LESSON DETAILS

The Point of Intersection Between Data and Video Games

Lesson Summary

Video games are packed with data. This lesson uses data that is available for Minecraft to demonstrate how a player can use data and mathematics to inform their choices so as to make good decisions while playing video games.

Grade: 9

Big Ideas

- Determining meeting places using intersection of lines
- Make informed decisions using mathematical tools such as graphing

Expectations and learning content

AA1. develop and explore a variety of social-emotional learning skills in a context that supports and reflects this learning in connection with the expectations across all other strands

- developing critical and creative mathematical thinking
- building healthy relationships and communicating effectively in mathematics

A1. apply the mathematical processes to develop a conceptual understanding of, and procedural fluency with, the mathematics they are learning

- Reflecting
- Connecting

A2. make connections between mathematics and various knowledge systems, their lived experiences, and various real-life applications of mathematics, including careers

B3. apply an understanding of rational numbers, ratios, rates, percentages, and proportions, in various mathematical contexts, and to solve problems

> **B3.1** apply an understanding of integers to describe location, direction, amount, and changes in any of these, in various contexts

B3.4 solve problems involving operations with positive and negative fractions and mixed numbers, including problems involving formulas, measurements, and linear relations, using technology when appropriate
B3.5 pose and solve problems involving rates, percentages, and proportions in various contexts, including contexts connected to real-life applications of data, measurement, geometry, linear relations, and financial literacy

C1. demonstrate an understanding of the development and use of algebraic concepts and of their connection to numbers, using various tools and representations
C1.2 create algebraic expressions to generalize relationships expressed in words, numbers, and visual representations, in various contexts
C1.5 create and solve equations for various contexts, and verify their solutions

C3. represent and compare linear and non-linear relations that model real-life situations, and use these representations to make predictions
C3.1 compare the shapes of graphs of linear and non-linear relations to describe their rates of change, to make connections to growing and shrinking patterns, and to make predictions
C3.2 represent linear relations using concrete materials, tables of values, graphs, and equations, and make connections between the various representations to demonstrate an understanding of rates of change and initial values
C3.3 compare two linear relations of the form $y = ax + b$ graphically and algebraically, and interpret the meaning of their point of intersection in terms of a given context

C4. demonstrate an understanding of the characteristics of various representations of linear and non-linear relations, using tools, including coding when appropriate
C4.1 compare characteristics of graphs, tables of values, and equations of linear and non-linear relations
C4.2 graph relations represented as algebraic equations of the forms $x = k$, $y = k$, $x + y = k$, $x - y = k$, $ax + by = k$, and $xy = k$, and their associated inequalities, where a, b, and k are constants, to identify various characteristics and the points and/or regions defined by these equations and inequalities
C4.4 determine the equations of lines from graphs, tables of values, and concrete representations of linear relations by making connections between rates of change and slopes, and between initial values and y-intercepts, and use these equations to solve problems

Cross Curricular Connections

Learning Goals and Success Criteria

LG1 - We are learning to connect the concepts in linear relations with a video game application.

SC1. I can identify the y-intercept as the initial value of a linear relation.
SC2. I can identify the slope of a line as the speed that a player is travelling.
SC3. I can identify the point of intersection of two lines as being the time and distance at which two players could meet to make a trade using different methods.

LG2 - We are learning to determine our meeting places using various methods.

SC1. I can determine the point of intersection between two lines using graphing software.
SC2. I can estimate the meeting place of two players travelling on different paths at different speeds by reasoning numerically.

LG3 - We are learning to verify our meeting places using various methods.

SC1. I can verify the meeting place using linear equations.
SC2. I can verify the meeting place by reasoning numerically.

LG4 - We are learning to interpolate to determine data that we do not have.

SC1. I can describe a process to determine a missing value that lies between two known values in a linear relation.
SC2. I can connect the property of constant rate of change when describing why my process does not work on a non-linear relation.

Ideally, students and teacher will co-construct learning goal(s) and success criteria, and they will be reviewed throughout the lesson.

