their test scores, which will convince some students that exercise can help you brain work better, while at the same time learning about proper research study design, and the statistical topics mentioned above.

I plan to teach this unit during the coming year in to 120 students in 6th grade math.

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Aaron Kollar

Background Information

Piedmont IB Middle School

Piedmont IB Middle School is an *International Baccalaureate* school located in Charlotte, North Carolina. *International Baccalaureate* schools are worldwide, and the focus of *International Baccalaureate* schools still adhere to the Common Core State Standards (CCSS), but those standards are taught in a way that teaches the students about global connectedness and cultural identity. Piedmont is also a magnet school, which means the students and families who attend Piedmont do so by choice. The unique makeup of Piedmont creates an amazing climate of driven students that come from a variety of backgrounds. In order to stay at Piedmont for grades 6-8, students must pass all of their classes, avoid any major discipline problems, and volunteer within their community. Twenty hours of community service are required of all 6th graders, twenty five hours of community service are required for all 7th graders, and 8th graders must complete a community service project that they spend a minimum of 30 hours completing. As a result of these requirements, our students learn what it means to help others outside the classroom. In my opinion, it makes our students more humble, and I believe it has a positive effect on our school culture and our discipline.

Using data compiled from the 2014-2015 school year, Piedmont serves 947 students. 68% of our students are African-American, 15% are white, 7% are Hispanic, 7% are Asian, 5% are Multiracial, and 1% are Pacific Islander. Around 50% of our students are on free and reduced lunch, which is another way of saying that about half of our students live in poverty[1]. The fact that we are a magnet school, however, means that those impoverished students go to school with classmates' whose parents are doctors, lawyers, and bankers. Last year, Piedmont was awarded an "A+" rating by the state of North Carolina, based on our test scores. The culture at Piedmont encourages innovation, creativity, and hands on learning. Teachers are comfortable taking risks and conducting lessons that may not be found in an everyday textbook. The administration trusts the teachers at Piedmont to make decisions about what is best for the students of Piedmont, so the teachers do not feel that anyone is looking over their shoulder, and they do not feel as though they need to conform to any certain style of teaching.

At Piedmont, I teach 6th grade Math. As stated previously, we follow the Common Core State Standards in Mathematics. In 6th grade, there are large emphases on Ratios, Proportions, Decimal Operations, Surface Area, Volume, and Measures of Center (among other things). My unit focuses on learning the different ways to calculate a Measure of

Center, as well as the different ways to display a Measure of Center. In the 6th grade at Piedmont, students are split into "Honors" and "Standard" classes. Based on how they do in 6th and 7th grade, our honors students can complete both Math I and Math II in the 8th grade. Math I and Math II are high school courses in Charlotte Mecklenburg Schools, so some of our brightest students will complete two high school courses before they graduate Piedmont. The rest of the honors students will complete Math I in the 8th grade, and our standard students will complete the 8th grade curriculum as laid out in the CCSS (Common Core State Standards). This unit can be done with both honors and standard classes.

Background Knowledge of Students

Each school year, my students come to me with a variety of math backgrounds. Some are great with fractions, but struggle with geometry. Some are great at geometry, but struggle with multiplying and long division. Some are really good at everything, and still some are not strong in any category. Most of them, as a result of too much standardized testing, do have a strong desire to "get the answer" as quickly as possible. They struggle with open-ended questions, and questions that require a lot of perseverance to solve. They have been trained that the answer is always "A", "B", "C", or "D". This type of thinking is appropriate for a multiple choice test, but this type of thinking is less applicable to making an important life decision, inventing something new, solving a problem that has several possible solutions. Most of my students are all either eleven or twelve years old, with the exception of a few students. Despite the differences that my students have as far as their race, household income, math ability, etc., the fact that they are all eleven or twelve years old means that they have much in common. As it pertains to this unit, my students are *supposed to* come to me with knowledge of how to calculate the mean and median of a set of data. In my experience, however, most of them do not remember what mean and median are, let alone how to calculate them.

Rationale and Content Objectives

Rationale

The United States has a health problem. According to the Organization for Economic Co-operation and Development (OECD), in 2012 the United States spent $8,233 per person on health issues. The next two highest spenders, Norway and the Netherlands, spent over $3,000 *less* per person on average. One of the reasons that we spend so much on the health of our citizens is obesity. According to the Center for Disease Control (CDC), the United States has an obesity rate of 36%, which is more than one in three adults. In addition, the obesity problem is getting worse at an alarming rate. According to the CDC, in 1990 the United States had an obesity rate of 23%[2]. The fact that our obesity rate has increased from 23% to 36% in just 25 years is disturbing. With obesity comes a multitude of medical conditions, including but not limited to: asthma, coronary

disease, chronic obstructive pulmonary disease, high blood pressure, diabetes, and cancer.

