Curriculum Unit Title

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This curriculum unit is recommended for:
Mathematics Grades 6-9, Algebra I, Algebra II, and Geometry

Keywords: algebra, geometry, sports, sports analysis, Pythagorean theorem, Pythagorean expectation, statistics, probability, surface area, ratios, percents, tables, graph, decimals

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

Synopsis:

This middle school mathematics unit is taught in the second semester of the school year as a review and reinforcement of pre-algebra concepts that were taught in the first semester. This unit is used as a complement to middle school mathematics courses that are taught in sixth, seventh and eighth grade classrooms in North Carolina. This unit is used to show the real-life application and connection of ball sports to algebraic math concepts. Students will examine the ball sports of football, basketball, soccer and baseball through a variety of activities.

By combining math instruction with activities involving sports, students will have a better opportunity for grasping complex concepts and how they are used in the real world. By showing students how math and science concepts are used in the design and participation of sports, students will be able to have fun with sports while gaining a better understanding of complex math concepts in algebra and geometry. This unit will correlate and combine developing math skills, research skills, writing skills, and speaking and presentation skills. Students will be able to explore the real world mathematical concepts involved in sports activities while they are able to develop creative ideas and projects.

I plan to teach this unit during the coming year to 18 students in Horizons 5th Grade, Mathematics 6-9th Grade.

Mathletics are Fun!: Analyzing Ball Sports with Pre-Algebraic Concepts

Lisa Ashworth

Rationale

Many students struggle with visualizing how complex math concepts are applied in the real world. Students often feel that they are asked to memorize formulas and theorems and only use them to compute answers for exercises and tests. For example, the Pythagorean Theorem, as well as formulas involving volume or surface area, or solving equations using combinations and permutations can become painstaking processes that a student must endure to survive higher math classes.

On the other hand, many students enjoy participating in sports, watching sports, or even inventing new "sports" or "games" for entertainment. They enjoy the excitement of competitive sports or games. They also enjoy discussing college and professional teams and analyzing their successes or failures.

By demonstrating how key pre-algebra concepts are used in sports, students will be able to see how math is an integral part of real world sports. When students see a clear purpose for a math formula or a concept, they can internalize the math concept, and they can improve their understanding of how the math applies usefully in the real world.

Introduction

Barringer Academic Center is an elementary school in Charlotte, N.C., that contains students in kindergarten through fifth grade. The school contains students that have a wide range of abilities. There are students who perform at a basic academic level all the way up to those who perform at a high academic level. The Horizons program is a kindergarten through fifth grade academic program within Barringer for students who are classified as highly gifted. The curriculum for the Horizon students is accelerated two to three years above their current grade level. The students who will be participating in this math and sports curriculum unit are in the third through fifth grade of the Horizons program. These students use middle school math curriculum which includes pre-algebra, algebra, and geometry concepts. These students study and master many advanced math concepts in seventh through eleventh grade math curriculum. While they learn math concepts that are several years above their fifth grade peers, they are still ten and eleven year olds who like to play and watch many sports as well as make up many new games and activities while they are at school recess time. These students learn many of their math concepts through inquiry-based activities in the classroom. They often enjoy discovering new ideas or designing new games or activities that correlate with their math and literature curriculum.

The city of Charlotte, North Carolina, is a major center for the automobile racing sport known as NASCAR. Charlotte is also home to the professional football team known as the Panthers and the professional basketball team known as the Bobcats. There is also a minor league baseball team called the Charlotte Knights. The Charlotte area is also home to two major

colleges, Davidson College and the University of North Carolina at Charlotte, which offer multiple college sports teams including competitors in basketball and football. In addition to the many sporting events that Charlotte students have exposure to in the region, students also have the opportunity to play sports on league teams throughout the area. A brief survey of these students indicates that many of the third through fifth grade Horizons students are involved in soccer teams, and they often choose to play soccer during recess at school.

By combining math instruction with activities involving sports, students will have a better opportunity for grasping complex concepts and how they are used in the real world. Many students feel that competitive sports are fun to watch, play, and analyze. By showing students how math and science concepts are used in the design and participation of sports, students will be able to have fun with sports while gaining a better understanding of complex math concepts in algebra and geometry.

This unit will correlate and combine developing math skills, research skills, writing skills, and speaking and presentation skills. It will provide the differentiation needed to meet the varying needs of developing creative skills in my students. Students will be able to explore the real world mathematical concepts involved in sports activities while they are able to develop creative ideas and projects. This is a key element to creative problem solving and an important skill for my students to continue to develop.