CONSIDERATIONS THROUGHOUT THE LESSON

Differentiated Instruction and Universal Design for Learning

- Use Flexible Groupings to create small groups. This could be Visibly Random Groupings or Heterogeneous Groupings designed to allow all students to be successful.
- Wait time: Wait at least 30 seconds before accepting any answers from students when working as a whole class. This allows students who need more time to consider their own responses and to frame how to communicate their thinking to do so before they hear responses from others (whose thinking may be different from their own).

- Provide scaffolding (prompts) only to those students who require guidance to continue in the learning.
- Students may need support accessing and using graphing technology

Assessment

Throughout the lesson the teacher will listen to the students correctly and effectively using mathematical language to describe their mathematical thinking.
As the teacher moves from team to team, they will provide descriptive feedback as appropriate.
The Success Criteria should be used by students to self assess. They can also be used by the teacher for ongoing assessment using observation and conversation.
Selected student teams will present their findings at the end of the lesson.

Exit cards

RESOURCES AND LEARNING ENVIRONMENT

Educator Resources Needed

Space for students to work in pairs
Projection equipment to share visuals with the class
Access to graphing software

Materials needed by students

Access to graphing software such as Desmos, Geogebra, graphing calculators, etc.

Considerations related to the learning environment

Word Wall Vocabulary

Speed, initial value, rate of change, slope, y-intercept, point of intersection, interpolation

LESSON CONTENT

Minds-On (20 minutes)

Introduce the lesson by telling students that this activity will focus on learning how data can be used to make a person a better game player.

Whole Class

In the game Minecraft, there are various means of transportation and a set of speeds associated with each that vary with certain circumstances. For example, the sneaking speed on flat terrain is 1.3 m/s, while another speed, with a different set of circumstances, is 10.51 km/h. Ask students Which is faster? 1.3 m/s or 10.51 km/h? How do you know?

Give students 1 minute to consider this question silently. Ask them to turn to an elbow partner and, in 15 seconds or less, they will explain what their thinking is. The student whose first letter in their first name is closest to Z should speak first. (If their names start with the same letter, move to the second letter in their first name, and so on.) They will not share with the class at this time.

Ask students: What relationships do we know that can help us figure this out?
Anticipating steps in student reasoning:

- Kilometres are longer than metres, and hours are longer than seconds.
- 1 km is 1000 m
- 10 km is 10 000 m
- 0.51 km is 510 m
- 1 h is 60 m
- 1 m is 60 s
- 1 h is 3600 s

Record all the relationships on a board or chart paper so that everyone can see.

Instruct students to work with their elbow partner to decide which is faster. Give student pairs about 5 minutes to work out their solution. Circulate and touch base with each pair.
Anticipating common struggles:

- Students will be unsure whether to multiply or divide.
- Prompts:
    - When converting from m to km, should the number that represents your distance become larger or smaller?
    - When converting from seconds to hours, should the number that represents your time become larger or smaller?

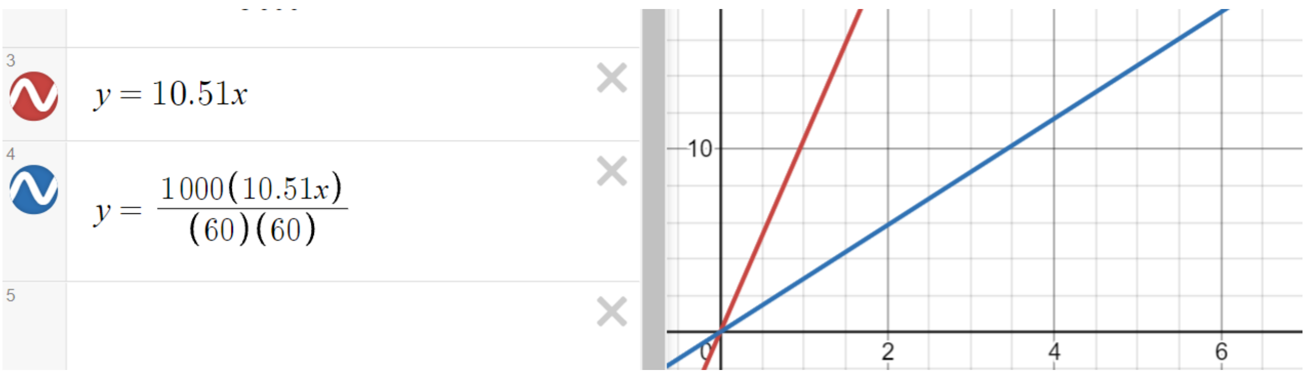
Note any unexpected struggles that seem to be commonplace and talk about these together as a whole class. Otherwise, share prompting questions to the student pairs who are struggling.

