Trashketball: Part 1

Scatter Plots and Lines of Best Fit

K20 Center, Kate Raymond, Levi Patrick, Samantha Marshall
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Grade Level	8th – 9th Grade	**Time Frame**	200 minutes
Subject	Mathematics	**Duration**	3-5 class periods
Course	Algebra 1, Middle School Mathematics		

Essential Question

How can linear relations and data analysis help us to understand the abilities of people?

Summary

In this lesson, students toss balls of trash, or "trashketballs," into a wastebasket, recording their shooting percentage at various distances from the basket. With distances measured and percentages figured, students create a scatter plot and a line of best fit to make a linear model of the shooting skills of the class. This is a great, simple, and inexpensive lesson that addresses many significant Algebra 1 concepts, including expressions, data analysis, scatter plots, and linear equations. Students should understand how to write the equation of a line when given its graph before participating in this lesson.

Snapshot

Engage

Students analyze data that can be used to maximize scores in bowling.

Explore

Students create an algebraic expression for shooting percentages and make a prediction about shooting percentage. They use their expression to verify their prediction and make more predictions about the relationship between the distance from the basket and scoring percentage. Finally, students conduct an experiment and gather data to test their hypothesis.

Explain

Students use their formula and the data they collected to create a scatter plot for the relationship between shooting percentage and distance from the basket.

Extend

Students work together to define “correlation,” “positive correlation,” “negative correlation,” and “relatively no correlation.” Students use these terms to describe the relationship illustrated by their scatter plots. They then work to create a definition of the term "line of best fit," draw a hypothesis for the line of best fit for the data, and write the equation for their line of best fit. Students then use technology to find the line of best fit.

Evaluate

Students compare and contrast the line of best fit they found by hand with the line of best fit they found using technology. Then, they use the line of best fit to make predictions about shooting percentages.

Standards

ACT College and Career Readiness Standards - Mathematics (6-12)

AF301: Solve routine one-step arithmetic problems using positive rational numbers, such as single-step percent

Oklahoma Academic Standards for Mathematics (Grade 8)

PA.A.1.1: Recognize that a function is a relationship between an independent variable and a dependent variable in which the value of the independent variable determines the value of the dependent variable.
PA.A.1.2: Use linear functions to represent and explain real-world and mathematical situations.

Oklahoma Academic Standards for Mathematics (Grade 8)

A1.F.1.2: Identify the dependent and independent variables as well as the domain and range given a function, equation, or graph. Identify restrictions on the domain and range in real-world contexts.
A1.D.1.2: Collect data and use scatterplots to analyze patterns and describe linear relationships between two variables. Using graphing technology, determine regression lines and correlation coefficients; use regression lines to make predictions and correlation coefficients to assess the reliability of those predictions.

Attachments

- Bowling with Jacob—Trashketball Part 1 - Spanish.docx
- Bowling with Jacob—Trashketball Part 1 - Spanish.pdf
- Bowling with Jacob—Trashketball Part 1.docx
- Bowling with Jacob—Trashketball Part 1.pdf
- Lesson Slides—Trashketball Part 1.pptx
- Trashketball—Trashketball Part 1 - Spanish.docx
- Trashketball—Trashketball Part 1 - Spanish.pdf
- Trashketball—Trashketball Part 1.docx
- Trashketball—Trashketball Part 1.pdf
- Using Technology to Create a Line of Best Fit—Trashketball Part 1 - Spanish.docx
- Using Technology to Create a Line of Best Fit—Trashketball Part 1 - Spanish.pdf
- Using Technology to Create a Line of Best Fit—Trashketball Part 1.docx
- Using Technology to Create a Line of Best Fit—Trashketball Part 1.pdf
- Vocabulary for Teachers—Trashketball Part 1.docx
- Vocabulary for Teachers—Trashketball Part 1.pdf

Materials

- Lesson slides (attached)
- Bowling With Jacob handout (attached; one per student)
- Trashketball handout (attached; stapled; one per student)
- Using Technology to Create a Line of Best Fit (attached; optional)
- Blank paper (one for each pair of students)
- Green sticky notes (one sticky note per student)
- Red sticky notes (one sticky note per student)
- Markers
- Wastepaper basket
- Tape measures (at least one for every three students; ideally one per student)
- TI-84 Plus or other graphing calculators
- Red pen or marker (one per student)

Preparation

Set-Up Before Lesson

Place an empty wastebasket somewhere in the room so that there is space free of obstacles in front of it. You will use this wastebasket to demonstrate the Trashketball game.

