

Math Academy

Play Ball!

Explorations in Data Analysis & Statistics



A Letter from the Author



Congratulations! You've just found your answer to the question, "What can I do to create real enthusiasm for mathematics in all my students?"

Created by teachers for teachers, the Math Academy tools and activities included in this booklet were designed to create hands-on activities and a fun learning environment for the teaching of mathematics to our students. On Math Academy days I often found that I couldn't make it from my car to my classroom without being stopped by enthusiastic students wanting to know every detail of the upcoming day's events. Math Academy days contributed to a positive school-wide attitude towards mathematics on our campus.

This booklet contains the *Math Academy – Play Ball! Explorations in Data Analysis and Statistics*, which you can use to enhance your math instruction while staying true to the academic rigor required by the state standards framework.

This effort would not have been possible without support from The Actuarial Foundation.

I sincerely hope that you enjoy implementing the *Play Ball! Math Academy* with your students. When you do, you will find that your students engage with mathematics on a whole new level. The Actuarial Foundation is truly a great partner in furthering mathematics education!

For the kids!

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What is a Math Academy?

When the Math Academy concept was first developed, it was designed as a half-day or full-day event which allowed students to deepen their understanding of math while interacting with volunteers from the community (see page 24 for ideas on working with community volunteers). The activities we selected for these events were hands-on, standards-based lessons which applied mathematical principles in real-world scenarios.

Each Math Academy began with a brief school assembly featuring a guest speaker who represented that day's particular theme. Themes included math related to restaurants, sports, nature, shopping, fine arts and other topics, as well as focused on math-related careers. After the assembly, students rotated to different classrooms where they engaged in various activities related to mathematics and the day's coordinating theme.

Included in this booklet is the *Math Academy-Play Ball! Explorations in Data Analysis and Statistics*, which has all the activities we used for the sports Math Academy. This Math Academy is designed to help students understand the connection between sports, data collection, and statistical analysis. As the students play each "game", they will collect, organize, display, and analyze the data from the game results.

You may choose to implement a grade-level or school-wide Math Academy as we originally designed it, or you may prefer to implement these activities in your own classroom. Whichever format you use, keep in mind that the goal is to help your students see the relevance of mathematics in real-life contexts.

Getting Started

Math Academy Format

You may choose to conduct your Math Academy as a school-wide event, as a grade-level rotation, or as a single-classroom experience. If you will be holding your Math Academy for a single classroom, you may want to invite a guest speaker to speak with your class about how mathematics is used in his/her job (rather than putting on a school-wide or grade-level assembly as described below).

Math Academy Schedule

Schedule and times may vary depending on format being used.

- Opening assembly (optional) — 15 minutes
- Directions and Math Journals — 15 minutes
- Activity Rotations — 30–45 minutes per activity
- Assessment and Closure — 15 minutes

Introduction

Announce to the students that today they will be working with collecting, displaying, and analyzing data. Everyone knows at least a little bit about sports – and some know a lot! Explain to them that during this Math Academy, they will be playing table-top versions of different ball games, and during each one, they will collect, display, and analyze the data from the game. The data they will be collecting and analyzing will help them understand how statistics are used in different sports.

Guest Speaker Presentation (optional)

Beforehand, arrange for someone in the sports industry to talk to the students about the mathematics in the sports. Possible guest speakers may include an athlete, a cheer-leading squad, an employee of a sports team, or a coach. One school invited a man who, several years before, had been the bat boy for the Arizona Diamondbacks when they won the World Series. Although this guest speaker will primarily be focused on the sports aspect of this Math Academy theme, you may want to work with him/her ahead of time to assist with including mathematical ideas in the talk.



Theme

Play Ball! Explorations in Data Analysis and Statistics

Objective

Understand and apply concepts of data collection, representation, and analysis in a sports context

Getting Started (continued)

TEACHER TIPS

- We asked our students to use graphic organizers to record their thoughts and findings in their math journals. This creates a great connection to our language arts curriculum.
- The best results are achieved when 45 minutes are allowed in each classroom – about 30 minutes for the activity and 15 minutes for clean-up and reflection. The students can use their math journals to record their findings during the activities and write reflections on the journal's blank pages.

Use of Math Journals

Students record their findings in their “Math Journals” during each activity. These journals should contain all recording sheets for the activities as well as blank paper for the extension activities. Before beginning the Activities Rotation, students should spend about 10 minutes writing in their math journals, including their reflections from the assembly as well as briefly describing what they already know about data analysis and statistics.

Activities Rotation

If multiple classes are participating in the Math Academy, each classroom should host a different activity so students will rotate from classroom to classroom in order to complete each activity. If only one class is participating, the students may rotate from one activity to the next around the room, or they may do each activity as a whole class, one game after the other. Activities begin on page 11. For best results, plan on three to five activities for your Math Academy.

Note: Games in this booklet are not created by The Actuarial Foundation, but provided as a fun component to your teaching the lessons provided.

Closure and Assessment

Once all activities are completed, the students may return to their homeroom classes for final reflections and assessment. See pages 22 and 23 for sample post quiz and survey.

Note: There are no teacher answer keys in this booklet since all activities are open-ended and answers will vary.

Key Vocabulary

- Average
- Mean
- Median
- Mode
- Range
- Sample
- Bar graph
- Line graph
- Line plot
- Circle/Pie graph
- Histogram
- Scatterplot
- Table/Chart
- Prediction
- Scale
- X-axis
- Y-axis

Graphing Sports Data in *Play Ball!*

Although data from any of the sports games in this booklet may be displayed using a variety of graphical representations, the following graph types are matched up with the following games in *Play Ball!* Please feel free to use any graphs with any data from the games in this booklet.