Show students this image. Ask students to identify what these two graphs have to do with the problem they just worked on. Collect student responses.
Now ask the class:

- Why does it make sense that both graphs pass through (0, 0)? What does this mean in the context of Minecraft?
- Will these lines ever intersect again? (Will they ever pass through the same point again?) Make sure that you consider what these graphs represent when you describe your answer and your reasoning.)

Wait at least 30 seconds before accepting any responses from students.

Note: If you have observed that some pairs were not combining the relationships correctly, ask that they revisit their thinking.



Action (110 minutes)

Part 1. Whole Class

Present students with data about [Walking Speeds](#).

Ask students what they notice and what they wonder.

Anticipating student responses:

- Why do they give speeds in m/s as well as km/h?
- Why do blocks per second and m/s, and 1000 blocks per hour and km/h match up?
- What are Souls Speeds?

Looking at the way the data is represented.

Ask students the following questions. Wait at least 30 seconds before calling on students to share their thoughts.

Questions:

- What is good about representing the speed data as a table?
- What is good about representing the speed data as a graph?
- Is the data in the table organizing well? If so, why? If not, what might work better?
- We see in the table that "blocks per second and m/s" are in the same heading. Even if you had never played this game before, what does this tell you? (It seems to tell us that each block is 1 m.)

Assessment listen for's:

- As students reflect on the appropriateness of representing speed data in these two forms, listen for well-argued justifications as to why one is better than the other.
- Are students able to make connections between the representation and what it might be used for?

Ask students:

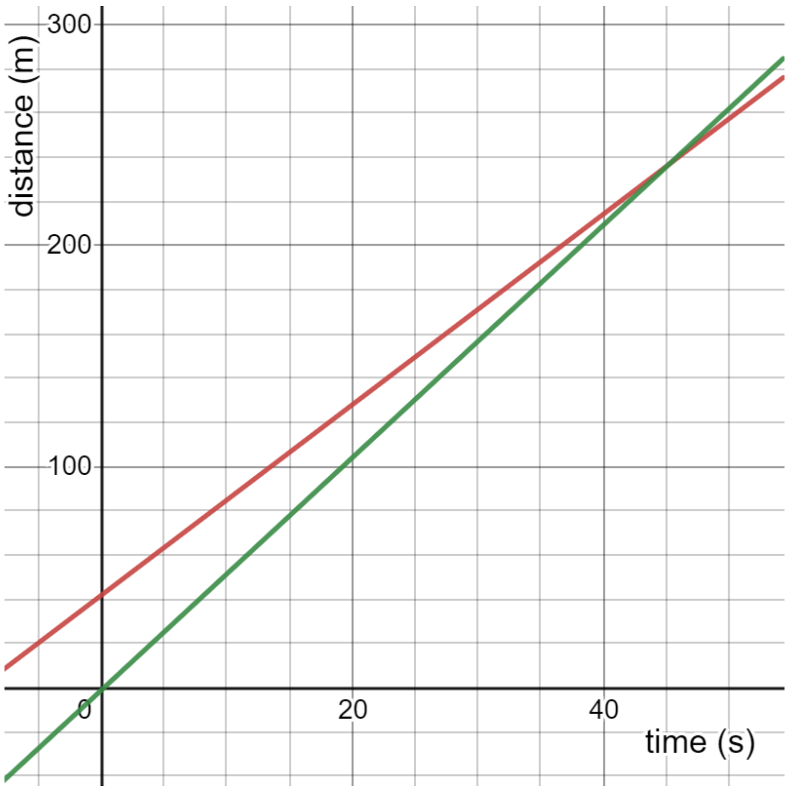
- Do you think that presenting the data as a table is a good way of organizing the data? If so, why? If not, what might work better? (Allow students to share their thoughts (after the 30 second wait time).)

Note to teacher: Before going on to Part 2, explain that Soul Speed is an enchantment that can be applied to boots. The three Soul Speed enchantments allow a player who has put them onto their boots to travel more quickly if they are on soul sand or soul soil.