Classroom Background

As one of five Horizons teachers at Barringer, I am responsible for twelve to fifteen students who are working in three different math textbooks with pre-algebra and geometry concepts that range in sixth through eighth grade level. These students are from third through fifth grade classrooms in the Horizons program. They received pre-assessments at the beginning of the school year in order to group them with similar students in their ability range. I am responsible for individualizing and differentiating each student's curriculum to fit the abilities of each student. Some of the students are operating at two years above their current grade level, while others are four to five years above grade level.

Within my Horizons math classroom, I often have to plan for individual or paired math instruction for my students. I introduce new concepts in groups of two, three, or four students with oral instruction using a textbook, Smart Board, and manipulative objects. Following this introduction to new concepts, students are "set free" to work at their own pace through the investigations of the Pearson Connected Mathematics textbooks. Students demonstrate their understanding through classwork investigations, peer tutoring, verbal observations, as well as formal assessments. Because students are working at their own pace, they need time and experiences with hands-on activities in order to explore the new concepts that they are learning. It is also important that they have opportunities to create new ideas and applications using these math concepts. They also need the opportunity to share and present these new ideas and applications within the classroom.

By incorporating sports activities and analysis into my math curriculum, students will have the opportunity to explore fun, creative ways to learn and apply these middle school math concepts. Students will have the opportunity to see how math concepts such as statistics,

probability, surface area, ratios, percents, tables, graphs and the Pythagorean Theorem have an important role to play in the execution of many sports.

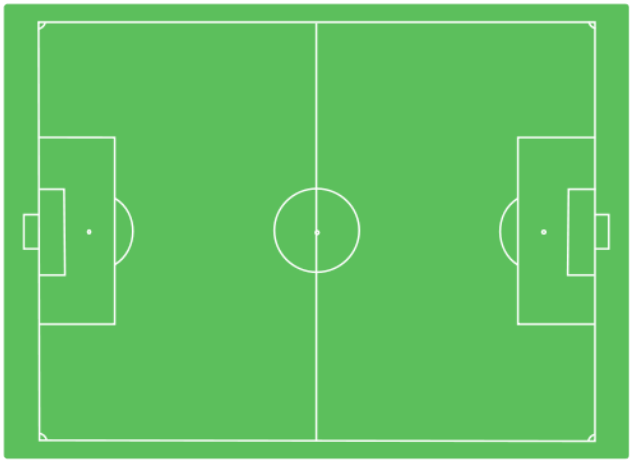
Mathematical Content Objectives

Numbers and Operations Standards for Grades 6-8

Students will design a fantasy football team while exploring relationships between numbers using fractions, decimals and percents to solve problems that determine how well their fantasy team is performing from week to week during the NFL season. Students will compare and order fractions, decimals, and percents. They will use ratios and proportions to represent quantitative relationships.[1] They will sharpen their calculator skills as they compute exponents and use scientific notation. They will also need to review their skills of prime factorization. Students will need to easily compute arithmetic operations with fractions, decimals, and integers as well as use the associative, commutative, and distributive properties of addition and multiplication. Students will also acquire a better understanding of the different uses of variables. As the students practice these concepts each week while computing real world NFL statistics, they will see how their fantasy teams are impacted by the real world "numbers" of the statistics. The numbers in the statistics will have meaning for the students as they attempt each week to see if the team of players they assembled is a winning team.

Measurement Standards for Grades 6-8

Students in my previous classes have loved playing soccer at recess. They have often discussed designing a soccer field on our school playground and asking PTA to help financially support this activity. I would like for the students in this class to design a soccer field for Barringer Academic Center and submit it to the PTA Board for review. Students will use the mathematical concepts of area, angles, shapes, surface area, and measurement in order to design their own soccer field at school. They will be able to draw, construct, and describe geometrical figures and how they relate to one another as they design their soccer field.



I would also like to have them examine how a soccer ball is designed and what shapes, angles or measurements go into designing this ball. Students will practice designing a soccer ball using tiling patterns. Students will also be interested to know that a new soccer ball is designed for every World Cup. There are engineers who study the seaming pattern of a soccer ball and how that impacts the flight of the ball when it is kicked. In the 2001 World Cup qualification match, David Beckham made a memorable goal that led sports engineering researchers at the University of Sheffield to study his goal from an aerodynamic perspective[2](Chartier, p. 1). I have an internet web link under the classroom activities to show the students how math is used in the design of soccer balls and the techniques used to strategically kick them for successful goals.

Statistics and Probability using the Pythagorean Expectation

In baseball's Pythagorean Expectation, students will learn and use the Pythagorean Theorem and baseball statistics from major league teams as well as Charlotte's minor league team the Charlotte Knights. The use of the Pythagorean Theorem is transformed into a formula called the Pythagorean Expectation[3](*Mathletics*, Wayne L. Winston). Students will examine statistics of several baseball teams and try to predict whether they will have a winning or losing season. By plugging in the statistics of runs scored and runs allowed into the Pythagorean Expectation formula, it is possible to acquire an estimate of the percentage of games won in a season.

$$\text{winning } \% = \frac{(\text{points scored})^2}{(\text{points scored})^2 + (\text{points allowed})^2}$$

This information can help sports statisticians predict whether they think teams will have a winning or losing season. The common core standard for statistics and probability includes investigating chance processes and evaluating probability models.