The most disturbing part of our obesity trend is how obesity is affecting our children. In the United States, 35% of children are overweight or obese[2]. In Charlotte Mecklenburg Schools, 36% of our students are either overweight or obese[3]. As the children of our country grow older, if they turn into obese adults, the economic impacts will be costly. Aside from the economic impact, I think most people would agree that our obesity trend needs to be turned around for the simple fact that we do not want our citizens to suffer with chronic illness as they age.

As most people know, there are two things that one can do to combat obesity. Those two things are to eat a healthy diet and exercise. Going forward in this unit, I will focus on combating obesity through exercise. In 2013, 44% of school administrators reported cutting significant time from physical education and recess so that their students could spend more time focusing on reading and math. I believe these types of cuts to physical education and recess are sending our students the wrong message. We seem to be really good at convincing young students that the best way to get ahead in life is to sit still while focusing on reading and math. The truth, however, is that inactive students do not perform as well in the classroom as their active counterparts.

I believe that if we can reach our children at an age when they are young enough to be able to break any poor health habits they have developed, but old enough to understand how staying active can be beneficial for them, then we can make a change. Middle School students fit this description quite well, and it is my hope that my unit can be something that convinces my students to stay healthy by way of exercise.

A third reason that I want to convince my students to start exercising more, aside from economic and health reasons, is simple. Research strongly suggests that students who exercise more do better in school. A study published by *PLOS ONE* suggests that overall good fitness can enhance learning and memory in children.[4] Another study conducted by Charles Tilman of the University of Chicago noted that 7 to 9 year olds who participated in a 60-minute, after-school exercise class had better focus, processed information more quickly and performed better on cognitive tests than children who didn't exercise.[5] In 2004, the California Department of Education compared test scores and fitness levels from over 1,000,000 5th, 7th, and 9th graders. The results were stunning, as there was almost a direct, positive correlation between a student's physical fitness and their scores on standardized tests.[6] Overall, the amount of research on exercise and cognitive function that has been conducted over the last decade is overwhelming. Of course, it should be noted that the current research provides a *correlation* between exercising and cognitive function, but as of yet the research does not provide *causation* between the two. Scientists, however, are getting closer to understanding, on a cellular level, why staying physically fit helps our brain perform better.

One of the things that researchers are starting to understand more about is a protein in the human brain called brain-derived neurotrophic factor, or BDNF. BDNF acts like "Miracle Gro" for neurons. As a result of exercise, some neurons produce BDNF. When BDNF is produced in our brains, it helps to keep our existing neurons healthy, while at the same time acting as a catalyst to promote new neurons. Healthy existing neurons and the creation of new neurons in our brain allows our brain to, for lack of a better phrase, work better. Because BDNF is released mostly in the hippocampus, cortex, and basal forebrain, it helps to promote the cognitive skills of memory, learning, and higher thinking.[7]

Content Objectives

Based on the reasons previously stated (economic impact, lack of suffering, better learning), the goal of my unit is to convince my students that they should be exercising, while at the same time teaching them about *Measures of Center*, which is a 6th grade math objective. My strategy is to conduct a study, using my own students as the "guinea pigs", that will show the benefits of exercise on learning. When my students see the outcome of my study, they will have no choice but to understand the benefits of exercise. After they process the results of my study, they will use those results to create a poster that displays the mean and median of the data, as well as displays a box plot, dot plot, and histogram of the data. All of these representations of the data are skills that 6th graders must learn as part of the Common Core State Standards.

Teaching Strategies

At my school, we always start the year off by making the students take a 100-question multiplication and division test in five minutes or less. The only way to pass is to earn a 95% or better. When the test is given on the first Friday of the school year, most students do not pass, and several do not come close. The reasoning behind this test is that my teachers and I have found that as elementary teachers teach more *foundational* mathematics in grades 3-5, there is less time for the memorization of math facts. Please note, I do not think this result is a bad thing. In fact, I feel quite the opposite. It is my opinion that when students develop a *conceptual* understanding of math first, they are much better prepared for the problem solving and critical thinking aspects of math that they will encounter down the line. Unfortunately, the conceptual approach does lead to our students coming into 6th grade with less familiarity with math facts. To get them "up to speed", we keep giving them this five-minute, 100-question test until they are able to pass it.

The first part of my unit involves this test. Because I teach four classes a day, two of my classes will serve as the "control" group, and two of my classes will serve as the "exercise" group. For convenience moving forward, I will refer to these groups as the

control group or the exercise group. It is critically important that there is an even distribution of math abilities among the control and exercise group. If, for example, I teach two honors classes and two standard classes, I would put one honors and one standard class in the control group, and I would do the same for the exercise group.

