Proximity Data Game

Teacher Facilitation Guidelines

If you have not done so already, please play *Proximity* and watch the short student and teacher videos before or as you read these notes. Also, you should look at the student worksheet for *Proximity*.

Learning Goals

- Students strengthen their understanding of proportional relationships and how linear equations model real-world situations. (The relevant CCSSM standards are listed at the end of this document.)

Prior to Students Playing

- Set a goal for students to complete a certain level by the end of the activity. This creates some urgency and accountability for students and motivates them to focus on mastering the game and the underlying mathematics. In *Proximity*, it might be appropriate for Algebra 1 students to aim to unlock the third level by the end of the period. The scores needed to unlock each level are shown in the Levels dialog box on the game screen. **Note: The student worksheet for *Proximity* guides students only until they have unlocked the third level.**
- Depending on your students' experiences, consider giving them a real-world problem involving a $y = kx$ or $y = mx + b$ model prior to playing this game. For example:

  > Sylvia and Michael have to estimate the number of candies in a bag. There are a lot and they don't want to count them all! All the candies are the same type and size. They count out 12 candies and weigh them: 48 grams altogether. Then they weigh all the candies and get 196 grams. How many candies should they say were in the bag?

- For suggestions on how to prepare to play Data Games with students, go to the Teacher FAQ section of the Data Games website (http://play.ccssgames.com/faq-page).

During Gameplay

- **Overall Notes**
  - *Proximity* consists of levels of increasing mathematical challenge. Students usually try to use a guess-and-check approach for as long as it helps them succeed, rather than using the data or the math skills they have learned. The game is designed so they can succeed with this approach for the first level; but by the second level, it will be difficult to win without analyzing the data and applying the math they have learned. The desire to perform well and advance to higher levels usually motivates them to analyze the data.

  - The secret, teacher shortcut to unlock levels is to hold down the Option+Shift keys (Mac) or the Alt+Shift keys (Windows) while clicking on the red circle for the level you want to unlock.
  - An interesting aspect of *Proximity* is that *push* is the independent variable here, and it is shown in the graph in the usual placement for the independent variable, on the horizontal axis. But in *Proximity*, students know *distance* and are trying to find *push*. In $y = mx$ form, we know y and are trying to find x. Often we do the opposite of this, where we know the independent value on the x-axis, and try to determine the dependent value on the y-axis. So students need to think of the inverse operation, and divide *distance* by *slope* to find *push*. They don't need to use the word "inverse" or discuss it formally here though.

- **Level 1: Doc**
  - Students should figure out on this first level that they need to measure the distance from the ball to the goal before each shot. The game software helps instill this habit by prompting players to use the ruler to measure whenever they have not done so for the last 60 seconds.
  - On this level, the underlying equation of the line is the same for all students in every game: *distance* = 10 * *push*. Many students figure this out, and then spread the word to classmates that the rule is to divide the distance by 10. This is okay, because they won't be able to win that way on the next level!
  - If students don't readily figure out the rule, they should look at the data in the Table or Graph to see if they can figure out the relationship.
  - Students can get tripped up if they look at data that includes bounced shots, because the distance reported is the final distance from the ball to the hole, not the total distance traveled. The worksheet offers a helpful tip about this.

- **Level 2: Sneezy**
  - On the second level and above, the underlying equation changes for every game and every student. There is no longer a common rule that can be shared among students, and they need to create a movable line on the graph to model the relationship between the push and the distance the ball travels.
  - Once a movable line is created, the game provides its equation. Students may then use this equation to determine the push needed for any desired distance they have measured. This is similar to solving for x, given y and m, in a $y = mx$ equation. If students have recently been using the $y = kx$ form instead, you can modify the student worksheet accordingly.
  - Students should figure out it's helpful to use the *Clear Data* button between every game on this level, so they can focus only on the data points for their current game. The software prompts them to clear their data only the first time it's needed, when they change from the first to the second level; with hopes that they will realize on their own the importance of using this action in future appropriate times. The worksheet also hints at the value of clearing data. Alternatively, they can select a row of the table to see only that game's data highlighted in the graph.
  - To score 425 points consistently and unlock the next level, students need to figure out how to determine the line using only one guess *push*. To help them realize that there is a proportional relationship, or that the y-intercept is 0, the

worksheet prompts them to think about what the distance would be for a *push* of 0. The worksheet also guides them toward using the Graph's Gear Menu command, **Lock Intercept at Zero**. This helpfully secures one end of the line when dragging the line to best fit the data.