Ratios and Proportional Relationships

Students will use the sport of basketball to study the mathematical concepts of ratio tables, relationships between tables, percents and graphs as well as statistics and probability. I would like students to examine the salary systems for professional basketball players. I think that they would find it very interesting how teams arrive at the salary amounts. They could use player statistics to analyze proportional

relationships. These proportional relationships would be used to solve real world math problems. Students will use these statistics and ratios to make a determination of what most impacts the salary of a professional basketball player.

Writing Content Objectives

This unit will correlate and combine developing math skills, research skills, writing skills, and speaking and presentation skills. It will provide the differentiation needed to meet the varying needs of developing creative skills in my students. Students will be able to explore the real world mathematical concepts involved in sports activities while they are able to develop creative ideas and projects. This is a key element to creative problem solving and an important skill for my students to continue to develop.

Students will have a choice of completing a math and sports project that explores their own unique multiple intelligences. Students can design a new sport or changes to an existing sport such as "Walleyball." Students can design a new sports complex or a sports activity field or area. Students can design a new piece of sports equipment or clothing item for that sports activity. Students could design a new "league" or "team" within an existing sport. The two main requirements of this project are that the project must be related to sports, and it must contain a minimum of two middle school mathematical concepts that he/she is learning in math class.

Classroom Strategies

This seventh grade math unit should take approximately six to eight weeks to teach. It is important for students to have lots of hands on activities in order to adequately grasp the mathematical concepts associated with statistics, probability, geometry, number sense and the Pythagorean Theorem. In addition to class discussions, sports videos, math games and tricks, as well as practicing the math concepts in their textbook, *Connected Mathematics (for grade 7 and 8),* students will examine a variety of sports and statistics involved with those sports.

The first strategy in the teaching of this unit will be instruction of background knowledge and history. Students will begin the unit with background knowledge of a variety of sports and their origin. The classroom discussions will include how these sports include a variety of math concepts. The second major strategy in the teaching of this unit will offering hands-on instruction opportunities. Students will conduct and participate in projects, math games, cooperative learning, think-pair-share activities, as well as inquiry based instructionusing data analysis and research. By utilizing background knowledge and multiple hands-on experiences, students will be able to connect the concepts of seventh grade math with their everyday experiences of sports.

I will begin this unit of study first with whole group instruction on the basic concepts of numbers and operations, geometry, statistics, probability, ratios, percentages, as well as tables and graphs. After the whole group instruction, the class will be divided up into small groups to complete the different sports activities of this unit. In both whole group instruction and small groups, students will analyze the mathematical aspects that apply to different sports activities.

All of the concepts learned throughout this unit will be used to make connections, as the students are given opportunities to apply crucial math concepts dealing with probability and statistics with different sports activities.

Students will create tangible models to reflect understanding of operations with fractions, equivalent fractions, and mixed numbers. (Specific examples can be found within the classroom activities section of this unit.) I will conduct group discussions to informally assess everyone's understanding for adding and subtracting fractions, equivalence of fractions, and mixed numbers; as well as through formal assessments done in class. I will use hands-on models for them to actually see what they are doing while collaborating with their peers. I believe this will also help as they learn about mixed numbers.

Another important strategy that I will use in this unit is the development of research skills. I want students to increase their ability to conduct research and succinctly summarize the information that they find. They will use this research to analyze the mathematical concepts used in sports activities. They will also use their research skills to help design a new sports activity that consists of complex math skills involved in algebra and geometry.

Classroom Activities

Introductory Activities

History of Mathematical Design in Sports

Students will study the history and mathematical design between different sports in history. I will first model this activity by introducing the sport of *Wallyball*, which is also known as rebound volleyball. Like many other sports, math is used in many different aspects of the game to include the court, net and ball specifications, as well as the rules of the game. All the information needed for explaining this sport can be found at http://www.wallyball.com. There are also several YouTube videos that demonstrate how the game is played as well as the rules that involve mathematical concepts such as measurement and numbers and operations. After modeling how math is used in the sport of *Wallyball*, I will ask students to work in pairs and research a sport that they are interested in learning more about how mathematical concepts are used in those sports. The students will present their findings orally and in a short (3-5 minute) technology presentation such as Power Point or a Presi to the rest of the class.

Math and Sports and The Hobbit

Another introductory activity will be carried out during the reading and study of the fantasy novel known as *The Hobbit*. In the beginning chapters of the novel, the creative origin story of golf is included to arouse interest in sports played in *Middle Earth*. After the students read the story about golf in the novel, one of the writing activities will be to write their own origin story for another sport. Their origin story must include the math that is used in the implementation of the sport.