In order to maintain good standards of research, the teacher should not let the students know that they are the subjects of a research study. Telling the students about the study could compromise the results in several ways. Most likely, the students in the exercise group would feel a dose of the placebo effect, which may influence how focused they are when they study for their tests. Conversely, the students in the control group may feel like they are "missing out" if they are not part of the exercise group. Because middle school students love to talk and gossip, I am aware that even if I do not tell them about my research experiment, many of them will discover, on their own, that something different is going on with my classes.

After it is decided which classes will serve as the control group and which will serve as the exercise group, all students should be given the same five-minute multiplication/division test consisting of 100 problems. I usually get my tests from *math-aids.com*, which allows teachers to tailor the test, then it randomly generates that test. After the first week's test, the teacher needs to set aside some time, and I suggest 10 minute study sessions twice a week, for the students to study their math facts. The control group will simply be given ten minutes to study their math facts. The exercise group, however, will do some type of physical activity for 10 minutes, then they will study their facts for 10 minutes. The type of physical activity can vary, as long as it is vigorous, cardiovascular activity. Research has shown that vigorous cardiovascular activity improves working memory, and it is this research that I am trying to replication with the students.[8]

It is important that the type of studying that is done with the control class and the exercise class are the same, in order to lessen any variables that can account for the students' scores moving forward. To help control any variables, all students will use good old fashioned flash cards to study their math facts. The studying will be done as a partner activity, with one student quizzing the other for five minutes, then swapping places for the remaining five minutes. The only difference between how the two classes study for their tests should be that the exercise's group's heart rates are up, after they have done their physical activity.

On test day, the exercise group will repeat the process of having their students perform some sort of 10-minute, vigorous cardiovascular activity, while the control group does not. In the exercise group, I will get the students' heart rates up, let them cool down for two to three minutes, and then administer the five-minute test.

When the students take the test for the second time, the data from the control group and the exercise group need to be processed in a way that can show *improvement* from one test to the next, and it is this *improvement* that will be used to determine if exercise is having a positive benefit on the exercise group's test scores. To keep track of improvement, and not simply just a pass/fail rate, I suggest using what I will refer to as a *growth score*. So in both groups, the teacher will need to keep track of how many points a student improved from the first week to the second week. For example, if a student scored a 65 on the first test, then scored a 70 on the second test, this student would have a "growth number" of +5. If a student scored a 55 on the first test, then scored a 52 on the second test, that student's "growth score" would be a -3.

While students are taking the test in the second, third, and fourth week, it is imperative that the teacher have some sort of enrichment work for the students that have already passed the test. It is unnecessary and repetitive to make students who have already passed the test to take it again. Enrichment provides a great opportunity for *differentiation,* a recent buzz word in education. I suggest the "Math Stars" series of problems which are available for free online, and can also be found on the North Carolina Department of Public Instruction (NCDPI) website.

Because this process (exercise, study…exercise, test) will take up more class time than most teachers are comfortable giving up, this stage of the unit will continue for four weeks. By the end of four weeks there should be enough data to suffice in seeing if the exercise group had better outcomes than the control group.

Here is where things get a little sticky…It is my supreme hope that the exercise group's "growth scores" will show greater gains than the control group's "growth scores". In terms of how to analyze these scores, I suggest making a list of "growth scores" for each class, and using the mean and median of that class as a representation of the overall growth for the class. This way, you can compare honors classes to honors classes, and standard classes to standard classes. It is important to note that if the control group has better scores, or if there is not any significant difference in these scores, the rest of the unit can still be completed as written in this unit. For the purposes of the rest if this unit, I am going to type it with the *assumption* that the exercise group's scores were at least slightly better than the control group's scores.

When the students have completed their fourth test, and have accurately calculated growth scores for every student, it is time to tell the students that they have been unknowingly participating in a research study. I will ask if the students can guess what my hypothesis was (to see if exercising increases their scores on a math test). Because students are constantly talking to each other about the differences in their day-to-day classes, I expect that more than a handful of the students have figured out that some classes have to exercise before studying, while others do not. I will be honest and tell the students why I could not tell them about the study (placebo effect, etc.), and assure the

students that the exercise and control group were chosen arbitrarily, so that they classes do not think that I chose my "favorite" classes to be in the exercise group.

Although not officially part of the 6th Grade Common Core State Standards for Mathematics, it is important to teach students elements of good research study design as they are learning ways to manage and summarize data. It is equally important to teach them different ways to interpret and analyze their results.

At this point in the unit, the students will begin to do their first classroom activity that does not entail exercising, studying for, and then taking a multiplication/division test (detailed classroom activities to follow in this unit). First, I will teach the students about *mean* and *median.* In 6th grade math, students must know a lot about *measures of central tendency*, which begins by knowing how to calculate and interpret the mean and median of a set of data. The teacher should start with an activity, as boring as it may be, where the students simply find the mean and median of three or four sets of data. When the students can confidently *calculate* the mean and median of a set of data, we will turn our attention to *interpreting* the mean and median of a set of data.