Trashketball Location

For the Explore section of this lesson you will need an outside space (gym, cafeteria, or other area of the school with a large floor space) where students can stand 8 feet to 12 feet in a circle around the wastebasket.

15 minutes

Engage

Teacher's Note: Prior Knowledge

The point of this exercise is to engage students and to assess their prior knowledge about scatter plots and the use of data.

Use the attached **Lesson Slides** to guide the lesson. Display **slide 2–3** to share the lesson title and the essential question.

Display **slide 4** and share the lesson objectives with the students.

Divide students into groups of two or three and display **slide 5**. Pass out the attached **Bowling With Jacob** handout to each student. Have students work in their groups to complete the handout. Each student should record their responses on the handout.

After students have completed their work, display **slide 6** and ask each group to discuss their response to the first question: “Which weight of bowling ball do you think Jacob should use?”

After all groups have given their answers and reasoning, ask students if they noted any differences in the responses. Discuss any differences noted.

Display **slide 7–8** and repeat the above process for the other two questions on the handout.

30 minutes

Explore

Display **slide 9** and inform students they will be investigating data about shooting percentages. Ask students to work with a partner to create a definition for shooting percentage.

After a few minutes, ask for volunteers to share their definitions. Record the given definition on the board and ask other pairs how it differs from their own. Ask if any pair thinks the definition needs to be altered. Continue the discussion until the class agrees on the definition.

Display **slide 10** and have students work with their partners to create a formula for finding the shooting percentage.

Teacher's Note: Clarifying Questions

As students work on creating a shooting percentage formula, circulate around the room and ask guiding questions to clarify student thinking and reasoning. Common questions include: What information do we need in order to find a shooting percentage? Is that value a percentage? What can we do with these values in order to make the formula reflect the definition we created?

Pass out a sheet of blank paper and marker to each group. Have each of the student pairs write their formulas large enough for the class to see on a standard piece of paper. Post these papers around the room (or have students hold them up) so the other groups can view them. Ask if all of the formulas are equivalent or if there are differences. Have students discuss the differences they see. Ask students if these differences would result in different shooting percentage values then have them explain their thinking. Through this discussion, students should work together to create one formula for the class to use for determining shooting percentages.

Make sure students save the papers they wrote their formulas on. They will use these papers later to play Trashketball.

Teacher's Note: Common Obstacles

Some students may write formulas that require a certain number of attempted shots (100 is most common). If so, compare the formula they created with one that takes into account different numbers of attempted shots. Ask if the two formulas would result in the same value if 100 shots were attempted. Then, ask if you could still use both formulas if the shooter then took another 10 shots, for a total of 110 attempts. Students should reach the conclusion that allowing the shooter to attempt different numbers of shots makes the formula more flexible and useful. Other students may have written formulas that express a shooting ratio but not a percentage. You can have students do an example problem and check how reasonable their answer is to help them identify this problem. For example, if students write that a shooting percentage is solely determined by shots made divided by shots attempted, ask them what the shooting percentage would be if someone made 8 out of 10 shots. Their formula will result in 0.8. Point out that 0.8% is a very low percentage, especially considering the shooter made the majority of these attempts.

Display **slide 11**. Give each student a green sticky note and a red sticky note. For each of the examples below, have students hold up a green sticky note if they think the example should result in a high shooting percentage, or a red sticky note for a low shooting percentage result.

Optional Sticky Note Alternative

If there are no sticky notes available, you can use the Walking Vote instructional strategy as an alternative. Students can walk to the left side of the room for "high" and the right side of the room for "low".