Sport	Data Analysis/Statistics Concepts
Football	Bar Graphs/Line Graphs
Basketball	Histograms
Baseball	Averages – Mean, Median, Mode; Circle graphs; Percentages
Soccer	Scatterplots

Creating Graphs

There are many different ways to display data. When working through this Math Academy, you may choose to highlight one kind of graph (e.g., have students make bar graphs for every game) or you may choose to have the students make a different kind of graph for each game. Of course, you will want to introduce the construction for each kind of graph you ask your students to create beforehand. Below is a very brief description for the most common graphs studied in grades 3-8.

Bar Graphs (grades 3-8)

- Used to display/compare discrete sets of data.
- May be horizontal or vertical.
- Each category is represented by a bar that corresponds to the quantity indicated in the scale.
- The scale should start with “0” and “skip count” in equivalent increments.
- In most cases, the bars in a bar graph should not touch. Exceptions occur when continuous ranges are being compared (as in a histogram).
- The parts of a bar graph include the title, scale, scale label, categories, category label, and the data (represented by the bars).

Double Bar Graphs (grades 3-8)

- Resembles a single-bar graph (as described above), except that there are two sets of data for each category, thus two bars for each category.
- The bars are usually color-coded or shaded differently to indicate the different data sets within each category; When this is the case, a key should be included.

Line Plots (grades 3-8)

- Used to show a set of discrete data – usually one set of data with values less than 50.
- Consists of a number line, beginning with “0”; The scale is written along the number line and may “skip count” by any amount (usually by ones, twos, fives, or tens).
- Data points (x’s, dots, etc.) are placed above the number line over their corresponding values on the number line.
- The parts of a line plot include the title, number line, scale, scale label, and the data (represented by points or x’s above the number line, arranged in vertical columns).

Line Graphs (grades 3-8)

- Used to display continuous data (for example, data that changes over time).
- Should be set up like a bar graph.
- Data is displayed by placing points where the category lines and the scale lines intersect.
- Points are then connected by lines to indicate that the data is continuous.
- The parts of a line graph include the title, scale, scale label, categories, category label, and the data (represented by points and lines).

TEACHER TIPS

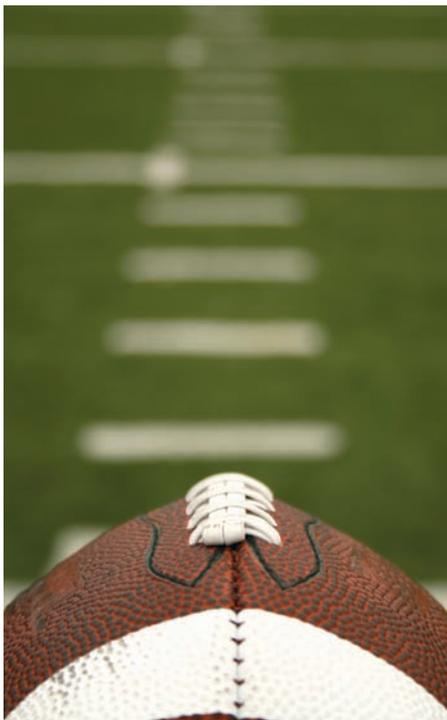
When working with students on Data Analysis and Statistics, it helps to have them go through a similar process each time, even though the skills needed will vary. My process looks like this:

1. Design question for data collection
2. Collect data
3. Display data
4. Ask questions about the data
5. Interpret/analyze/answer questions based on data
6. Compare data to other data sets

When creating graphs, it is often helpful for students to have a checklist for what should be included. For the checklist below, keep in mind that not all parts will be included with all graphs, but students should take these into consideration:

1. Title
2. Scale (start with “0”, “skip count” in even increments)
3. Scale label
4. Categories
5. Category label
6. Data (bars, lines, points, sections, etc. – depends on the type of graph)
7. Key

Getting Started (continued)



Circle Graphs (grades 3-8)

- Used to display parts of a whole set of data, with the circle divided into sections which are proportional to the quantity in each category.
- Each category is represented by a section of the circle that is proportional to the quantity of that category.
- The parts of a circle graph include the title, categories, a key, and the data (represented by proportional sections within the circle); Labels may appear in the scale, in each circle section, or both.

Histograms (grades 6-8)

- Special kind of bar graph.
- Used to show the comparison between ranges within the data.
- The ranges are displayed as the categories for the bar graph.
- Ranges should be uniform, and the bars should be touching when the histogram is completed (since the ranges are continuous).
- The parts of a histogram include the title, scale, scale label, categories, (ranges), category label, and the data (represented by bars which should touch if the ranges are continuous).