After the students practice calculating mean and median, I believe it is important to teach them *when* they should use the mean to represent a set of data, and *when* they should use the median to represent a set of data. The simple answer is, if there is an outlier or two in the data, then the median is usually a better choice – (for more details on this in the "Classroom Activities" section of this unit).

After the students understand the difference between mean and median, and when they are fluent in calculating the mean and median from a set of data, I will share the "growth scores" of all four groups (two exercise groups and two control groups). The students will then work together to calculate the mean and the median of the exercise group and the control group. Hopefully, the exercise group will be at least slightly higher than the control group. Students will also look for any outliers, and determine whether the mean or the median is a better representation of their data.

The next set of lessons involves creating a histogram out of the data. As before, I will first need to teach the kids how to create and interpret a histogram. Just like with mean and median, it is important that students are able to both create *and* interpret a histogram. When they have a concrete understanding of histograms, students should create a histogram out of the data that they have been given regarding the "growth scores" from the two classes.

After the students have calculated the mean/median of their data, and made a histogram out of it, they will to create a dot plot out of the data. This lesson should go quickly, as dot plots are easy to create. Finally, the students will display their data one more way, through a box plot. Because a box plot is far more complicated than

mean/median, histograms, and dot plots, teaching the students how to create and interpret a box plot will take a little bit longer. Moreover, because box plots are so complicated, I will have the students practice creating two or three box plots before even talking about how to interpret one. When students are familiar with how to construct and interpret a box plot, the students will now display their two sets of multiplication/division test data as a box plot. At this point in the unit, the students should have the mean and median of the control classes vs. the exercise class, as well as a histogram, dot plot, and box plot comparing the two classes. It is critical that they can *interpret* the data as well.

The next step in the unit gives the students the opportunity to creatively display their data. They can make a poster, a tri-fold, or a presentation on a computer. These displays will serve as the "official" assessment for this unit. (See the appendix for a rubric for this assessment.) The presentation must include the mean and median of the Exercise class vs. the Control class, as well as a histogram, dot plot, and box plot of the data. Students must also draw conclusions from the data. In a perfect world, an example of a conclusion one might draw from these data may be, "We did better than the control class, because we got our heart rates up through exercise before we studied and before we took our tests. Therefore, I think that exercising helps your brain work better." The students must also explain whether the mean or median is a better representation of this data, and what the different quartiles of the box plot suggest. Because you won't know the outcome in advance, what would you expect/want a kid to conclude if there's no difference (or negative correlation)?

Now that we have a finished product, and the students have drawn conclusions from their data, it is time for an extension. As an extension, my goal is to have the students dig up some research of their own. There is a lot of emerging research, which literally expands weekly, on the topic of exercise and the brain. Each student will be responsible for finding and presenting one study that has to do with the topic of exercise and the brain. Then, assuming the data shows more gains for the exercise group, we can honestly say that we have added one small piece of research to the rest of the existing research.

As an option, going even further, the teacher can have students analyze, or "pick apart" the study that they participated in. The class can have a conversation and explore questions like: *What did the teacher do well to control the study? What could the teacher have done better when setting up this study? Why couldn't we as subjects be in on the hypothesis? What things could have compromised the results of this study?* The students could even do some research to find studies that have had design flaws, bias, or a misrepresentation of the results.

This unit will conclude with one simple writing prompt, which will state, "*Why should I exercise?*" By making the students think and write about this question, it is my hope that it will solidify even more the many benefits that they have learned about exercise through this unit. After the answers to this writing prompt are complete, I will post them

in the room to remind the students of the importance of exercise. As yet another extension, students can make posters with the same title as the writing prompt above.

Classroom Activities

For the classroom activities section of this unit, I am going to skip ahead to the part of the unit where the students start calculating the mean and median, which is *after* they have exercised (or not) and tested for four weeks.

Lesson 1 (After four weeks of testing and data collection) – Calculating the Mean and Median

Students in 6th grade typically have had some exposure to calculating the mean and median of a set of data, but as a teacher, one would be making a huge error if they assume that all of their incoming students know how to calculate the mean and median of a set of data. For this reason, the teacher should take it slow, and practice with the students by taking some notes on how to calculate the mean and median on a set of data. Then, to practice, they can use the worksheet in Appendix 2. It is extremely important that the teacher stresses the meaning of mean and median, and not just how to calculate them.