Display **slide 12–16** and have students vote whether they think the formula is a high or low shooting percentage for each scenario.

Slide 12: Example 1: 7 attempts, 3 shots made

Slide 13: Example 2: 9 attempts, 8 shots made

Slide 14: Example 3: 5 attempts, 0 shots made

Pause here to ask if anyone can predict the exact value of the shooting percentage for the example on slide 14. Students should recognize that the shooting percentage is 0%, since zero shots were made.

Slide 15: Example 4: 12 attempts, 12 shots made

Pause here to ask again if anyone can predict the exact value of the shooting percentage for the example on slide 15. Students should recognize that the shooting percentage is 100%, since every attempted shot was made.

Slide 16: Example 5: 15 attempts, 16 shots made

Pause here and ask if the data for slide 16 seems reasonable. It should not be possible to make more shots than you attempted. Ask students if they can make a prediction about what the shooting percentage will be if they calculate it with this data. Students should recognize that it would turn out to be more than 100%.

Once they have made a prediction for each example, display **slide 17** and have students use their formula to calculate the shooting percentage. Have students verify that the values they get from the formula match the predictions they made.

Once the class is convinced that the formula they created accurately measures shooting percentage, display **slide 18** and introduce students to the game of Trashketball. Place an empty wastebasket somewhere in the room so that there is space free of obstacles in front of it. The wastebasket can be placed on a desk, table, or on the floor. Wad up a piece of paper and demonstrate shooting it into the wastebasket and retrieving it afterwards. Inform the students they will take the shots next.

Pass out the **Trashketball** handout to each student. Ask students to consider if and how moving away from the basket will affect the shooting percentage. Instruct students to record a hypothesis that describes what will happen to the shooting percentage as the distance between the shooter and the basket increases. Tell students to use the words "increase," "decrease," or "constant" to create the hypothesis. Students should record their hypotheses as a complete sentence.

Sample Hypotheses

As the distance to the basket increases, the shooting percentage will also increase. As the distance between the basket and the shooter increases, the shooting percentage will remain the same. As the distance between the basket and the shooter increases, the shooting percentage will decrease.

Ask students to identify the independent, dependent, and control variables for their hypotheses and record them on their handouts for question 2.

Teacher's Note: Vocabulary

It helps to emphasize that that dependent variable depends on the independent variable. You can also point out that the independent variable tends to be found in the premise of the hypothesis (first clause) and the dependent variable is usually found in the conclusion of the hypothesis (second clause).

Emphasize that control variables could affect the results of the experiment, unless they are controlled and forced to remain constant. Formal definitions of all of these terms can be found in the **Vocabulary for Teachers** handout.

Display **slide 19** and go over the Trashketball rules and expectations before leaving the classroom. Tell students to tear their formula papers in two. Each partner in a pair gets half of their paper to make a trashketball. Explain that every student will crumple up their half-sheet of paper and try to shoot it into the wastebasket.

Move students, the empty wastebasket, and several tape measures outside (or to the gym, cafeteria, or other area of the school with a large floor space). Have students bring their Trashketball handouts, a writing utensil, clipboard, and their crumpled papers on which they wrote their shooting percentage formulas.

Place the wastebasket in the middle of the floor and use the tape measure to measure an 8-foot radius from the basket. Have students form a circle around the basket at that distance, standing next to the partner with whom they originally wrote their shooting percentage formulas.

Have students look at question 3 of their Trashketball handout. Ask students what that means about the values in the chart. Students should be able to explain that the attempts made will equal the number of students in the class. Have them record this information on their charts and then ask students to make their first attempt from 8 feet.

Teacher's Note: Organizing the Activity

You may choose to have all students shoot simultaneously to decrease student anxiety about making or missing it with an audience. This eliminates the pressure of the class watching one student make a shot. However, it can also cause issues—especially when using a smaller wastepaper basket—as papers will collide with each other. Another option is to have students count off, and then have them shoot when their number is called. Calling off numbers in rapid succession allows students to shoot quickly (and avoid being watched) but at different times.