Part 2. Whole Class

Present the class with the following scenario:

> You need to do a trade with another player. You need to meet in order to do the trade. The problem is that you are travelling on different soul sand roads at different speeds, so you need to decide which is the right room to head to. At this moment, thinking of time as equal to zero (t = 0), you are at position 41.5 and the other player is at position 1.5. You are using normal walking speed, and the other player has walking speed with Soul Speed 2. You make a graph to represent both of your positions and speeds to find a location to meet.



Now you know where and when you will meet! The point where the two lines intersect is about (45, 236), so you will both be in the same place in 45 s, after you have walked 194.5 m.

Ask the class the question: How far does the other player have to walk? (Answer: 236 - (-1.5) = 237.5 m). Wait at least 30 seconds before beginning to accept answers. Keep accepting answers, without indicating which is correct, until there is a “majority opinion” that is the correct answer. Ask one student who has volunteered that answer to explain their reasoning or to describe their computation. Invite another student or two to confirm that they used the same process to arrive at that answer or to offer a different way to see the process.

Ask the class how they might confirm that both players will be at the same location at the same time. Anticipated responses:

Using an equation, substitute time and solve for distance:

$y = 4.317\,(45) + 41.5$

$= 236$

y = 5.267 (45) - 1.5
= 236

This tells us that both players will be at the same place in 45 s.

Using an equation, substitute time and solve for distance:

236 = 4.317 (x) + 41.5
= 45

236 = 5.267 (x) - 1.5
= 45

This tells us that it will take 45 s for both players to be at the same place.

Discuss why you need both equations to confirm your meeting distance and time.

Numerical reasoning:

If no students have offered this method (or an equivalent one), go over it with the class. This method serves many purposes when introducing points of intersection of two lines:

- It shows the recursive pattern of starting where you left off and increasing by the rate of change each time (since the change in x-direction is 1).
- It allows students to see, numerically, the pattern that can be observed in the graphs which is that the y values (distances) are getting closer and closer together, and then start to move apart again.
- It allows students to count how many times they have had to repeat this process, connecting the number of repetitions to the solution in x.
- It allows for students to notice the value of coding something that keeps repeating (a loop with a condition).
- It provides the opportunity to discuss how one interpolates when given a **linear** relationship.
- It provides the opportunity for students to practice interpolation.

Player 1 is walking at a speed of 4.317 m/s. The other player is walking with Soul Speed 2. Therefore, player 1 goes 43.17 m in 10 s. Player 2 goes 52.67 in 10 s.

Time (s)	Player 1 (starting at 41.5 m)	Player 2 (starting at -1.5 m)
0	41.5	-1.5
10	41.5 + 43.17 = 84.67	-1.5 + 52.67 = 51.17
20	84.67 + 43.17 = 127.84	51.17 + 52.67 = 103.84

30	127.84 + 43.17 = 171.01	103.84 + 52.67 = 156.51
40	171.01 + 43.17 = 214.18	156.51 + 52.67 = 209.18
50	214.18 + 43.17 = 257.35	209.18 + 52.67 = 261.85

Students will notice that, at 50 m, they are now moving apart again because the other player now has a greater distance.
Students will interpolate to determine that at 45 s, both players are at the same distance:

Player 1 midway (45 s)	Player 2 midway (45 s)
(257.35 + 214.18) / 2 + 471.53 / 2 ~ 236	(261.85 + 209.18) / 2 = 471.03 / 2 ~ 236

Part 3. Small Groups

Tell students that one game expert advises that coordinates are very handy for finding your way around, so you should keep track of the coordinates of where you were every now and then. Among other things, it will help you find your way back later.

Place students into visibly random teams of 2 (or 3 if required).
Assign one game to each team using the organizer provided. Each game has three "players". Each player has a speed and a location at time zero.

Track the teams assigned to each game in the table provided. (In most classrooms, there will be more than one team assigned to each game.) Encourage the teams to work together on each of their games. Let them know that they will both need to be prepared to present their findings and that they will both have to answer any questions about them.