Obviously, the mean is the average of a set of data, and the median is the middle number in a set of data. But why have both? Before investigating these questions, most students will say that the mean of a set of data is all you need to summarize a set of data. So why do we sometimes use the median to represent a set of data? One way for students to start to understand the importance of having both measures of center is to have them analyze the four questions that they answered on the mean and median worksheet from Appendix 2. If the class has a conversation about problems #2 and #4, they should come to the conclusion (with the teacher's help) that the median is a better representation of the data. In problem #2, there is an outlier on Tuesday, when Jessica only ran 0.5 miles. Jessica's mean distance is 18.4 miles, but she ran over 18 miles every single day except two. Therefore, the median of 21 miles is a better representation of how much Jessica runs on a typical day. Similarly, problem #4 includes an outlier and is another situation where the median is a better representation of the data than the mean. Another powerful example of why we would use the median of a set of data instead of the mean involves average household incomes in the United States. According to the 2011 US Census, the mean household income was almost $70,000, while the median household income was only $50,000. The teacher should prompt the students to talk about the possible explanations for the $20,000 difference between mean and median household incomes. After some discussion, the class should come to the conclusion that this is because there are some people in the United States that make tons of money, which pulls up the mean. Because there are not that many people that make tons of money, the median is less affected by these millionaires and billionaires. The teacher can then share with the class

that, according to the 2011 US Census, only 93 Americans made over $50,000,000 dollars that year, enough money to influence the mean, but it is not enough people to influence the median. During this conversation, the teacher should introduce the word *outlier* to the class as well.

When the teacher is confident that their students are comfortable calculating and interpreting mean and median, they should present the class with the "growth scores" from both the control and exercise groups. The students should then be instructed to calculate the mean and the median of this data. It is important for the teacher to encourage the students to take their time when calculating the mean and median. The reason being, there will be a lot of numbers. Average class sizes in 6^{th} grade are usually around 28-30 students. Therefore, the students will be calculating the mean and median of two groups, possibly of 60 numbers or more in each group. This situation poses a strong potential for error, because the typical 6^{th} grader does not enjoy focusing on something for this long. With strong potential for error, I recommend that the teacher gives the students the growth scores in order from least to greatest for both groups. That way, calculating the median will be a little easier. It is also essential that the teacher has already calculated the correct mean and median ahead of time, in order to re-direct students if the make an error.

Lesson 2 – Histograms

In math, a histogram shows the frequency that a set of data falls within certain intervals of numbers. It looks like a bar graph, but it is different in several ways. In a bar graph, there are typically words at the bottom of each bar, and in a histogram, there is a range of numbers at the bottom of each bar. Also, in a bar graph, the bars are typically separated, while in a histogram, all of the bars touch each other. To construct a histogram from a set of data, the students first need to learn how to create a frequency table. If a teacher were to use some quiz scores, for example, they can use a frequency table such as this one as a model for the students:

QUIZ SCORE RANGE (%)	**NUMBER OF STUDENTS**
100 – 90	~~𝍸~~
89 – 80	~~𝍸~~ I I I
79 – 70	I I I I
69 - 60	I I I

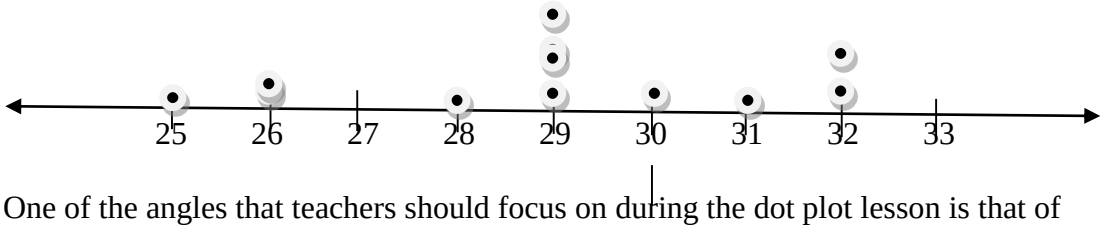
What is important to stress to students here, is that the left side of a frequency table should always display the data with a constant interval, and the right side of the table should have an *amount* of times something occurs within those intervals The teacher should never attach any of the students' names to any quiz or test data like this, and it is a good idea not to display any authentic failing scores. One strategy that is useful to help

students understand the concept of how a histogram works is to have the students brainstorm ideas of questions whose data would be appropriately represented by a histogram. The teacher could give some examples, such as: *What were the weights of all of the dogs at a dog show? (good histogram), What time of day do we eat lunch? (bad histogram), How much money does each one of the Carolina Panthers make per year? (good histogram), How many ounces are in a pound (bad histogram).* According to the 6th Grade Common Core State Standards, students should be able to recognize when a question will result in variability in the data, such as the first and third question above.[10]

After the students understand the concept of a frequency table, and how it relates to the concept of variability, the teacher can show the students how create a frequency table. Students then should be given the growth scores of the control and exercise groups, so that they can construct two histograms that they can compare.