Once all students have taken their shots, go to the wastebasket and count out how many wads of paper made it into the wastebasket. Have students retrieve a wad of paper—it does not have to be the one they threw—and then form a new circle nine feet from the basket. Continue shooting, recording, and forming circles at distances increasing by 1 foot each time until you run out of room in your space or on the chart.

Teacher's Note: Adjusting the Activity

You can have students shoot from distances smaller than 8 feet as well, but this might mean splitting the class into two groups and having the groups take turns, as there will be less room in circles formed at smaller distances. A good rule of thumb is to multiply the radius of the circle by four to determine how many students can comfortably fit around it.

Once all of the data is collected, display **slide 20** and let students work in groups of 2–3 to find the shooting percentages for question 3 of the handout. Provide each group or student with a calculator. Students may use calculators but should be sure to check their group's work before recording it on their own papers.

Once all of the shooting percentages are calculated, call on one group at a time to share their result for the shooting percentage at a specific distance. Have the other groups check the other groups' work. All groups should have the same result. If not, have disagreeing groups share their work and reasoning to settle differences. Continue calling on groups to share results until the class agrees on all of the shooting percentages. Once the class has reached agreement, have each student use the data to create a scatter plot for question 4 on the Trashketball handout.

25 minutes

Explain

Once all students have created their scatter plots, display **slide 21** and use the I Notice, I Wonder strategy to elicit their thinking. Ask students, “What do you notice about the connection between the two variables in your graph?” and “What do you wonder about the two connections between the two variables?”

Sample Student Observations and Questions

Students should notice a relationship between distance from the basket and shooting percentages. They may say something like, "We make fewer shots as we get farther away." You may want to rephrase this so that proper mathematics terminology is used. For example, you could say, "So, what you are saying is that as our distance from the basket increases, our shooting percentage decreases." Students may wonder what would happen if they were able to shoot from a closer range or from farther away. They may ask how far away they would need to get before the shooting percentage is 0, or how close they would need to be for the shooting percentage to be 100. Record all of these questions somewhere students can see them, but they do not need to be addressed at this time.

Explain to students that what they have noticed about the data is that there is a correlation or relationship between the variables. Display **slide 22** and ask students to work in pairs or groups of three to create a definition of correlation.

After every group has created a definition, have one member from each group share their group's definition. After all groups have shared, ask students what most (or all) definitions had in common, what seems necessary to include in the definition, and what is unnecessary. Create one class definition based on this discussion.

Display **slide 23**, and read the formal definition of correlation given in the Vocabulary for Teachers handout. Ask students to compare and contrast their definitions with the formal definition. Allow students to edit the class definition as needed. Once everyone is satisfied with the class definition, have students record it on their Trashketball handouts.

Display **slide 24** and ask students to return to their groups and consider the next three terms on the handout: positive correlation, negative correlation, and relatively no correlation. Have each group create their own definitions for each term. Have students share their definitions for each of the three terms and come up with a class definition for each term. Record the class definitions on the board.

Display **slide 25–27** and read the formal definitions for each of the terms and have students compare and contrast with the ones developed as a class. As a group make any changes to the class definitions. Once you have shown all three slides, have students record the final definitions on their handouts.

Teacher's Note: Terms

Encourage students to use the terms "independent variable" and "dependent variable" in their definitions. It is important for students to understand that a positive correlation means that the dependent variable increases as the independent variable increases, and a negative correlation means that the dependent variable decreases as the independent variable increases. Another way students might express this is that the independent and dependent variables exhibit the same behavior for positive correlations and opposite behaviors for negative correlations. Expressing the relations this way may save students confusion if they accidentally travel from right to left along a relation, rather than left to right.

Display **slide 28** and have students work in pairs to answer questions 5–6 on their handouts: “What type of correlation does the data have? How do you know?” and “What does your answer from question 5 tell you about the hypothesis you made in question 1?” Be sure to have students explain their responses.

Once students have recorded their answers, ask students to raise their hands if they found relatively no correlation in the data. If any groups raise their hand, ask one member of those groups to explain their group's reasoning to the class. Allow other students to ask that student questions or to analyze the group's reasoning.