Scatterplots (grades 6-8)

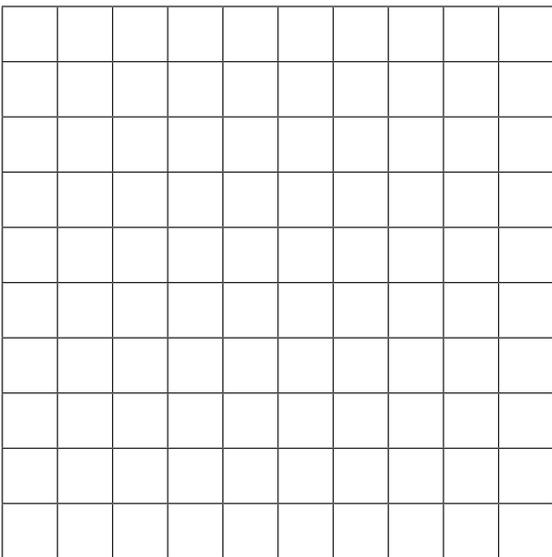
- Used to show how one variable affects another.
- Points are recorded on the graph to indicate trends (called correlations); The closer the points are to forming a line, the more correlated the two variables are; If the points are scattered with no indication of forming a line, then there is no correlation between the two sets of data.
- The parts of a scatter plot include the title, x-axis scale, x-axis scale label, y-axis scale, y-axis scale label, and the data which is a series of points plotted where the scale lines meet.

The Data Analysis Forms that follow on the next two pages may be used to create any of the above graphs. Note that one page includes grid lines while the other does not. Select which Data Analysis Form is most appropriate for your specific objective, and copy one per student for each game. When focusing on the mean, median, and/or mode, you may have the students show their work in the “Graph/Statistics” portion of the form, or they may include that data in the “Interpretation” area.

Data Analysis Form: *Game:* _____

Question	
Data: Graph/Statistics	
Interpretation: about graph	Questions

Data Analysis Form: *Game:* _____

Question	
Data: Graph/Statistics	
	
Interpretation: about graph	Questions

Math Academy Activity 1: *Football*

Objective Students will play a game of “football”, represent the results on a bar graph and/or line graph (or any type of graph), and analyze the data.

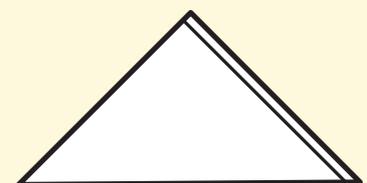
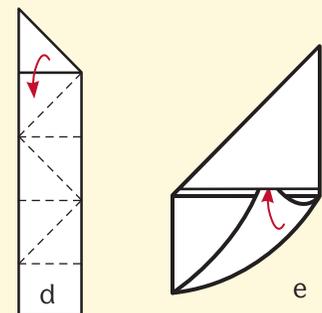
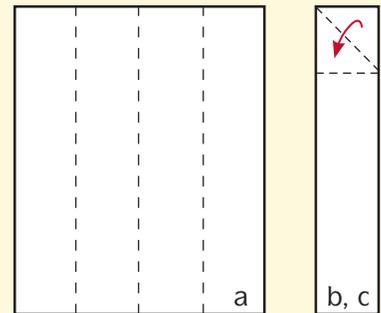
- Materials**
- 1 folded paper triangle (football) per group (see sidebar for instructions)
 - Scratch paper to keep score
 - 1 Data Analysis Form per student (pages 9–10)
 - Pencils

Directions for playing **Note:** Three people are needed to play this game: 2 players and 1 score keeper.

1. Players sit on opposite sides of a straight-edged table or desk.
2. Begin play by placing the football at the center of the table or desk (called the 50-yard line).
3. To score a touchdown, players take turns “flicking” the football with one finger, trying to make the ball stop on the opposite side of the table with part of the football hanging over the edge (see picture 1).
4. Players take turns, one flick each, back and forth until someone scores.
5. If the ball goes off the table, the other player places the football on the 50-yard line and begins play again.
6. When a touchdown is made, the player receives 6 points.
7. After a touchdown, the scoring player can kick a field goal. The scoring player holds the ball vertically between his/her finger and the table, and with his/her kicking hand, s/he flicks the ball with his/her finger. The other player is standing up while holding a field goal with his/her fingers arranged in the goal post position (see picture 2). If the ball goes between the two posts, it’s good for 1 point. **Note:** For your protection, it’s important that you do not have your face level with the goal posts.
8. Play continues until time is up.
9. **Note to Teacher:** Since football is played in quarters, you may want to structure the game-time accordingly. Perhaps allow 60 seconds per quarter. Recording scores by quarters also provides more options for creating graphs.

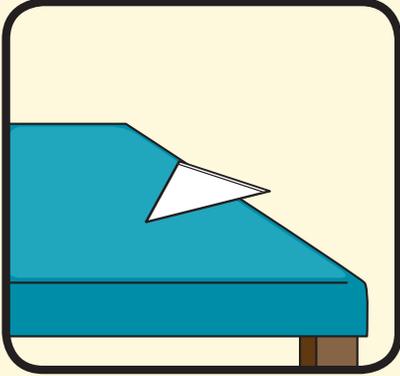
▶ PAPER FOOTBALL

- Fold a piece of paper in half, parallel to the long edge, then fold once more to create four long strips (a).
- Cut or tear off one of the strips (b).
- Turning the paper vertically on the table, fold the top corner down into a triangle (c).
- Continue to fold down, making the triangles until you run out of paper to fold (d).
- Tuck what ever excess paper into the “pocket” on the top of the “football” (e).



