

Trashketball: Part 2

Linear Inequalities

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Grade Level	9th Grade	**Time Frame**	3-4 class period(s)
Subject	Mathematics	**Duration**	180 minutes
Course	Algebra 1		

Essential Question

How can we compare different sets of data?

Summary

Students gather and analyze data, identifying all possible data that is less than, less than or equal to, equal to, greater than or equal to, or greater than the generated line of best fit.

Snapshot

Engage

Students work in pairs to interpret graphs and make conclusions involving inequalities.

Explore

Students sketch several possible answers to linear inequalities in order to determine what region(s) of a graph describe solutions to the inequalities.

Explain

Students create and interpret new situations and explain their interpretations.

Extend

Students design and conduct an experiment that changes one of the control variables. They collect their data and create a line of best fit, based on that data.

Evaluate

Students create and share verbal descriptions to match given graphs of linear inequalities.

Standards

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

AF602: Build functions and write expressions, equations, and inequalities for common algebra settings (e.g., distance to a point on a curve and profit for variable cost and demand)
AF702: Build functions and write expressions, equations, and inequalities when the process requires planning and/or strategic manipulation

Oklahoma Academic Standards for Mathematics (Grades 9, 10, 11, 12)

A1.A.2.1: Represent relationships in various contexts with linear inequalities; solve the resulting inequalities, graph on a coordinate plane, and interpret the solutions.
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

- Graphing Stories—Trashketball Part 2 - Spanish.docx
- Graphing Stories—Trashketball Part 2 - Spanish.pdf
- Graphing Stories—Trashketball Part 2.docx
- Graphing Stories—Trashketball Part 2.pdf
- Lesson Slides—Trashketball Part 2.pptx
- More Bowling with Jacob—Trashketball Part 2 - Spanish.docx
- More Bowling with Jacob—Trashketball Part 2 - Spanish.pdf
- More Bowling with Jacob—Trashketball Part 2.docx
- More Bowling with Jacob—Trashketball Part 2.pdf
- Shooting Percentage Graph—Trasketball Part 2.docx
- Shooting Percentage Graph—Trasketball Part 2.pdf
- Trashketball Part 2 —Trashketball Part 2.docx
- Trashketball Part 2 —Trashketball Part 2.pdf
- Trashketball Part 2—Trashketball Part 2 - Spanish.docx
- Trashketball Part 2—Trashketball Part 2 - Spanish.pdf

Materials

- Lesson Slides (attached)
- More Bowling with Jacob handout (attached; one per student)
- Trashketball Part 2 handout (attached; one per student)
- Shooting Percentage Graph (attached; one per class)
- Trashketball Part 1 handout (from Trashketball Part 1)
- Graphing Stories handout (attached; one per group)
- Colored pencils or markers (one set for the class)
- Graphing Paper (one per group)
- Index cards
- Tape
- Document camera
- Calculator
- Notebook or blank paper
- Waste basket(s)
- Measuring tape(s)

Preparation

Before beginning this Trashketball Part 2, teach Trashketball Part 1. Students will need the completed Trashketball Part 1 handout for this lesson.

Setup for Explain

Create an area in which students can tape the index cards from the activity. Divide this area into five columns and label the columns "less than," "less than or equal to," "equal to," "greater than or equal to," and "greater than."

15 minutes

Engage

Use the attached **Lesson Slides** to guide the lesson. Display **slide 2 t**o introduce the lesson. Move to **slide 3** and share the essential question with the class. Display **slide 4** to share the lesson objectives with the class.

Pass out the **More Bowling with Jacob** handout to each student. Display **slide 5** and have students complete this handout using a Think-Pair-Share strategy. Explain to students that first they will write their own responses and then share them with a partner. Provide students time to both answer the questions on the handout and find a partner. Once each group is done sharing their responses, display **slide 6** and have three pairs share-out their thoughts about part A. Compare and contrast these pairs' answers with your class.

Display **slide 7** and pick two or three different pairs to share their thinking about each of the parts B–E.

After everyone has shared, display **slide 8** and ask students why it might be useful for Jacob to know if he knocks down more or less pins than expected.

35 minutes

Explore

Hand each student a copy of the **Trashketball Part 2** handout to each student. Display **slide 9** and explain to students the graphs on the first page represent the shooting percentage of a class of 24 students. Each graph has a statement made by one of the students about his or her individual shooting percentage. Tell students to use the statement to sketch a possible line of best fit for the shooting percentage of the student. Stress that many answers are possible, as long as the line of best fit they sketch makes the given statement true.

After students have sketched all six lines of best fit, divide the students into six groups. Display **slide 10** and assign one problem for each group to examine together. Ask the groups to create rules for the line of best fit in their problem. Some thoughts for them to consider: What are the possible values for the slope? The y-intercept? Are there any other restrictions on the line of best fit?

Once all groups have created their rules, ask the group that examined the problem about Ariana to display their lines of best fit on a document camera. Then, have them share the rules they created.