Activities Using Math and Sports in Today's Society

Activity One: Fantasy Football

This activity will utilize the book, *Fantasy Football and Mathematics*, by Dan Flockhart. The purpose of this activity is for students to create and manage a team from professional football teams. Students compete against each other by keeping track of points that their "created" team earns during the season. The teams can earn points by scoring touchdowns, two-point conversions and accumulating passing, rushing, and receiving yards. The teams can lose points for interceptions thrown and fumbles lost. Each week, students add up the sum of the points that their team has earned through their players. The ultimate goal is for a team to acquire the most number of points in a week and eventually, in a season.

Students begin this activity by selecting players for their teams. The teacher first begins by asking for students in the classroom who are familiar with the sport of football to explain what the role is for the following players: quarterback, running back, wide receiver, kicker, and team defense. Those students with background knowledge of football are asked to share their expertise of the basic rules of football as well as the roles of major positions. Next, the teacher provides the students with a list of players and their costs. Each team is allowed a $40 million budget to select eleven professional players and two team defenses. These players range in costs from one million to five million dollars. Students are challenged to use their number and operation skills in order to keep their team selection within their budget. The team roster consists of two quarterbacks, three running backs, four wide receivers, two kickers and two team defense players. An example of the roster sheet is included in appendix 1 of this curriculum unit.

Each week (after the Monday night football game), students access the box scores from several different sources including www.espn.com, www.fantasysportsmath.com, and various other online newspapers. Teams can earn points for the following football actions:

- Kicks: point after touchdowns 1/48 or .021
- Field goal 1/16 or .063
- Touchdown 1/8 or .125
- Two point conversion 1/24 or .042
- Touchdown by a defense 1/8 or .125
- Safety by a defense 1/24 or .042
- Interception -1/12 or -.083
- Fumble -1/16 or -.063
- Passing Yards 1/48 for every 25 yards
- Rushing or receiving yards 1/48 for every 10 yards

Students access the statistics for each of their team members and then multiply them with the previous amounts to calculate the points that their team members earned for that week. This weekly scoring worksheet is also included in appendix 1. The subsequent equation is used to calculate the total points earned by the quarterbacks, running backs, and wide receivers in a week. The students use this equation with each player that participates each week to calculate a point total for that player. Some players may get more playing time than others, but that is a risk that a student takes when he/she chooses a player. The totals of each player are then added together to acquire a team total for the week.

$$\frac{1}{8}(T)+\frac{1}{24}(V)+\frac{1}{48}(P+R+C)-\frac{1}{12}(I)-\frac{1}{16}(F)=W$$

The variables in the equation stand for the following:

- T= number of touchdowns scored by passing, rushing, or receiving
- V= number of two-point conversions scored by passing, rushing or receiving
- P= number of passing yards divided by 25, then rounded down to the nearest whole number
- R= number of rushing yards divided by 10, then rounded down to the nearest whole number
- C= number of receiving yards divided by 10, then rounded down to the nearest whole number
- I= number of interceptions thrown
- F= number of fumbles lost
- W=total points scored for one week for individual player

When the students have completed computing their points each week for their teams, they are asked to summarize their findings in a graph. This graph can be in the format of a pie graph, a line graph or a bar graph. The students enjoy the friendly competition of comparing their team scores each with their classmates' scores each week. This project can last up to sixteen weeks during football season, or you can decide to shorten the competition by conducting the Fantasy Football competition a shorter number of weeks.

*Activity Two: Soccer Activities Involving Measurement and Tilin*g

Many of my students enjoy playing soccer at recess and on league teams outside of school. Students will be interested to learn how math plays a significant role in the development of a soccer ball. Algebra, geometry, and topology are all used to design the most effective ball in a competitive soccer match in the World Cup. An introductory activity for students would be to play a podcast that Tim Chartier gave for the American Mathematical Society where Chartier explains how math such as computational differential equations are used to design the most effective ball possible. The link to this podcast is http://www.ams.org/samplings/mathmoments/mm65-soccer-podcast. I think that students will find it fascinating to see the impact that complex math concepts have on the design of a soccer ball.

The first soccer activity involves examining the measurement specifications for designing a soccer field. The class will be divided into groups of four students, and they will be tasked to research what the current specifications are required for constructing a regulation soccer field for various types of soccer teams from little league teams of elementary students to professional teams who compete in the World Cup Championships. Students will examine the shapes (square, rectangle, circle, half-circle, and line) used in designing a soccer field along with the angle measurements and line measurements within the soccer field. The next step of this activity will be for the groups of four to begin to design a soccer field on the lower playground at our school that will fit alongside the other playground equipment that currently exists. The students may have to use mathematical ratios to shrink a regulation soccer field into a field that can work within the parameters of the current playground. The students will also need to investigate what type of goal posts/nets should be purchased by the PTA to use on this soccer field. After all of the research and planning have been done for this project, each team of four students will be

asked to present their findings for our current classroom. Following the presentations, the class will vote as to which plan would be the best to submit and present to the current PTA board.