Math Academy Activity 1: *Football*

► PICTURE 1



► PICTURE 2



Procedures for data collection, representation, and analysis:

1. Students play this game in groups of three (2 players and one score keeper) and collect data as a group. Determine beforehand what data is to be collected. (In Football, this is usually the score but may also be any other piece of information collected during the game including the number of times the ball went out of bounds, the number of field goals, etc.).
 2. After playing the game, either the teacher or the students should decide what will be graphed. Compose a question to be answered using the data.
 3. If a specific graph/statistic is being focused on, the teacher defines what kind of graphical representation for students to create.
 - Bar graphs and/or line graphs are recommended for all age groups playing Football.
 - See pages 7–8 for descriptions of types of graphs and graph construction.
 4. Students decide how to represent their data if not already designated by the teacher (there are fewer options in football than in basketball and baseball).
 5. Students create graphs, record descriptions, and compose questions about their graphs on the Data Analysis Form.
 6. **Optional:** Collect class data and have students create graphical representations, interpret the data, and compose questions based on the class data rather than on their individual games.
- Note:** mean, median, and mode are most applicable to class data rather than to individual data.
7. **Optional:** Teacher may reproduce the completed graphs and questions for other students to answer during follow-up.

Math Academy Activity 2: Soccer

Objective The students will play a game of “soccer”, represent the data on a scatterplot (or any type of graph), and analyze the data.

Materials

- 1 Soccer game board and spinner per group (page 14)
- 1 Data Analysis Form per student (pages 9–10)
- 1 paper clip per group
- Pencils
- Scratch paper for keeping score
- Game marker to represent the soccer ball (e.g., penny, bean, etc.)

Directions for playing

Note: This game requires two players and one score keeper. The score keeper may record whatever data is requested: goals, yards traveled, number of turns, etc.

1. Place “soccer ball” on the dark line in the center of the game board.
2. Players take turns spinning the paper clip on the spinner and moving that many yards toward his/her opponent’s goal (each line on the game board represents ten yards).
3. Each time a player gets to his/her opponent’s goal, s/he scores one point.
4. Each quarter lasts exactly one minute. The score keeper should also keep track of the time. After four minutes, the game is over.

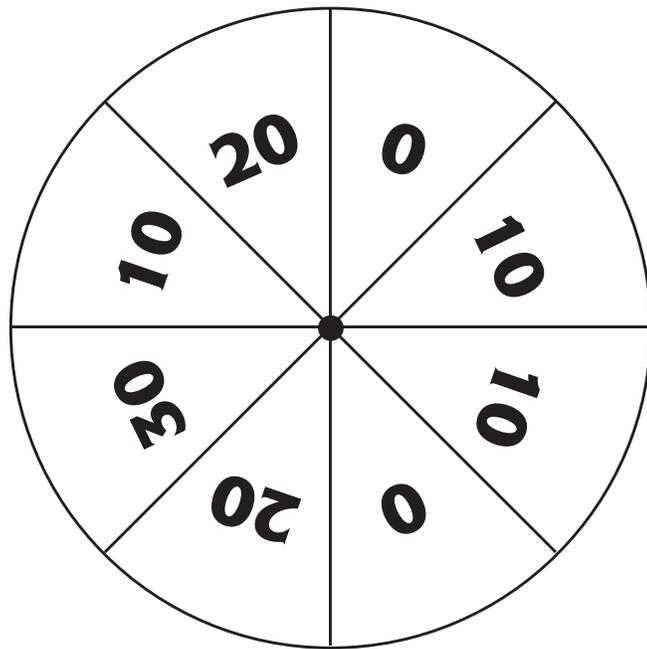
Procedures for data collection, representation, and analysis:

1. Students play this game in groups of three and collect the data as a group (2 players and one score keeper; score keeper collects data which may include scores, yards traveled, number of turns, etc.)
2. After playing the game, either the teacher or the students should decide what will be graphed (in Soccer, this is usually the score but may also be any other piece of information collected during the game including the number of yards traveled by each player, etc.). Compose a question which will be answered with the graphs/statistics.
3. If a specific graph/statistic is being focused on, the teacher defines what kind of graphical representation for students to create.
 - Bar graphs and/or line graphs are recommended for younger students.
 - Scatterplots are recommended for older students.
 - See pages 7–8 for descriptions of types of graphs and graph construction.
4. Students create graphs, record descriptions, and compose questions about their graphs on the Data Analysis Form.
5. **Optional:** Collect class data and have students create graphical representations, interpret the data, and compose questions based on the class data rather than on their individual games. **Note:** mean, median, and mode are most applicable to class data rather than to individual data.
6. **Optional:** Teacher may reproduce the completed graphs and questions for other students to answer during follow-up.