Possible Student Response

Students should have created the rule that the line of best fit for Ariana's shooting percentage appears above the line of best fit for the class. If not, ask questions to guide them to this conclusion.

Provide the group who is presenting with colored pencils and the **Shooting Percentage Graph**. Then, using the document camera, have them shade in the area of the graph that could contain Ariana's line of best fit. Emphasize that students are looking to shade in the space where anyone could have drawn a line and still be correct. They should shade in the area above the class's line of best fit. Have the students label this area "Region 1" (or R1).

Ask the students in the group to describe the relationship between Ariana's shooting percentage and the class's shooting percentage. They should say something like, "Ariana's shooting percentage was higher than the class shooting percentage." Have them label R1 with "higher than" or equivalent words of their choice.

Next, have the group that examined the problem about Bethany present in the same manner as the Ariana group did above. On the same large copy of the graph that has already been shaded for Ariana, have this group use a second color to shade in the area where Bethany's line of best fit could be. Label this area R2.

Ask the students in this group to describe the relationship between Bethany's shooting percentage and the class's shooting percentage. They should say something like "Bethany's shooting percentage was less than the class shooting percentage." Have them label R2 with the words "less than" or equivalent words they choose.

Continue, having the group that examined the problem about Camila present. When they attempt to shade, the class should notice that they are shading the same area as that one that was shaded for Ariana. Ask the class to consider what the differences are, if any, between the statement about Camila's shooting percentage and the statement about Ariana's shooting percentage. Guide the class in a discussion until they reach the conclusion that Camila's shooting percentage could have been equal to the class's shooting percentage, whereas Ariana's could only have been higher.

Ask the group that examined the problem about Bethany to identify where in the graph a shooting percentage equal to that of the class would be. They should point to the class's line of best fit. Have this group highlight the class's line of best fit with a third color and then label it with R3 and "equal to." Explain to the class that if you want to show that this is strictly less than or greater than a given line, you make the line dotted. For values that could also be equal to the values, the line is solid.

Now, have the Dante group present. This time, the whole graph has already been shaded. So, rather than asking Dante's group to shade, ask them where Dante's line of best fit could be. They should identify R2 and R3. Ask students to determine if R3 (the line of best fit) should be dotted or solid.

Have the remaining two groups, Elijah and Francisco, present and describe where their lines of best fit would be.

Possible Student Response

The Elijah group should report that Elijah's line of best fit would start in R1 for small distances but fall into R2 for large distances. The Francisco group should report that Francisco's line of best fit would start in R2 for small distances and rise into R1 for large distances.

Point out to students that the class's line of best fit is labeled with its equation. In other words, R3 can be described mathematically using the equation y=-4.6627x+98.214. Ask students how they might mathematically describe R1 and R2. Have students work in pairs to try to write these descriptions.

Teacher's Note: Student Difficulties

If students are having difficulties, point out that R3 (the line of best fit) had been labeled with "equal to," and that R1 and R2 were both labeled. Tell students to consider the labels given to each region when writing the mathematical descriptions.

Students should conclude that R1 could be described by the inequality y>-4.6627x+98.214 and that R2 could be described using the inequality y<-4.6627x+98.214.

Display **slide 11** and ask students to work in pairs to write an inequality for at least four of the six students they just discussed (Ariana, Bethany, Camila, Dante, Elijah, and Francisco). After they have the opportunity to write these inequalities, as for a volunteer to share his or her inequality for Ariana. Make sure every pair of students agrees with this inequality.

Repeat this process for Bethany, Camila, and Dante. Be sure that students use the signs for greater than or equal to and less than or equal to for Camila and Dante, respectively.

Ask for a volunteer to share his or her results for Elijah. You should not receive any volunteers. Ask if anyone wrote an inequality for Elijah. Again, no one should respond. Ask students why they choose not to write an inequality for Elijah. Students should respond that it is impossible to write an inequality for Elijah, since his shooting percentage was greater than the class's shooting percentage for some values and less than the class's shooting percentage for others. Repeat this discussion for Francisco.

20 minutes

Explain

Display **slide 12**. Put students in pairs. Have students pull out their Trashketball handouts from Trashketball Part 1 and examine the list of control variables.

Pass out two index cards for every control variable to each pair. Have pairs brainstorm ways the control variables could be changed. For each control variable, they should make a hypothesis about a way the control variable could be changed so shooting percentage improves, and one way each control variable could be changed so that shooting percentage decreases. Have students record each change made to the control variable on separate index cards. They do not need to write down their hypotheses. In other words, they should write down "make the basket bigger" rather than "make the basket bigger to improve shooting percentage." Be sure to instruct students to write large enough on the index cards that their writing is visible from across the room.

Teacher's Note: Possible Response Discussion

Students will claim that some of the control variables cannot be improved, which may be true (e.g., if the control variable was "ability to see the basket," this variable cannot be improved). As students begin to make these claims about different controls, stop the class and discuss them. If no group is able to brainstorm a way to improve one of the control variables, tell students to skip that hypothesis. You should still wind up with many different proposed changes for a variety of control variables.