Their task:
Your team is Player 1. Using the positions and speeds provided, and by graphing the three lines representing each player's distance at time t, determine which player, Player 2 or Player 3, you should meet with to make the earliest possible trade.

- Using mathematical reasoning, which player do you believe will likely be the best one to meet to make the trade? Record this on your "Reasoning" sheet before you begin graphing.
- Be able to state where and when the trade will be made.
- Determine how long it will be (both time and distance) until the trade can be made.

- Verify that the meeting place is correct (allowing for the fact that the points are being determined through graphing) using any method of your choosing.

Allow teams to choose any method to determine the meeting location (point of intersection). Circulate as teams are working to get a sense of how well they are able to construct linear equations with the given information. Take note of which methods for verifying their solutions are being chosen most frequently. Stop and have conversations with students about what they are doing and how they are making decisions. Ask if they are noticing anything different in their cases that they didn't notice when the class did an example together.

Teacher Note: The eight games have been created on Desmos and are shared in the appendices.

Extension Opportunities

Have students calculate the percent improvements that are achieved using each of the 3 Soul Speeds to decide if trying to gain an additional Soul Speed is worthwhile.

Present students with a steep curve and two points on the curve and ask how they might interpolate to get the y-value of the midpoint between the two x values.
For additional practice calculating percentages, do not give students the completed table "Transportation Speeds with Soul Speeds". Rather, have them complete the Speed 1 and Speed 2 columns using the game's rule that "speed" has the effect of increasing an entity's walking speed by 20% multiplied by the effect level.

Consolidation (15 minutes)

Once teams have completed their work, ask three or four teams who had chosen different methods to verify their solutions to present their work and their decision making. Allow students to ask questions to the presenting teams.

Invite the teams to share anything they noticed as they worked through their solutions. Ask students to think about the challenges they encountered in trying to solve this problem. What strategies did they use to overcome these challenges?

Exit cards:
Reflecting: Students will revisit their initial reasoning in light of what they have learned during this activity.

Connecting: Ask students to consider why a player might want to do this sort of analysis when playing a game such as Minecraft. They will record their thoughts on their exit cards.

Appendices

Transportation in Minecraft (for Action Part 1)

Method	Conditions	Average speed in m/s (blocks per second)	Average speed in km/h (1000 blocks per hour)
Walking	Flat terrain	4.317	15.54
	Soul Speed 1	6.066	21.84
	Soul Speed 2	6.519	23.47
	Soul Speed 3	6.972	25.1
Sprinting	Flat terrain	5.612	20.2
	Soul Speed 1	7.885	28.39
	Soul Speed 2	8.475	30.51
	Soul Speed 3	9.064	32.63
Sneaking	Flat terrain	1.3	4.68
	Soul Speed 1	1.819	6.55
	Soul Speed 2	1.949	7.02
	Soul Speed 3	2.92	10.51

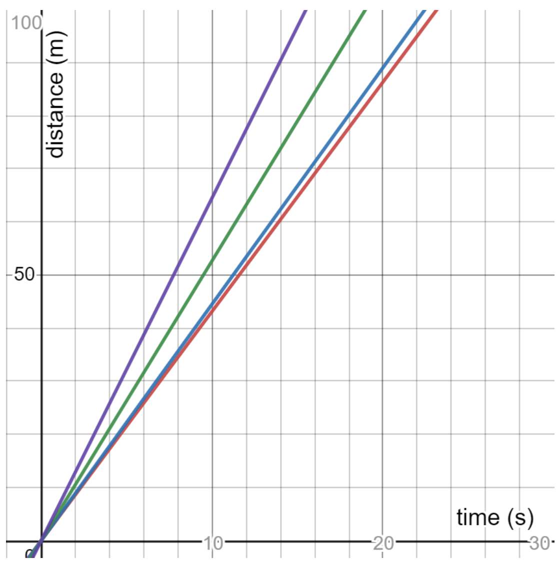
Source: Transportation – Minecraft Wiki

Walking Speed with Soul Speeds (for Action Part 1)

Representation 1 - Table

	Walking
Normal	4.317 blocks/s
Soul Speed 1	4.451 blocks/s
Soul Speed 2	5.267 blocks/s
Soul Speed 3	6.451 blocks/s

Representation 2 - Graph



Transportation Speeds with Soul Speeds (for Action Part 3)