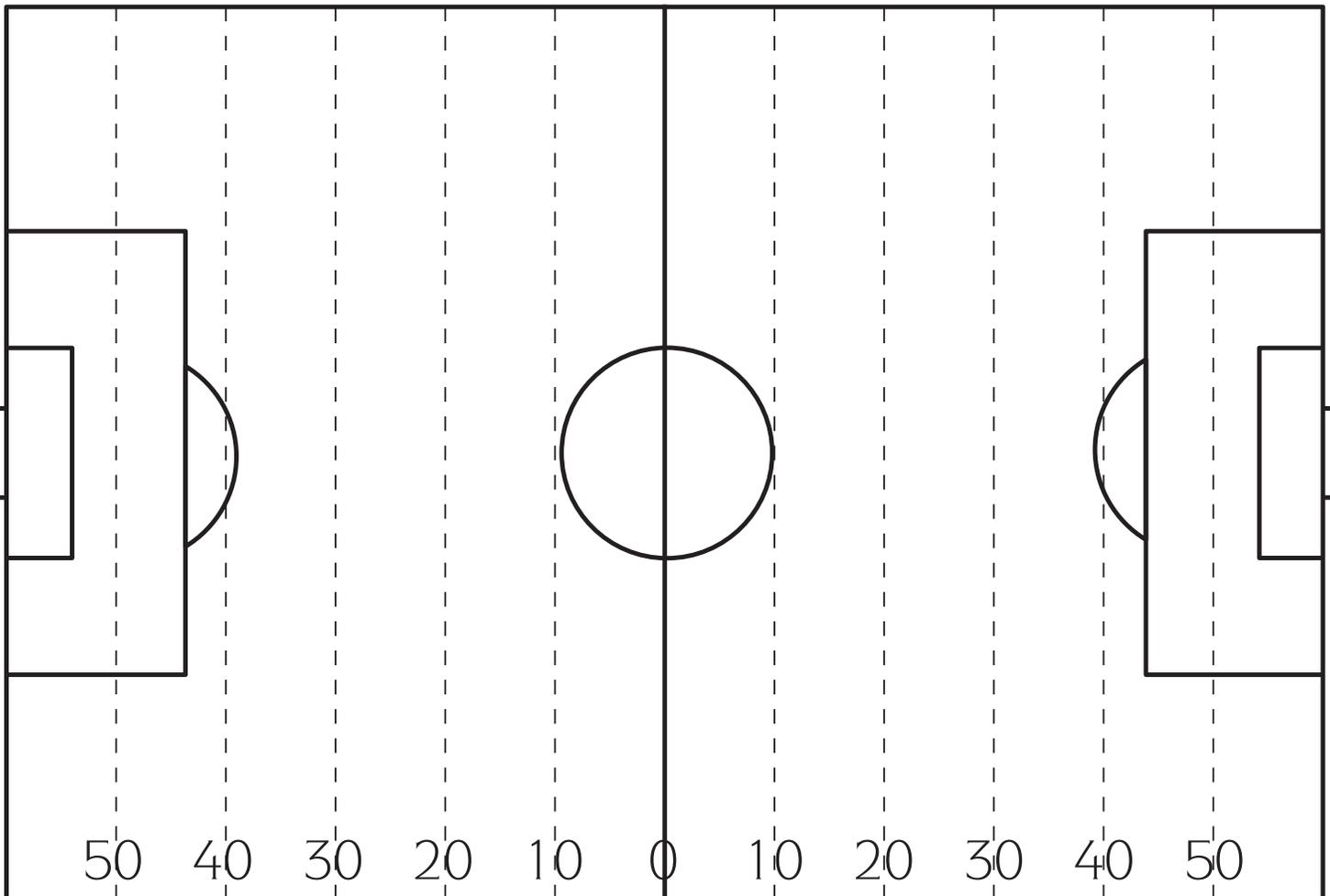
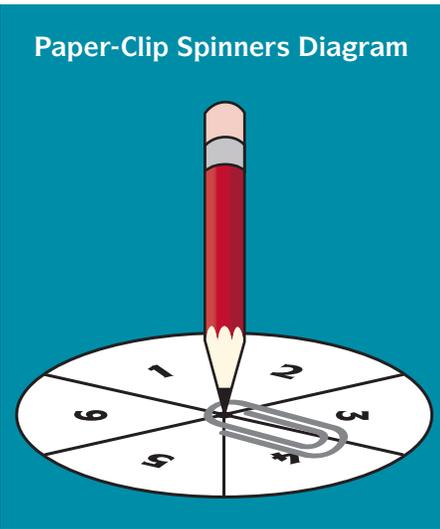


Math Academy Activity 2: Soccer Gameboard

Game Spinner



Paper-Clip Spinners Diagram



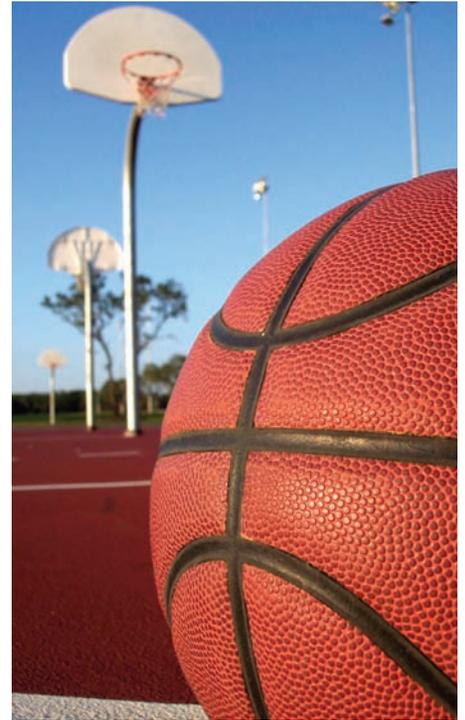
Math Academy Activity 3: *Basketball*

Objective Students will play a game of “basketball”, represent the data on a histogram (or any type of graph), and analyze the data.

- Materials**
- 1 Basketball game board per group (page 16)
 - 1 Paper clip per group
 - 1 Basketball Score Sheet per group (page 17)
 - 1 Data Analysis Form per student (pages 9–10)
 - Pencils

Directions for playing **Note:** Three people are needed to play this game: 2 players and 1 score keeper. (Go over the score sheet before the game.)