Lesson 3 – Dot Plots

A dot plot, just like a histogram, must represent data with variability. A dot plot is simply a number line with vertical columns of dots that represent the frequency of the numbers in a data set. If the class pondered and researched the question, "How many students are in each homeroom in the sixth grade?", that question could produce a dot plot such as this one:



One of the angles that teachers should focus on during the dot plot lesson is that of interpreting the mean and median from a dot plot. In my experience, most students can easily calculate the mean and median from a set of numbers, but when you give them a dot plot and ask them "what is the mean and median?", they struggle to draw the actual numbers out of the dot plot, even if they understand how a dot plot works. Another mistake that 6th grade students make when creating a dot plot is within the number line. Some students do not see the importance of keeping a consistent interval in the numbers on their number line. If given a set of data that only contains 3's, 5's, 7's, 8's, and 9's, some students will create a number line that only has a 3, 5, 7, 8, and 9 on it, with no allotted space for the 4 or 6. Although this detail seems minute, it is a mistake that I have seen all the way up to high school Algebra students when they are trying to sketch the graph of a quadratic equation.

Now that the students know what a dot plot is, they should construct two dot plots to represent the control group and the exercise group.

Lesson 4 – Box Plots

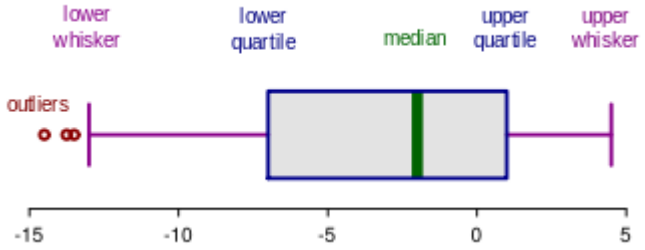
Box plots are not an easy thing for a 6th grader to wrap their head around. So, when teaching box plots, the teacher needs to remain calm, patient, and be ready for as many anticipated errors that they can think of. Learning how to construct a box plot requires memorizing a few steps, and learning how to interpret a box plot involves a lot of trial and error on the learner's part. When I teach my students how to create a box plot, I teach it through the following steps.

1. Find the median of your numbers.
2. Split your set of numbers into an upper and lower half. If you only had one median, you DO NOT include it in either your upper or lower half. If you had 2 medians (and had to find the average of them), you include one in the upper half of your numbers and one in the lower half of your numbers.
3. Find the median of your lower and upper half of numbers. These are called the first and third quartiles, or the lower and upper quartiles.
4. Identify the smallest and biggest number. These are called the maximum and minimum, or the upper extreme and the lower extreme.
5. Create a 5-number summary of your data in a table similar to this one:

Minimum	**Lower Quartile**	**Median**	**Upper Quartile**	**Maximum**

6. Create a number line that extends from slightly below minimum to slightly above the maximum.
7. Place a dot above each number in your 5-number summary. Connect the minimum to the lower quartile with a straight line. Connect the upper quartile to the maximum with a straight line. Draw a rectangle from the lower quartile to the upper quartile. Draw a line through your rectangle at the median.
8.

Although there are many variants to exactly how a box plot looks, the standard 6th grade box plot looks similar to the image below:



After the students can create a box plot, it is important that they know how to interpret one. Box plots are useful in showing the spread of a set of data, and the ranges that the numbers of a set of data fall into. Many students mistakenly think that in a box plot, if a box or line is *longer* than the other boxes or lines, it means that there are *more* numbers

in that given quartile. This conclusion is not accurate. In any given box plot, the amount of numbers in each quartile is the same (or very close to the same), and students typically have difficulty understanding this concept, even after they have been given the opportunity to construct a box plot. One would assume that after constructing a box plot, and seeing that each quartile has the same number of numbers in it, that this would be obvious, but I assure you that for 6th grade students, it is not.

By now, the students should be used to the data of the control and exercise groups. Because the students already know the median of the data, at least one part of creating a box plot from the data is already done. While students create box plots of the experiment data, the teacher should be ready to pull a small group of students and work with them, as there will almost certainly be some students that are overwhelmed by the length of the process.

Lesson 5 – Introducing the Final Product

The final product of this unit will also serve as its assessment. The assessment of this unit will test how well the student can construct and interpret the median and mean of our exercise experiment's data, as well as create a histogram, dot plot, and box plot of the data. Along with these visual representations of the data, students will also have to interpret and explain, either orally or in written form, each representation of the data. Students can choose to make a poster, tri-fold, computer presentation, or a video to display their results. The students will also be required to submit a 1-2 page written evaluation of the experiment. This evaluation is really open ended and the students should not feel the need to satisfy any certain requirements when they write their evaluation. They will be graded on the accuracy of their representations of the data, as well as their interpretations and explanations of each representation. For a rubric for this final product, please see Appendix 3.