The second soccer activity involves using tiling to design a soccer ball. Students will examine the Wikipedia webpage, http://en.wikipedia.org/wiki/Spherical_polyhedron , for information on spherical tiling and how tessellations work with spherical shapes. Students will be divided up into groups of four and they will be given a set of *Zome Tools* in which they can create a 3-dimensional polyhedron that would resemble a soccer ball. A fun way for students to see if they have created spherical tessellation resembling a soccer ball is to have them dip their Zome Tool creation in a bubble solution so that they can see the faces of the ball through the bubble solution that creates a tessellation. They will also be given KNEX pieces to design other 3 dimensional shapes that could be viewed as tessellations of other polyhedrons. Another way of demonstrating spherical tiling would be to construct a 3-dimensional polyhedron by folding paper into shapes that resembles soccer balls.

Activity Three: Baseball and the Pythagorean Expectation

Before students begin learning what the Pythagorean Expectation is and how it pertains to professional baseball, they will complete two warm-up activities that deal with reading and understanding statistics. The first introductory activity depicts professional baseball attendance statistics in a table and asks students to portray these statistics in a scatter-plot graph. Two important seventh grade math skills that students use in this activity are determining what statistics/variables go on the "x" and "y" axis as well as how to develop the appropriate scales on their graphs to plot their points. The statistics for this activity are from collected attendance numbers of the 1997 National League baseball games as well as the population of the cities where the teams are located. This student activity sheet is found on page 43 in a student activity workbook entitled *REAL-LIFE MATH: Tables, Charts, and Graphs* by Tom Campbell. The teacher's guide for this activity is found on page 42 of this activity book.

Another warm-up activity for baseball is to have students practice reading and interpreting professional baseball box scores. This will help students better analyze statistics before they begin the Pythagorean Expectation activity. In another activity from the book, *REAL-LIFE MATH*, students will be given the box scores from Game 1 in the 1997 World Series between the Florida Marlins and the Cleveland Indians. Students are asked to examine the box scores for this game and answer ten questions about the game. The box scores, student activity questions, and teacher's guide are found on pages 18-20.

The third activity involves evaluating the success of baseball teams in a season and helps sports statisticians predict future success of these baseball teams. The Pythagorean Expectation is a formula used by statisticians to estimate how many games a baseball team should have won in a season based up the number of runs that they scored and allowed.

$$\text{winning } \% = \frac{(\text{points scored})^2}{(\text{points scored})^2 + (\text{points allowed})^2}$$

This formula can also be examined to look at how lucky a team was in a season based on comparing the actual winning percentage with the Pythagorean Expectation winning percentage. This theorem has also been used in other sports. For example, in any sports where the formula is found predictive one can compare a team's success to the formula's predictive success. If this is done mid-season, for example, one can gain insight on the team's possible success for the second half of the season. For example, a "lucky" team half way through the season may have it's luck "run out" and not perform as well in the second half. This formula can offer such insight.

Within a classroom of 18 students, students will be asked to look up stats in baseball for a year of their choosing in order to check the validity of this theorem. I will model this activity using 2013 Major League Baseball data[4]. The data for the Pythagorean expectation from comes from WolframAlpha. For example, the data for the Astros can be found at: http://www.wolframalpha.com/input/?i=astros. Within these stats you will see a panel of data that states "2013 game stats". To the left you will see "total". You can change this setting to hitting. Then, you'll see "runs" as 610 for the Yankees and 848 for the opponent. For the Pythagorean Expectation, this is the statistic we want. There are 162 regular season games and the Astros won 51 games in the regular season. So, the Pythagorean Expectation for the 2013 Astros is: 610^x/(610^x + 848^x) = 51/162 = 0.3148. Bill James, the originator of the Pythagorean Expectation, says that the value of x should be 2. Note though, this won't produce equality since using x = 2 is only an estimation.

If you solve for x in the above equation for the Astros, you'll find x is about 2.36. First, we'll show in a moment how to solve for x without complicated steps of algebra. Second, why aren't we finding x = 2? Was Bill James wrong? Remember, the formula isn't perfect, so for some teams, an exponent (that is, the value of x) will be higher than 2. Other times it will be lower than 2. We want an exponent for all the teams, not just one that perfectly predicts for the Astros.