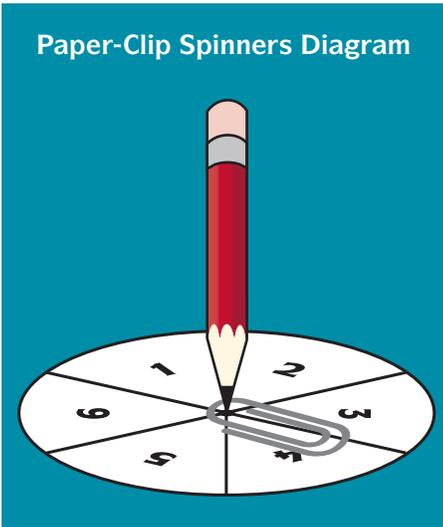
1. Players take turns spinning the paper clip on the top spinner. The scorekeeper should record all statistics listed on the data sheet.
2. If a player spins a free throw, s/he should spin the paper clip on the bottom spinner twice to determine whether or not s/he made the two free-throw shots. One point is scored or each free throw that is made.
3. The scorekeeper is also the timekeeper. Each quarter should be 1–2 minutes in duration (define before the game begins).



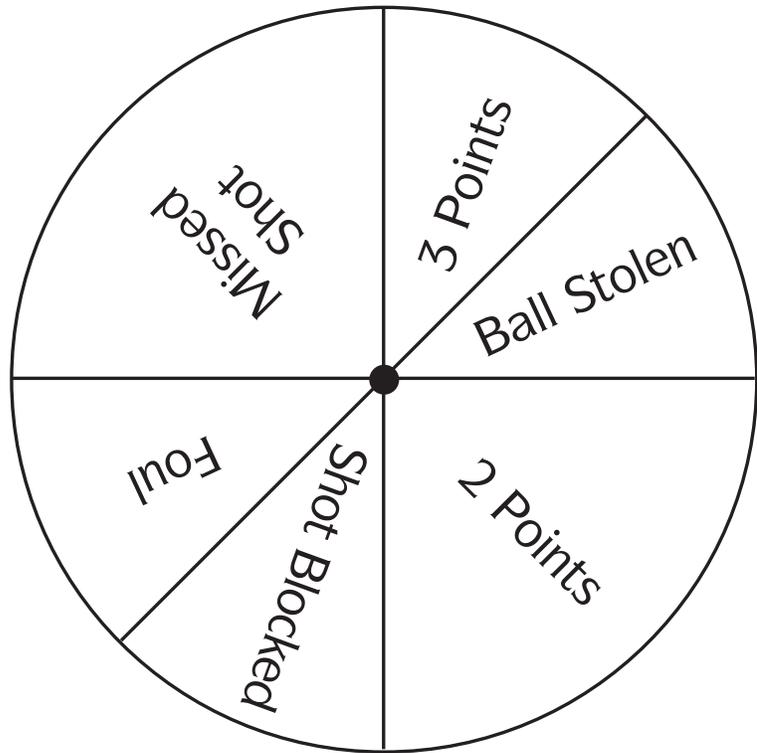
Procedures for data collection, representation, and analysis:

1. Students play this game in groups of three (2 players and one score keeper) and collect data as a group.
2. After playing the game, either the teacher or the students should decide what will be graphed (in Basketball, there are many statistics to choose from on the score sheet). Compose a question which will be answered with the graphs/statistics.
3. If a specific graph/statistic is being focused on, the teacher defines what kind of graphical representation for students to create.
 - Bar graphs and/or line graphs are recommended for younger students.
 - Histograms are recommended for older students.
 - See pages 7–8 for descriptions of types of graphs and graph construction.
4. Students create graphs, record descriptions, and compose questions about their graphs on the Data Analysis Form.
5. **Optional:** Collect class data and have students create graphical representations, interpret the data, and compose questions based on the class data rather than on their individual games. **Note:** mean, median, and mode are most applicable to class data rather than to individual data. Class data of final scores also provides a rich data set for creating histograms.
6. **Optional:** Teacher may reproduce the completed graphs and questions for other students to answer during follow-up.

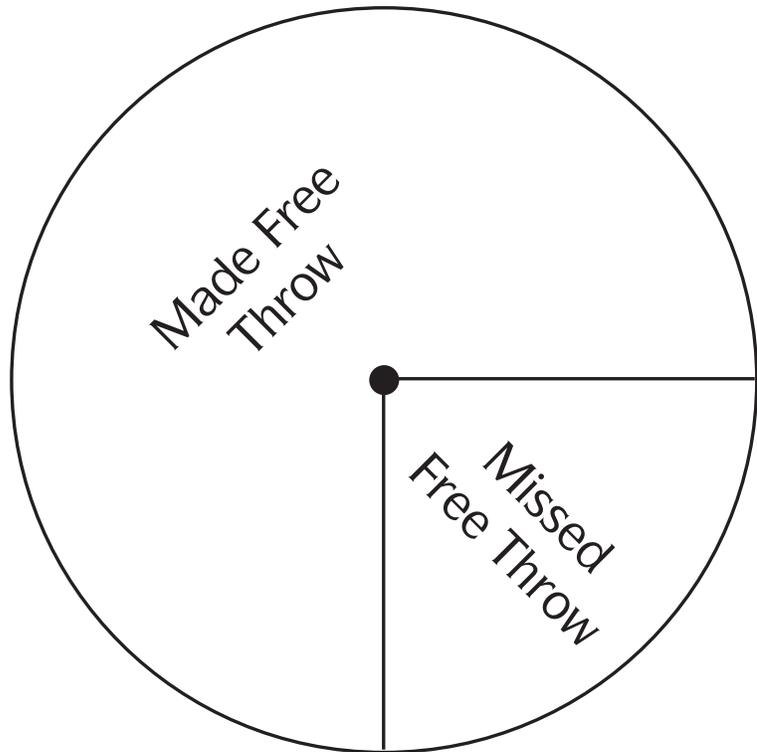
Math Academy Activity 3: *Basketball Spinners*



Game Spinner



Free Throw Spinner



Math Academy Activity 3: *Basketball Score Sheets*

Quarter	Player 1—Tally the Points	Points	Player 2—Tally the Points	Points
1				
2				
3				
4				
FINAL SCORE:			FINAL SCORE:	

Basketball Statistics Game Summary (Score keeper should track stats during the game)		
Action	Player 1	Player 2
2 Pointers		
3 Pointers		
Missed Shot		
Ball Stolen		
Shot Blocked		
Fouled		
Free Throw – Made		
Free Throw – Missed		

Math Academy Activity 4: *Baseball*



Objective

The students will play a game of “baseball”, compute their batting averages, analyze the means of central tendency, and represent the data on circle graphs (or any type of graph).