Once groups have all written their changes, collect all of the students' index cards to make a deck. Point out the area you created prior to the lesson.

Display **slide 13** and explain to the class that they will draw one card from the deck and tape it in the column they feel is the most likely result. Pick one student to draw the top card from the deck and place it in the column they feel is most likely the result. Then, have that student pick another student from the class to have the next turn. That next student needs to explain whether he or she agrees or disagrees with the placement of the first card. If the student disagrees, give both students an opportunity to explain their reasoning. Then, poll the class to determine where the card should be posted. Move it to the appropriate column, if necessary.

Teacher's Note: Activity Value

Most of the disagreements will be about whether "equal to" should be part of the inequality. Students will disagree about whether the change will make the shooting percentage "greater than" or "greater than or equal to" the original shooting percentage. While students should carefully consider these differences—especially for very small distances (like zero) or very large distances (where the shooting percentage is likely to be zero no matter what)—there isn't necessarily a "right" answer. The value of this activity comes from engaging students in thinking about these questions.

The first student can now sit down, and the second student can draw the next card and repeat the above process.

Continue drawing cards until you have several cards placed in each column or until you run out of cards.

Teacher's Note: Repetition

If any student draws a card that has the same idea as an earlier card, feel free to let them skip the card and draw another.

You should now have several cards under in each column. For each column, discuss which modifications suggested can be feasibly and safely tested. Once ideas that are not feasible or safe are eliminated, let the class vote on one strategy from each column they wish to test.

Divide the class into five groups and assign the strategies chosen from each column to the groups.

30 minutes

Extend

Display **slide 14** and tell each group that they are responsible for designing and conducting an experiment that will allow them to create a line of best fit. Provide groups with a list of materials you have available for them to use such as wastebasket(s), paper, and measuring tape(s). Groups should write a procedure and create a method of organizing and recording their data. Be sure to have students get your approval of their plans before beginning their experiments. When you review their plans, make sure that they will be able to record the data they collect in a reasonable manner. However, do not correct any flaws in their design plan that you see. This will allow their peers to evaluate the design plans later.

Teacher's Note: Authentic Engagement

You might be tempted to give your students an organizing structure like a table to use during this phase of the lesson. However, requiring students to create that structure themselves engages them more authentically in thinking about what data needs to be collected and how best to display the data.

Allow groups to take turns performing their experiments and collecting data. Once they have collected their data, provide each group with graph paper. They should plot the data and graph a line of best fit, either by hand or by using technology.

Teacher's Note: Additional Work

It may be helpful to have other work or a game for students ready, as some groups will likely have to wait for use of the wastebasket before they can perform their experiments.

Once every group has created their lines of best fit, have each group present their procedure and results. Encourage the other groups to give feedback, especially if there are design flaws. If no group is able to point out a design flaw, you may ask the presenting group about it yourself.

Teacher's Note: Identifying Design Flaws

One common design flaw is having different students shoot from different distances. This does not control the shooter. Groups should either have one volunteer make all the shots or have every student in the group shoot from every distance to find an average. You can (and should) discuss which of these designs make the resulting data more comparable to the original line of best fit for the whole class.

Display **slide 15**. Have students plot a line of best fit they found for the class's shooting percentage. See Trashketball: Part 1 for methods of creating a line of best fit.

Have students compare their results to the predictions made by the class. Was the new shooting percentage greater than or less than the original? Were they ever equal?

20 minutes

Evaluate

Display **slide 16**. Tell students they have now seen an example in which inequalities helped to compare different people's athletic performances. Ask students to work with a partner to brainstorm other situations in which inequalities might be useful.

Teacher's Note: Common Examples

Salaries: Person A earns a $1000 dollar raise every year, while person B always earns more (or always earns less) than person A. **Growth**: A tree grows a certain number of inches a year. A second tree is always taller or shorter as it grows. **Budget:** A customer needs to buy two items (x and y) but cannot afford to spend more than a certain amount. **Earnings**: You have two ways of earning money and want to earn at least a given amount of money. **Errors:** A musician makes fewer errors each time a piece is practiced. A second musician always makes more or fewer mistakes.

Have each pair of students share their ideas. Record each idea on the board or somewhere else the class can see it.

Pass out the **Graphing Stories** handout. Display **slide 17**. Tell students that for each graph, they are to write a story that could be described using the linear inequality shown. They may use the list they brainstormed for ideas. They should consider the following:

- Whether the line is increasing or decreasing.
- Whether the line is solid or dashed.
- Whether the shading is above or below the line.

Teacher's Note: Example Story

You may want to create the first story with them, as an example. The stories should be very simple. Something like, "An oak tree is planted when it is 4 feet tall and grows 2 feet every 3 years. A nearby elm tree is never any taller than the oak tree," describes the first graph well.

After they write out the story, they should also write an algebraic inequality to describe the graph shown. Even if you write the first story with the students, have them write the inequality on their own. Check their answers before allowing them to complete the rest of the problems.

Resources

- K20 Center. (2014). Think-pair-share. Strategies. https://learn.k20center.ou.edu/strategy/139