Appendix 1: Implementing Teaching Standards

The teaching standards that this unit addresses come from the Common Core State Standards (CCSS). The CCSS are broken down into five major topics, which are: *Ratios*

and Proportions, Number Sense, Geometry, Expressions and Equations, and *Statistics and Probability.* This unit focuses on teaching from the topic of *Statistics and Probability.* In 6th grade, under the topic of *Statistics and Probability* students are expected to learn about the different measures of center, and how to appropriately display measures of center. The measures of center that 6th grade students are expected to master are *mean, median,* and *mean absolute deviation*. Students are expected to be able to create and interpret a *histogram, dot plot, and box plot* to display a set of numerical data. Students should also be able to distinguish the difference between a statistical (or numerical) question, such as "How many pets do you have?", and a categorical question, like "What is your favorite color?"

Using test data as our set of numerical data, this unit teaches how to calculate and interpret the mean and median of the data. Then, the students will learn how to create and interpret a histogram, dot plot, and histogram. Eventually, the students will create a display of their class' data in the form of a histogram, dot plot, and histogram.

The specific Common Core State Standards that are addressed are as follows[10]:

- *CCSS.Math.Content.6.SP.A.3* - Recognize that a measure of center for a numerical data set summarizes all of its values with a single number, while a measure of variation describes how its values vary with a single number.
- *CCSS.Math.Content.6.SP.B.4* - Display numerical data in plots on a number line, including dot plots, histograms, and box plots.
- *CCSS.Math.Content.6.SP.B.5* - Summarize numerical data sets in relation to their context, such as by:
    - *CCSS.Math.Content.6.SP.B.5.a* - Reporting the number of observations.
    - *CCSS.Math.Content.6.SP.B.5.b* - Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.
    - *CCSS.Math.Content.6.SP.B.5.c* - Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.
    - *CCSS.Math.Content.6.SP.B.5.d* - Relating the choice of measures of center and variability to the shape of the data distribution and the context in which the data were gathered.

Appendix 2: Mean and Median Worksheet

MEAN AND MEDIAN

1. Juan is taking a survey of his classmates' shoe sizes. His results are in the table below. Calculate the mean and the median of his data.

Student Number	**Shoe Size**
1	8
2	4
3	5
4	5
5	7
6	3
7	10
8	6

2. Jessica is getting ready for a marathon. Each day, she records the amount of miles that she runs. On Tuesday, she did not feel well, so she had to stop after only a ½ mile. Calculate the mean and median of Jessica's distances.

Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
18	0.5	22	23	21	19	25

3. Every time it snows, Mark writes down how many inches of snow stick to the ground. So far, he has recorded the snowfall (in inches) as:

   1 , 2 , 5 , 3 , 5 , 2 , 3 , 1 , 1 , 6 , 3 , 2

   What is the mean and the median of Mark's data?

4. Rebecca is the starting point guard for her school's basketball team. So far, through 7 games, she has scored the following amount of points. What is the mean and median of Rebecca's point total?

Game 1	18 points
Game 2	16 points
Game 3	22 points
Game 4	3 points
Game 5	20 points
Game 6	23 points
Game 7	17 points

Appendix 3: Rubric for Final Product

Rubric for **Experiments with Exercise** Final Product

	0-5 Points	0-5 Points	0-5 Points
Mean and Median	Mean and Median are accurately calculated.	Mean and Median are displayed in a way that is clear to the audience.	Student can accurately interpret and explain the mea and median
Histogram	The Histogram is accurately aligned with the data.	Histogram is displayed in a way that is clear to the audience.	Student can accurately interpret and explain the histogram
Dot Plot	The Dot Plot is accurately aligned with the data.	Dot Plot are displayed in a way that is clear to the audience.	Student can accurately interpret and explain the dot plot
Box Plot	The Box Plot is accurately aligned with the data.	Box Plot are displayed in a way that is clear to the audience.	Student can accurately interpret and explain the box plot
Written Summary	The summary is a well thought out, thorough evaluation of the entire experiment.	The written summary is grammatically correct.	The written summary is neat

TOTAL = 75 points

Notes

1. "Piedmont Open Middle School." - Charlotte, North Carolina. Accessed October 26, 2015. http://www.greatschools.org/north-carolina/charlotte/1278-Piedmont-Open-Middle-School/details/.

2. Kane, Jason. "Health Costs: How the U.S. Compares With Other Countries." PBS. Accessed October 28, 2015. http://www.pbs.org/newshour/rundown/health-costs-how-the-us-compares-with-other-countries/.

3. "Adult Obesity Facts." Centers for Disease Control and Prevention. September 21, 2015. Accessed October 28, 2015. http://www.cdc.gov/obesity/data/adult.html.