  - Slopes that are not whole numbers are also introduced at this level.

- **Level 3: Dopey**
  - This level introduces variability, so while there is still one underlying linear equation, not all data points lie exactly on it. The equation is different for all students, and changes significantly each game. Students may need coaching to adjust their movable line to best fit all data as new points are added.
- **Level 4: Bashful**
  - For this and the next two higher levels, Happy and Grumpy, there is a "rough" on the field that affects the motion of the ball. Some students may be able to solve the complex equations for exactly how the deceleration of the ball changes, but that won't be easy for all students. Instead, you might have them first determine qualitatively what's going on. (The ball slows down faster. How do you know? Can you see it in the data?) Then they might be able to develop, empirically, a rule of thumb for how to alter a strictly proportional model to get a pretty good value for the *push*.
- **Level 5: Happy and Level 6: Grumpy**
  - Additional challenges are added: slopes change with each game and each push.
- **Possible Extensions**
  - Discuss with students why in *Proximity* it takes only one wild guess to determine the line. The Data Game *Shuffleboard* also only requires one wild guess, whereas two guesses are required in *Cart Weight*. The reason is that in *Proximity* and *Shuffleboard*, the *y*-intercept, or starting position, is already known, while in *Cart Weight* the *y*-intercept cannot be found without additional guess. The underlying mathematical axiom is the same in every game: "Two points determine a line."
  - Reinforce students' Algebra skills by asking how they could come up with the equation of the movable line if the computer didn't provide it.

Answers to Student Worksheet Questions

- "(Q1) What do you think is the highest possible score in each game?" **– 600**
- "(Q2) Describe briefly how playing on the Sneezy level is different than playing on the Doc level:" **– On the Sneezy level, the underlying equation is different than it was on the Doc level, and it changes with every game.**
- "(Q3) Looking at the data points for the most recent game on the graph, what type of relationship or function does there seem to be between *push* and *distance*?" – **Linear**
- "(Q4) What does the slope of your movable line represent in this game? Explain." – **The slope represents how far the ball travels for each unit of *push*,**

or how far it travels with a *push* of 1.

- "(Q5) What does the *y*-intercept of your movable line represent in this game? Explain." – **The *y*-intercept is 0, because if you push the ball with 0 force, it travels 0 distance.**
- "(Q6) Explain to a new student how to win on the Sneezy level of this game. Write your explanation below." – **Explanations will vary, but should include how they know that the line passes through (0, 0), that you need to make one guess push and then fit the movable line through the two data points, and that you use the equation to substitute in values for *distance* to find *push*.**

Challenges Introduced on Each Level

Level	Equation changes with each game	Non-Whole Numbers	Variability (not all points lie exactly on line)	"Rough" patch present
1: Doc				
2: Sneezy	⊗	⊗		
3: Dopey	⊗	⊗	⊗	
4: Bashful		⊗	⊗	⊗
5: Happy	⊗	⊗	⊗	⊗
6: Grumpy	⊗	⊗	⊗	⊗

Relevant Common Core State Standards for Mathematics

- Analyze proportional relationships and use them to solve real-world and mathematical problems (6.RP.1, 6.RP.2, 6.RP.3, 7.RP.1, 7.RP.2)
- Understand the connections between proportional relationships, lines, and linear equations. (8.EE.5)
- Use functions to model relationships between quantities (8.F.4)
- Investigate patterns of association in bivariate data (8.SP.1 – describe linear association; 8.SP.2—fit a line to data; 8.SP.3—interpret slope and intercept in linear model to solve problems)
- Represent and solve equations and inequalities graphically (A.REI.10)
- Interpret functions that arise in applications in terms of the context (F.IF.4)
- Interpret expressions for functions in terms of the situation they model (F.LE.5)
- Summarize, represent, and interpret data on two categorical and quantitative variables (S.ID.6)
- Interpret linear models (S.ID.7)
- Make sense of problems and persevere in solving them (Standard for Mathematical Practice - 1)
- Model with mathematics (Standard for Mathematical Practice - 4)
- Use appropriate tools strategically (Standard for Mathematical Practice - 5)
- Attend to precision (Standard for Mathematical Practice – 6)