Materials

- 2 dice per group
 - 1 Baseball game board per group (page 20)
 - 9 colored game pieces per player (two colors – one color per player) to represent the baseball players
 - 1 Baseball Score Sheet per group (page 21)
 - 1 Data Analysis Form per student (pages 9–10)
-

Directions for playing

Note: This game requires two players and one score keeper. Go over the score sheet ahead of time.

1. Determine who will be player 1 and player 2. The Score keeper should record statistics in the top portion of the score sheet during the game. (Player 1 records for player 2, and player 2 records for player 1.) Separate each action with a comma or a hyphen (e.g., 2B, O, HR, O, W, 1B, 1B, O).
 2. In turn, each player rolls two dice and adds them together. Keep rolling, moving, and recording until 3 outs have been rolled. Use the chart on the game board to determine how to move on the game board.
 - Single – move forward to first base – all other markers move forward one base only if forced
 - Double – move forward to second base – all other markers move forward as forced
 - Triple – move forward to third base – all other markers move forward as forced
 - Home run – move around all bases and back to home – all other markers move forward as forced
 - Walk (bases on balls) – move forward to first base – all other markers move forward one base only if forced
 - Out – no movement – record as “O” and continue until three outs are collected
 3. Each time a marker crosses “home base”, place the marker in the “Score Box”. Once that turn is over, record the number of markers in the “Score Box” as the score for that inning.
 4. Once a player collects three outs, his/her turn is over.
 5. Players take turns until all nine innings are completed.
 6. Once all nine innings are completed, total the scores and fill out the statistics summary at the bottom of the score sheet based on the top portion.
-

Math Academy Activity 4: *Baseball*

Procedures for data collection, representation, and analysis:

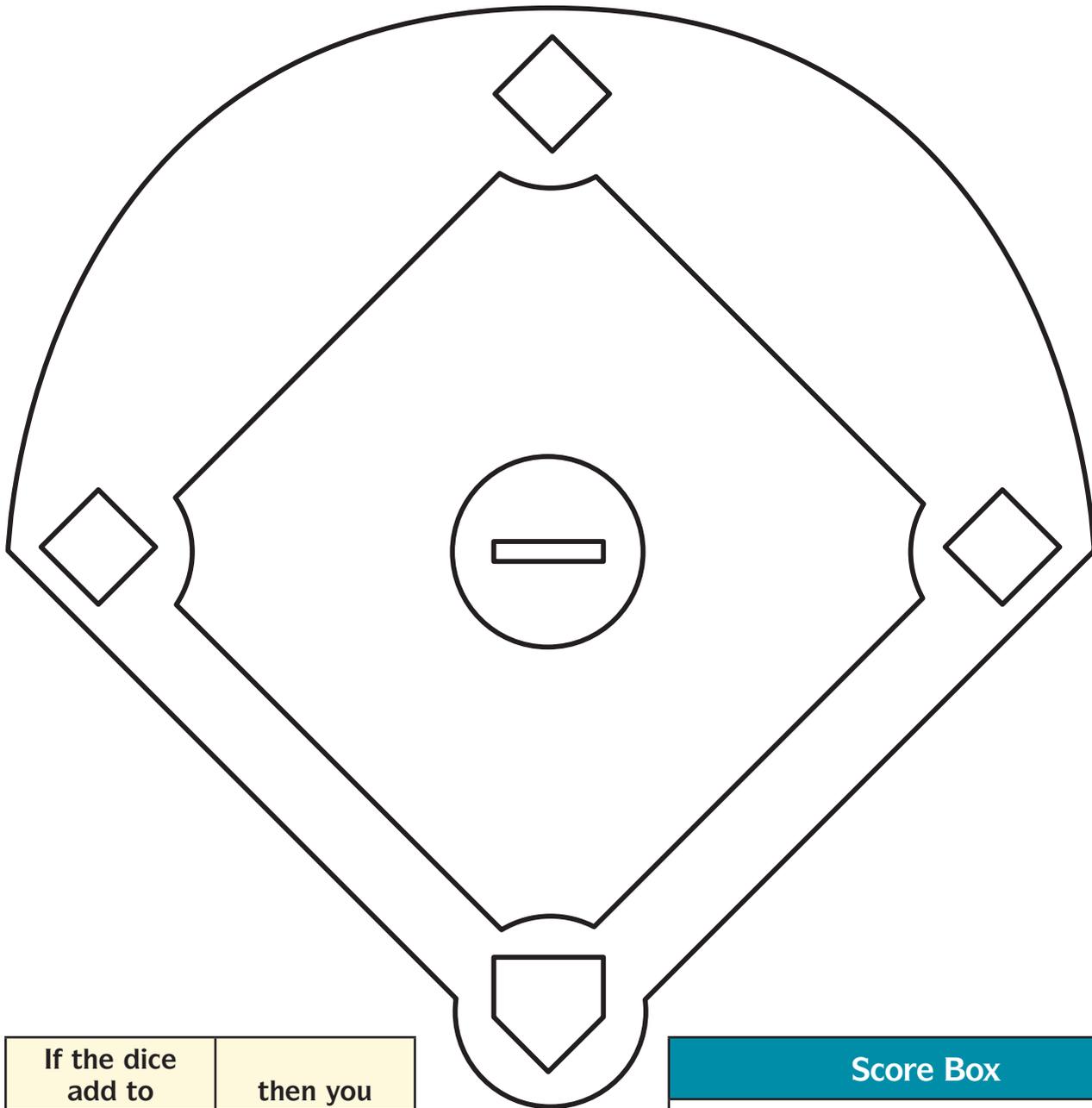
1. Students play this game in pairs and the score keeper records the data.
2. After playing the game, either the teacher or the students should decide what will be graphed (in Baseball, there are many statistics to choose from on the score sheet). Compose a question which will be answered with the graphs/statistics.
3. If a specific graph/statistic is being focused on, the teacher defines what kind of graphical representation for students to create.
 - Bar graphs and/or line graphs are recommended for younger students.
 - Measures of central tendency are recommended for older students (mean, median, mode, range).
 - Also, circle graphs are recommended if looking at the data as a whole.
 - See pages 7–8 for descriptions of types of graphs and graph construction.
4. Students create graphs, record descriptions, and compose questions about their graphs on the Data Analysis Form.
5. **Optional:** Collect class data and have students create graphical representations, interpret the data, and compose questions based on the class data rather than on their individual games. **Note:** mean, median, and mode are most applicable to class data rather than to individual data. Circle graphs may also be useful to illustrate one set of whole-class data.
6. **Optional:** Teacher may reproduce the completed graphs and questions for other students to answer during follow-up.