(Note: “Speed” is a “status effect” that increases an entity’s walking speed by 20% multiplied by the effect level)

	Walking	**Crouching**	**Sprinting**	**Sprinting with Speed 1**	**Sprinting with Speed 2**	**Walking with Speed 2**
Normal	Game 1 Player 1 4.317 Start: (0, 0)	Game 2 Player 1 1.295 Start: (0, 45)	Game 7 Player 1 5.612 Start: (0, 169)	Game 3 Player 1 6.735 Start: (0, 32)	Game 4 Player 1 7.857 Start: (0, -81)	Game 6 Player 3 6.044 Start: (0, 37)
Soul Speed 1	Game 6 Player 1 4.451 Start: (0, 136)	Game 3 Player 2 1.335 Start: (0, 220)	Game 1 Player 2 5.786 Start: (0, -14)	Game 4 Player 2 6.944 Start: (0, 11)	Game 5 Player 3 8.101 Start: (0, 43)	Game 8 Player 2 6.231 Start: (0, 72)
Soul Speed 2	Game 2 Player 2 5.267 Start: (0, -27)	Game 4 Player 3 1.580 Start: (0, 431)	Game 8 Player 3 6.847 Start: (0, 19)	Game 5 Player 2 8.217 Start: (0, 10)	Game 7 Player 2 9.585 Start: (0, -9)	Game 3 Player 3 7.374 Start: (0, -60)
Soul Speed 3	Game 8 Player 1 6.451 Start: (0, 50)	Game 5 Player 1 1.935 Start: (0, 101)	Game 6 Player 2 8.386 Start: (0, -3)	Game 2 Player 3 10.063 Start: (0, -55)	Game 1 Player 3 11.740 Start (0, -67)	Game 7 Player 3 9.030 Start: (0, 54)

Desmos Walking Speeds

Tracking the teams (for Action Part 3)

Game 1 Team 1: Team 2:	**Game 2** Team 1: Team 2:	**Game 3** Team 1: Team 2:	**Game 4** Team 1: Team 2:
Game 5 Team 1: Team 2:	**Game 6** Team 1: Team 2:	**Game 7** Team 1: Team 2:	**Game 8** Team 1: Team 2:

Reasoning

We reason that Player ________ will be the best player to arrange to trade with because

Exit Cards

Reasoning

We reasoned that Player ________ would be the best player to arrange to trade with. We had reasoned that

What we found out was that

Name: ____________________________________

Date: _____________________________________

Period / Subject: ___________________________

Explain in your own words how mathematics plays a role in video games.

Name:

____

Date: _____________________________________

Period / Subject: ___________________________

Explain in your own words an optimization strategy that you learned in this lesson.

Name: ____________________________________

Date: _____________________________________

Period / Subject: ___________________________

Explain in your own words how mathematics plays a role in video games.

Name:

____

Date: _____________________________________

Period / Subject: ___________________________

Explain in your own words an optimization strategy that you learned in this lesson.

Desmos Game Graphs

Game 1
Game 2
Game 3
Game 4
Game 5
Game 6
Game 7
Game 8

Percent Improvements using Soul Speeds

	A	B	C	D	E	F	G
1		**Walking**	**Crouching**	**Sprinting**	**Sprinting with Speed 1**	**Sprinting with Speed 2**	**Walking with Speed 2**
2	**Normal**	**4.317**	**1.295**	**5.612**	**6.735**	**7.857**	**6.044**
3	**Soul Speed 1**	**4.451**	**1.335**	**5.786**	**6.944**	**8.101**	**6.231**
4	Percent Improvement	**3.10%**	**3.09%**	**3.10%**	**3.10%**	**3.11%**	**3.09%**
5	**Soul Speed 2**	**5.267**	**1.58**	**6.847**	**8.217**	**9.585**	**7.374**
6	Percent Improvement	**22.01%**	**22.01%**	**22.01%**	**22.00%**	**21.99%**	**22.01%**
7	**Soul Speed 3**	**6.451**	**1.935**	**8.386**	**10.063**	**11.74**	**9.03**
8	Percent Improvement	**49.43%**	**49.42%**	**49.43%**	**49.41%**	**49.42%**	**49.40%**