So, how do we find such an exponent? We'll do this by first making two guesses for the value of x. I'll take 1 and 4. If I plug this in I get 610^1/(610^1 + 848^1) = 0.418, and 610^4/(610^4 + 848^4) = 0.2112. Note, one of them is too high and the other is too low since the winning percentage is 0.314. The key is getting one value that's too high and one that's too low.

So, I know the value for the exponent will be between 1 and 4. So, I take the value in the middle which (1+4)/2 = 2.5. Now, I plug this in as x and find 610^2.5/(610^2.5 + 848^2.5) = 0.3050. This is produces an estimated winning percentage that is too low. So, we now know the x we want is between 1 (which produced an estimate that was too high) with 2.5 (which produces an estimate that was too low). So the exponent is between 1 and 2.5. We again find the midpoint which is (1 + 2.5)/2 = 1.75. Now, we plug that in for the exponent and find 610^1.75/(610^1.75 + 848^1.75) = 0.3597, which produces an estimate that's too high. So, we now know our estimate is between we replace 2 (which produced an estimate that was too low) with 1.75 (which produced an estimate that was too). Now, we know our desired exponent is between 1.75 and 2.5. Note, at each step we are shrinking the interval on which we know the exponent exists. So, we continue this process until the interval is so small that we have 1 or 2 decimal places of accuracy. For the Astros this would be 2.36.

The same process can be repeated for every team. We can see this for every team in 2013 in the table below. The last column is the exponent that perfectly predicts the winning percentage of that team with the Pythagorean expectation.

Team	Runs scored	Runs allowed	Wins	Pythagorean Exponent
Angels	733	737	78	13.62
Astros	610	848	51	2.36
Athletics	767	625	96	1.83
Blue_Jays	712	756	74	2.89
Braves	688	548	96	1.65
Brewers	640	687	74	2.44
Cardinals	783	596	97	1.47
Cubs	602	689	66	2.77
Diamondbacks	685	695	81	0
Dodgers	649	582	92	2.51
Giants	629	691	76	1.32
Indians	745	662	92	2.31
Mariners	624	754	71	1.31
Marlins	513	646	62	2.07
Mets	619	684	74	1.74
Nationals	656	626	86	2.64
Orioles	745	709	85	2
Padres	618	700	76	0.99
Phillies	610	749	73	0.96
Pirates	634	577	94	3.44
Rangers	728	631	91	1.74
Rays	695	644	91	3.26
Red_Sox	853	656	97	1.52
Reds	698	589	90	1.32
Rockies	706	760	74	2.35
Royals	648	601	86	1.64
Tigers	796	624	93	1.23
Twins	614	788	66	1.5
White_Sox	598	723	63	2.38
Yankees	650	671	85	-3.11

Note, the exponents that lead to equality in the Pythagorean Expectation for each team vary from -3.11 to 13.62. Note, this impacts the guesses that are needed for the initial exponents. Remember, one must produce an estimated winning percentage that's too high and the other too low. So, the guesses may need to go up to 20 and down to –10.

Remember, the goal of the formula is to find an estimate that is, in some sense, best for all the teams. There are advanced statistical techniques that can do this. However, let's simply take the average of all the exponents in our table (the last column). After doing this, we compute an average of 2.1383. Note, that's pretty close to Bill James' number. In fact, if we exclude the 2 outliers of the Yankees and the Angels, we get 1.9157. With or without the outliers, our value, when rounded equals 2!

A class or group of students could compute such a table or part of the table. Students would pool their numbers together to fill in the entire table. Then, they could compute the average and compare it to Bill James' exponent. Note, the data will match more closely some years more than others. Yet, this, in itself, is an important discussion. Further, the data of this unit allows a teacher to show that some years that data can be very close to matching James' work.

Activity Four: Professional Basketball Players and Their Salaries

Many people wonder how professional athletes earn their salaries. Unfortunately, salaries are not computed by some formula, so it is hard to find an exact correlation between exact statistics and salary amounts. Today, this is an ongoing, active area of economic research. Is it based on points scored? Is it based upon winning seasons? Is it based upon "records" achieved? In this activity, students would be asked to examine the total amount of salaries paid to players on a team. Next, they could work to figure out what proportion of the total salaries that player is paid. From there, they would see what percentage of points, rebounds or other assists that player has achieved. How close is it to the salary? Is any player close to that ratio? Is there any correlation even loosely related?

The website, http://stats.nba.com/?PlayerOrTeam=Player&StatCategory=Points, is an excellent tool for examining statistics as they could potentially relate to the salaries of the players. On this website, it would be important to identify the point leaders in NBA basketball. Do they rank the same by their salaries? How much of a match is there? What about rebounding and other basketball variables? Students could also do the same thing with baseball. For example, with power hitters, students could find their on-base percentage and compare that to the batting average. On-base percentage amount is considered a better statistic in baseball than batting average. This activity is a fun and interesting way to see how professional sports arrive at salary amounts for the players.