Teacher's Note

It may be helpful to allow students to use a document camera to display their handouts as they explain their reasoning to the class.

Next, ask students to raise their hands if they found that there was a positive correlation in the data. If any groups raise their hand, ask one member of those groups to explain their group's reasoning to the class. Allow other students to ask that student questions or to analyze the group's reasoning.

Finally, ask students to raise their hands if they found that there was a negative correlation in the data. If any groups raise their hand, ask one member of those groups to explain their group's reasoning to the class. Allow other students to ask that student questions or to analyze the group's reasoning.

After all three views have been presented and analyzed, poll the class to determine if everyone agrees on the kind of correlation the data represents. If not, continue the discussion until a consensus is reached.

Possible Student Response

Students should reach the conclusion that shooting percentage and distance from the basket are negatively correlated.

30 minutes

Extend

Display **slide 29**. Point out to students that their data is close to being linear, but it is not perfectly linear. Tell students that, in cases like this, they will need to work with a line of best fit. Ask students to work in pairs or groups of three to consider the term "line of best fit." What could the definition be? Why would a line of best fit be useful? What would some of the characteristics of a line of best fit be?

After several minutes, each group should share their definitions of a line of best fit. Discuss each definition and what they have in common. Use this discussion to create a class definition for line of best fit. Have students record the final definition on question 7 of the handout.

Next, have each group share one characteristic of a line of best fit. Record the characteristics somewhere all students can see.

Possible Characteristics Observed by Students

The slope of a line of best fit should be positive for positive correlations and negative for negative correlations. The line should pass through as many points as possible. The line should have the same number of points above and below it.

Ask students to pick the three most important characteristics listed on the board. Discuss these characteristics until the class comes to an agreement about which three are most important. Have students record these characteristics on question 8 of the handout.

Then, direct students to complete question 9 on the handout by drawing a line that fits as many of the listed characteristics as possible. Finally, have students complete question 10 on the handout by writing the equation of the line they drew.

In pairs or groups of three, have students meet in groups to discuss their lines of best fit and complete question 11 on their handouts.

Display **slide 30** and discuss with the class the similarities and differences they found. Ask students if they can be sure of which line best fits the data. Students should come to realize that, although their equations are all similar, they do not yet have the ability to choose a "best" line.

Explain to students that computer programs and calculators have the ability to find a "best" fit by examining every possible line and finding the one line that minimizes the distance between it and the points on the scatterplot. Demonstrate how to find a line of best fit (linear regression) using a graphing calculator or spreadsheet software and the data from the Bowling With Jacob handout.

Teacher's Note: Optional Handout

The document **Using Technology to Create a Line of Best Fit** gives step-by-step directions for using Microsoft Excel or a TI-84 and is attached to this lesson. Video explanations can also be found in the resource section.

After demonstrating using the data from the Bowling With Jacob handout, display **slide 31** and have students find the line of best fit for the trashketball data.

15 minutes

Evaluate

Call on one student to share the equation they found for the line of best fit using technology. Have other students verify that they found the same equation and the same line of best fit. If there is disagreement, have students show how they got a different equation. This may involve having students read off the coordinates they used as input, as this is usually the reason for discrepancies.

Display **slide 32** and have all students use a red pen or marker to graph the new line of best fit found using technology on their scatter plots. Ask students how graphs of the two lines of best fit compare. Which one do they think is a better line of best fit and why?

In groups of two or three, have students complete questions 12–14 on their handouts. After all groups complete these questions, have groups share their responses and discuss them with the class.

Allow the groups to complete question 15. After all groups complete these questions, have groups share their responses and discuss them with the class.

Teacher's Note: Trashketball Part 2

Consider teaching Trasketball Part 2 after completing Part 1. Students will need the Trasketball handout from Part 1 in the second lesson.

Resources

- K20 Center. (n.d.). I notice, I wonder. Strategies. https://learn.k20center.ou.edu/strategy/180
- K20 Center. (n.d.). Walking vote. Strategies. https://learn.k20center.ou.edu/strategy/4126