► FUN FACT

Baseball managers use numbers from batting averages, ERA's, HR's, and RBI's, etc. to get a better understanding of each player's efficiency, his contribution to winning. Actuaries use numbers to help them get a better understanding of what it takes for a company to "win" — to set aside money for the future, to make a profit, etc.

Math Academy Activity 4: *Baseball Diamond*



If the dice add to	then you
7, 11	hit a single
4	hit a double
2	hit a triple
12	hit a home run
9	walk
3, 5, 6, 8, 10	out

Score Box

Math Academy Activity 4: *Baseball Score Sheets*

Use this code to collect the data from your baseball game:

Single = 1B; Double = 2B; Triple = 3B; Home run = HR; Walk = BB (base on balls); Out = O

Inning	Player 1	Runs	Player 2	Runs
1				
2				
3				
4				
5				
6				
7				
8				
9				
FINAL SCORE:			FINAL SCORE:	

Baseball Statistics Game Summary (Complete this section after the game is over)			
Action	Definition	Player 1	Player 2
AB	at bats (how many times you rolled the dice)		
H	number of hits (singles + doubles + triples + home runs)		
1B	number of singles		
2B	number of doubles		
3B	number of triples		
HR	number of home runs		
BB	number of walks (bases on balls)		
O	number of outs		
AVG	batting average – $H \div AB$; show to the thousandths place		
OBP	on base percentage – $(H + BB) \div AB$; show to the thousandths place		

Alignment with Standards

The unit included in this *Play Ball!* booklet takes into account all of the process standards outlined in NCTM's *Principles and Standards for School Mathematics* (NCTM, 2000), including communication, connections, problem solving, reasoning and proof, and representation. References to those types of processes should be made throughout the activities. As for the content standards, the primary concentration is on the data collection and analysis objectives found in the *Data Analysis* standard. The performance objectives for each of these areas include the following:

Instructional programs from pre-kindergarten through grade 12 should enable all students to —

- **formulate questions** that can be addressed with data and collect, organize, and display relevant data to answer them;
- **select and use** appropriate statistical methods to analyze data;
- **develop and evaluate** inferences and predictions that are based on data.

Grades 3–5

- design investigations to address a question and consider how data-collection methods affect the nature of the data set;
- collect data using observations, surveys, and experiments;
- represent data using tables and graphs such as line plots, bar graphs, and line graphs;
- recognize the differences in representing categorical and numerical data;
- describe the shape and important features of a set of data and compare related data sets, with an emphasis on how the data are distributed;
- use measures of center, focusing on the median, and understand what each does and does not indicate about the data set;
- compare different representations of the same data and evaluate how well each representation shows important aspects of the data;
- propose and justify conclusions and predictions that are based on data and design studies to further investigate the conclusions or predictions.

Grades 6–8

- formulate questions, design studies, and collect data about a characteristic shared by two populations or different characteristics within one population;
- select, create, and use appropriate graphical representations of data, including histograms, box plots, and scatterplots;
- find, use, and interpret measures of center and spread, including mean and interquartile range;
- discuss and understand the correspondence between data sets and their graphical representations, especially histograms, stem-and-leaf plots, box plots, and scatterplots;
- use observations about differences between two or more samples to make conjectures about the populations from which the samples were taken;
- make conjectures about possible relationships between two characteristics of a sample on the basis of scatterplots of the data and approximate lines of fit;
- use conjectures to formulate new questions and plan new studies to answer them.



▶ TEACHER TIP

You will want to check with your own state framework to select performance objectives which are specific to your students.



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