Culminating Activity

Students will have a choice of completing a math and sports project that explores their own unique multiple intelligences. Prior to students beginning this project, I will review the rules of *Wallyball* from the beginning of this unit. I will explain how the rules and mathematical applications changed from when this sport originated to today. Another sport that I will show as an example for comparison is Australian Rules football. This version of football is very different from our American football. Students can design a "new sport" or make changes to an existing sport. Students can design a new sports complex or a sports activity field or area. Students can design a new piece of sports equipment or a clothing item for that sports activity. Students could also design a new "league" or "team" within an existing sport. The two main requirements of this project are that the project must be related to sports, and it must contain a minimum of two

middle school mathematical concepts that he/she is learning in math class. Students will complete the unit with an oral presentation of their culminating project.

1. Dan Flockhart, *Fantasy Football and Mathematics*,(San Francisco, Jossey-Bass, 2007), 10.
2. Tim Chartier, "*Mathematical Moment podcast on using math to analyze soccer kicks*", http://www.ams.org/samplings/mathmoments/mm65-soccer-podcast (accessed November 24, 2013).
3. Wayne L. Winston, *Mathletics: How Gamblers, Managers, and Sports Enthusiasts Use Mathematics in Baseball, Basketball, and Football*, (Princeton, Princeton University Press, 2009), 3-10.

Appendix 1

Fantasy Football Team Roster _____

Player Position	Name(s)	Team	Total Cost
Quarterback #1			
Quarterback #2			
Running Backs (3)			
Wide Receivers (4)			
Kickers (2)			
Team Defense #1			
Team Defense #2			

Multiplication	Player #1	Player # 2	Player # 3
Number of TDs (touchdowns) times 1/8			
Number of 2 point conversions or safeties times 1/24			
Number of passing yards (in 25s) times 1/48			
Number of Rushing Yards (in 10s) times 1/48 Number of Receiving Yards (in 10s) Times 1/48			

Number of PATS (points after TDs) times 1/48 Number of FGs (field goals) times 1/16			
Number of Interceptions times (- 1/12) Number of Fumbles lost times (- 1/16)			
Total Individual Points 30/48 Total Team Points 30/48 +			

Appendix 2: Implementing Common Core Standards

Common Core Math Standards

Analyze proportional relationships and use them to solve real-world and mathematical problems.

These standards are used in analysis of football, basketball and baseball statistics within this math and sports curriculum unit.

- CCSS.Math.Content.7.RP.A.1 Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like or different units. *For example, if a person walks 1/2 mile in each 1/4 hour, compute the unit rate as the complex fraction* $^{1/2}/_{1/4}$ *miles per hour, equivalently 2 miles per hour*.
- CCSS.Math.Content.7.RP.A.2 Recognize and represent proportional relationships between quantities.
  - CCSS.Math.Content.7.RP.A.2b Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships.
  - CCSS.Math.Content.7.RP.A.2c Represent proportional relationships by equations. *For example, if total cost t is proportional to the number n of items purchased at a constant price p, the relationship between the total cost and the number of items can be expressed as t = pn*.
- CCSS.Math.Content.7.RP.A.3 Use proportional relationships to solve multistep ratio and percent problems. Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error.

Draw construct, and describe geometrical figures and describe the relationships between them.

These standards are used in the design of a soccer field or a soccer ball, as well as the final unit student project of designing a new sport or modifying an existing sport.

- CCSS.Math.Content.7.G.A.1 Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.
- CCSS.Math.Content.7.G.A.2 Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions. Focus on constructing triangles from three measures of angles or sides, noticing when the conditions determine a unique triangle, more than one triangle, or no triangle.

Solve real-life and mathematical problems involving angle measure, area, surface area, and volume.

These standards are used in the design of a soccer field or a soccer ball, as well as the final unit student project of designing a new sport or modifying an existing sport.

CCSS.Math.Content.7.G.B.4 Know the formulas for the area and circumference of a circle and use them to solve problems; give an informal derivation of the relationship between the circumference and area of a circle.

- CCSS.Math.Content.7.G.B.6 Solve real-world and mathematical problems involving area, volume and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.

Investigate chance processes and develop, use, and evaluate probability models.

These standards are used in analysis of football, basketball and baseball statistics within this math and sports curriculum unit.