4. Cooke, Kim. "Physical Education." Charlotte Mecklenburg Schools Health and. Accessed October 28, 2015. http://www.cmshpe.com/physical-education.html.

5. Raine, Lauren B., Hyun Kyu Lee, Brian J. Saliba, Laura Chaddock-Heyman, Charles H. Hillman, and Arthur F. Kramer. "The Influence of Childhood Aerobic Fitness on Learning and Memory." *PLoS ONE* 8, no. 9 (2013). doi:10.1371/journal.pone.0072666.

6. Deardorff, Julie. "The Best Brain Exercise May Be Physical." Chicagotribune.com. Accessed October 29, 2015. http://www.chicagotribune.com/lifestyles/health/sc-hlth-0506-exercise-for-the-brain-20150430-story.html.

7. "Program Resources." - Physical Fitness Testing (PFT) (CA Dept of Education). Accessed October 29, 2015. http://www.cde.ca.gov/ta/tg/pf/pftresources.asp.

8. Ratey, John J., and Eric Hagerman. *Spark: The Revolutionary New Science of Exercise and the Brain*. New York: Little, Brown, 2008.

9. Sardinha, Luís B., Adilson Marques, Sandra Martins, António Palmeira, and Cláudia Minderico. "Fitness, Fatness, and Academic Performance in Seventh-grade Elementary School Students." *BMC Pediatrics BMC Pediatr* 14, no. 1 (2014): 176. doi:10.1186/1471-2431-14-176.

10. "Grade 6 » Statistics & Probability." | Common Core State Standards Initiative. Accessed October 31, 2015. http://www.corestandards.org/Math/Content/6/SP/

Annotated List of Readings for Teachers

Raine, Lauren B., Hyun Kyu Lee, Brian J. Saliba, Laura Chaddock-Heyman, Charles H. Hillman, and Arthur F. Kramer. "The Influence of Childhood Aerobic Fitness on Learning and Memory." *PLoS ONE* 8, no. 9 (2013). doi:10.1371/journal.pone.0072666. This study compared how kids who participated in an after school physical activity club and kids who were not getting physical activity after school and how they performed on certain cognitive tasks. The results, which are really well explained with words and graphs, show that the more physically active kids did better on the cognitive tasks.

Ratey, John J., and Eric Hagerman. *Spark: The Revolutionary New Science of Exercise and the Brain*. New York: Little, Brown, 2008. Perhaps one of the most extensive pieces of literature available on the topic of exercise and the brain. John Ratey has made it his mission to spread the word about the effects of exercise on our brain, and he does a really good job in this book. If someone needs convincing that there is a link between exercise and cognitive function, I highly recommend they read this book.

Deardorff, Julie. "The Best Brain Exercise May Be Physical." Chicagotribune.com. Accessed October 29, 2015. http://www.chicagotribune.com/lifestyles/health/sc-hlth-0506-exercise-for-the-brain-20150430-story.html. This article, written in the Chicago Tribune, is a pretty nice summary of not only some of the current research looking at exercise and thinking, but it also explains some of the science behind it. Since it is a major newspaper, it explains things that are in layman's terms.

Baker, Al. "Despite Obesity Concerns, Gym Classes Are Cut." The New York Times. July 10, 2012. Accessed October 26, 2015. http://www.nytimes.com/2012/07/11/education/even-as-schools-battle-obesity-physical-education-is-sidelined.html?_r=2. As the title suggests, this article provides evidence that cutting gym classes in favor of more math and reading does not produce the intended results. In addition to the lack of academic gains, cutting gym classes is also a bad idea because of the growing obesity problem in this country.

Annotated List of Readings for Students

Ayan, Steve. "Smart Jocks." *Scientific American Mind Sci Am Mind* 21, no. 4 (2010): 42-47. doi:10.1038/scientificamericanmind0910-42. This article debunks the notion of the "dumb jock" by providing evidence that students in school that get regular exercise tend to also do better in the classroom.

Ratey, John J., and Eric Hagerman. *Spark: The Revolutionary New Science of Exercise and the Brain*. New York: Little, Brown, 2008. Perhaps one of the most extensive pieces of literature available on the topic of exercise and the brain. John Ratey has made it his mission to spread the word about the effects of exercise on our brain, and he does a really good job in this book. If someone needs convincing that there is a link between exercise and cognitive function, I highly recommend they read this book.

Wallace, Kelly. "Kids Have Three times Too Much Homework, Study Finds - CNN.com." CNN. Accessed October 28, 2015. http://www.cnn.com/2015/08/12/health/homework-elementary-school-study/index.html. This article will probably justify what many students feel all the time, and that is the fact that they might have too much homework to do. This article shows that many teachers and schools do not follow the recommended protocol for how much homework students of different ages should have.