- CCSS.Math.Content.7.SP.C.5 Understand that the probability of a chance event is a number between 0 and 1 that expresses the likelihood of the event occurring. Larger numbers indicate greater likelihood. A probability near 0 indicates an unlikely event, a probability around 1/2 indicates an event that is neither unlikely nor likely, and a probability near 1 indicates a likely event.
- CCSS.Math.Content.7.SP.C.6 Approximate the probability of a chance event by collecting data on the chance process that produces it and observing its long-run relative frequency, and predict the approximate relative frequency given the probability. *For example, when rolling a number cube 600 times, predict that a 3 or 6 would be rolled roughly 200 times, but probably not exactly 200 times*.
  - CCSS.Math.Content.7.SP.C.7a Develop a uniform probability model by assigning equal probability to all outcomes, and use the model to determine probabilities of events. *For example, if a student is selected at random from a class, find the probability that Jane will be selected and the probability that a girl will be selected*.
- CCSS.Math.Content.7.SP.C.8 Find probabilities of compound events using organized lists, tables, tree diagrams, and simulation.
  - CCSS.Math.Content.7.SP.C.8a Understand that, just as with simple events, the probability of a compound event is the fraction of outcomes in the sample space for which the compound event occurs.

- CCSS.Math.Content.7.SP.C.8b Represent sample spaces for compound events using methods such as organized lists, tables and tree diagrams. For an event described in everyday language (e.g., “rolling double sixes”), identify the outcomes in the sample space which compose the event.
- CCSS.Math.Content.7.SP.C.8c Design and use a simulation to generate frequencies for compound events. *For example, use random digits as a simulation tool to approximate the answer to the question: If 40% of donors have type A blood, what is the probability that it will take at least 4 donors to find one with type A blood?*

Common Core Reading/Writing Standards:

Key Ideas and Details

These standards are used in the research of sports and the final written and oral student presentation of a new sport or modification to an existing sport.

- CCSS.ELA-Literacy.RI.7.1 Cite several pieces of textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.
- CCSS.ELA-Literacy.RI.7.2 Determine two or more central ideas in a text and analyze their development over the course of the text; provide an objective summary of the text.
- CCSS.ELA-Literacy.RI.7.3 Analyze the interactions between individuals, events, and ideas in a text (e.g., how ideas influence individuals or events, or how individuals influence ideas or events).

Bibliography, Resources, and Reading List

"AMERICAN WALLYBALL ASSOCIATION®." AMERICAN WALLYBALL ASSOCIATION®. http://www.wallyball.com (accessed November 24, 2013).

The Wallyball website is used under the introductory activity of this unit where students explore how math is used in sports and in the modification of sports.

Campbell, Tom. "Box Scores and Baseball Attendance." In *Tables, charts and graphs*. Portland, ME: J. Weston Walch, 1998. 18-20,42-45.

This book is an activity book that has several activities that incorporate math and sports. The activity cited gives students practice with baseball statistics and math.

Flockhart, Dan. *Fantasy football and mathematics: a resource guide for teachers and parents*. San Francisco, CA: Jossey-Bass, 2007.

This book is used to help teachers carry out a fantasy football experience in their math classroom.

Gonick, Larry, and Woollcott Smith. *The cartoon guide to statistics*. New York, NY: HarperPerennial, 1993.

This book is used to gives a teacher ideas to use in the classroom where sports and math are used together.

"Home." NBA Stats -. http://stats.nba.com/?PlayerOrTeam=Player&StatCategory=Points (accessed November 24, 2013).

This website is used to find statistics that can help students predict and analyze NBA player salaries.

"Mathematical Moment podcast on using math to analyze soccer kicks." Mathematical Moment podcast on using math to analyze soccer kicks. http://www.ams.org/samplings/mathmoments/mm65-soccer-podcast (accessed November 24, 2013).

This podcast is used to show students how a soccer ball is designed to help soccer players have improved success when kicking a ball on a soccer field.

"Related Queries." astros. http://www.wolframalpha.com/input/?i=astros (accessed November 24, 2013).

This site is used to locate baseball statistics that can be used in the activity to predict a winning season for a baseball team.

Wikimedia Foundation. "Spherical polyhedron." Wikipedia. http://en.wikipedia.org/wiki/Spherical_polyhedron (accessed November 24, 2013).

This site is used in the activity where students examine the design of a soccer ball as it relates to geometry.

Winston, Wayne L.. *Mathletics: how gamblers, managers, and sports enthusiasts use mathematics in baseball, basketball, and football*. Princeton: Princeton University Press, 2009.

This book is used numerous times in this unit for using statistics in baseball, basketball, and football to analyze and predict wins and player salaries.

"fantasy football stats." ESPN. http://www.espn.com (accessed September 30, 2013).

This website is used to calculate statistics each week in the Fantasy Football activity of this curriculum unit.

'Be Like Mike' on the Court – and Bill James in the Classroom. http://www.huffingtonpost.com/tim-chartier/be-like-mike-on-the-court_b_4367961.html by Tim Chartier and Lisa Ashworth, *Huffington Post* Article on Pythagorean Expectation, 2013.

This *Huffington Post* Article was co-authored by Tim and myself to explain how to calculate a winning season with statistics and the Pythagorean Expectation.