Sharks, Minnows, and Math: Exploring Linear vs. Exponential Growth

Abstract
This embodied learning lesson uses a game of Sharks and Minnows to help high school students physically experience and compare linear vs exponential growth. Students first play a version of the game where one shark tags minnows that are "out" for the rest of the round (linear growth). They then play a version where tagged minnows become sharks (exponential growth). Afterward, students graph the two scenarios, discuss their shapes, and connect their physical experience to math models. The activity emphasizes how real-world processes, such as viral spread or population growth, can grow exponentially rather than linearly.

Keywords
- High school
- Algebra 1
- Linear growth
- Exponential growth
- Embodied learning
- Classroom game
- Sharks and Minnows

Goals
Students will understand the conceptual and visual difference between linear and exponential growth through a physical game and guided reflection.

Learning Objectives
By the end of this lesson, students will be able to:
1. Define and distinguish between linear and exponential growth.
2. Explain how the number of participants in the game changes over time in each version.
3. Represent linear and exponential relationships graphically and identify their key features (slope, rate of change, curvature).
4. Connect the physical experience of the game to real-world phenomena (e.g., virus spread, compound interest).

Assessment
To assess student understanding, during gameplay, note whether students can verbally describe how the number of "sharks" or "tagged" players changes over time. After both rounds, students graph the data they collected and explain in pairs which model fits each version of the game. The final reflection sheet (Step 6) serves as a brief formative assessment: students identify one example of linear and one of exponential growth and

sketch their graphs side by side. Use these checkpoints to access conceptual understanding, visual interpretation, and the student's connection of embodied experience to mathematical representation.

Purpose/Rationale

Linear and exponential growth are central mathematical ideas that often feel abstract to students. This lesson transforms those ideas into a tangible, memorable experience. Using embodied learning helps students internalize the difference between steady addition (linear) and rapid multiplication (exponential). The activity also encourages teamwork, observation, and data interpretation.

Prior Preparation

Instructor:
- Secure a gym, field, or large open space.
- Prepare two data collection sheets (one for each version).
- Review safety guidelines and rules.

Students:
- Wear sneakers and comfortable clothing for movement.
- Review definitions of linear and exponential functions in advance.

Materials/Resources
- Open gym or outdoor field
- Whiteboard or markers
- Data recording sheets or whiteboards
- Graph paper or devices with Desmos/GeoGebra

There is no cost because all materials and resources should be available to teachers. This lesson's materials are entirely adaptable for schools with limited resources.

Bibliography and Sources for Further Reading

- Playworks. "Sharks and Minnows." *Game Library*, https://www.playworks.org/game-library/sharks-and-minnows/
- Mavilidi, Myrto‐Foteini, et al. "A Narrative Review of School-Based Physical Activity for Enhancing Cognition and Learning: The Importance of Relevancy and Integration." *Frontiers in Psychology*, vol. 9, 2018.
- **TED-Ed.** "How to Play Sharks and Minnows." *YouTube*, uploaded by TED-Ed, 26 July 2023, https://www.youtube.com/watch?v=pbyCfuGe9iY

6-STEP PROCEDURE FOR EXPERIENTIAL EDUCATION

1. Introduction: "Set Up for Success" (10 minutes)

- Begin by asking students to describe something that "grows fast," such as social-media followers or a rumor.
- Introduce key terms: linear growth and exponential growth.
- Explain that the class will play two short rounds of a tag game to model these patterns.
- Emphasize that students will use their bodies to represent mathematical change.
- Review safety rules and explain that data from each round will be recorded and graphed afterward.
- Ask students to predict which version of the game will finish faster.

2. Exploration: "Do It" (20 minutes total)

Round 1: Linear Growth (10 minutes)

1. Start with one shark and 10–15 minnows.
2. Each time the shark tags a minnow, that minnow is "out" and must stand to the side.
3. Record the total number of tagged minnows after each round.

Round 2: Exponential Growth (10 minutes)

1. Reset. Start again with one shark.
2. Each tagged minnow becomes a shark for the next round.
3. Record the number of sharks after each round.

Adaptations:

- For smaller classes, shorten rounds or reduce the field size.

Accessibility:

- Allow walking rather than running.

Potential issues:

- Overcrowding: Mark clear boundaries; assign a student referee for safety.

3. Sharing: "What Happened?" (10 minutes)

Ask students to describe what they noticed:

- Which game ended faster?
- How did the number of sharks or tagged players change each round?

Record student observations in a visible table on the board.

4. Processing: "What's Important?" (10 minutes)

Guide students to graph both sets of results (round vs. number of tagged players).
Discuss:

- How do the shapes differ?
- Which one adds a constant number each round (linear)?
- Which one multiplies (exponential)?

5. Generalizing: "So What?" (10 minutes)
Connect to real-world phenomena:

- Virus spread ("one person infects two others")
- Rumor or social media shares
- Interest growth in a savings account

Ask: "Where in real life do you see exponential patterns like this?"

6. Application and Wrap-Up: "Now What?" (10 minutes)

Students complete a short reflection:

- Write one real-world example of linear growth and one of exponential growth.
- Sketch both graphs side by side.
- The teacher summarizes takeaways and revisits the opening graphs, reinforcing conceptual links.

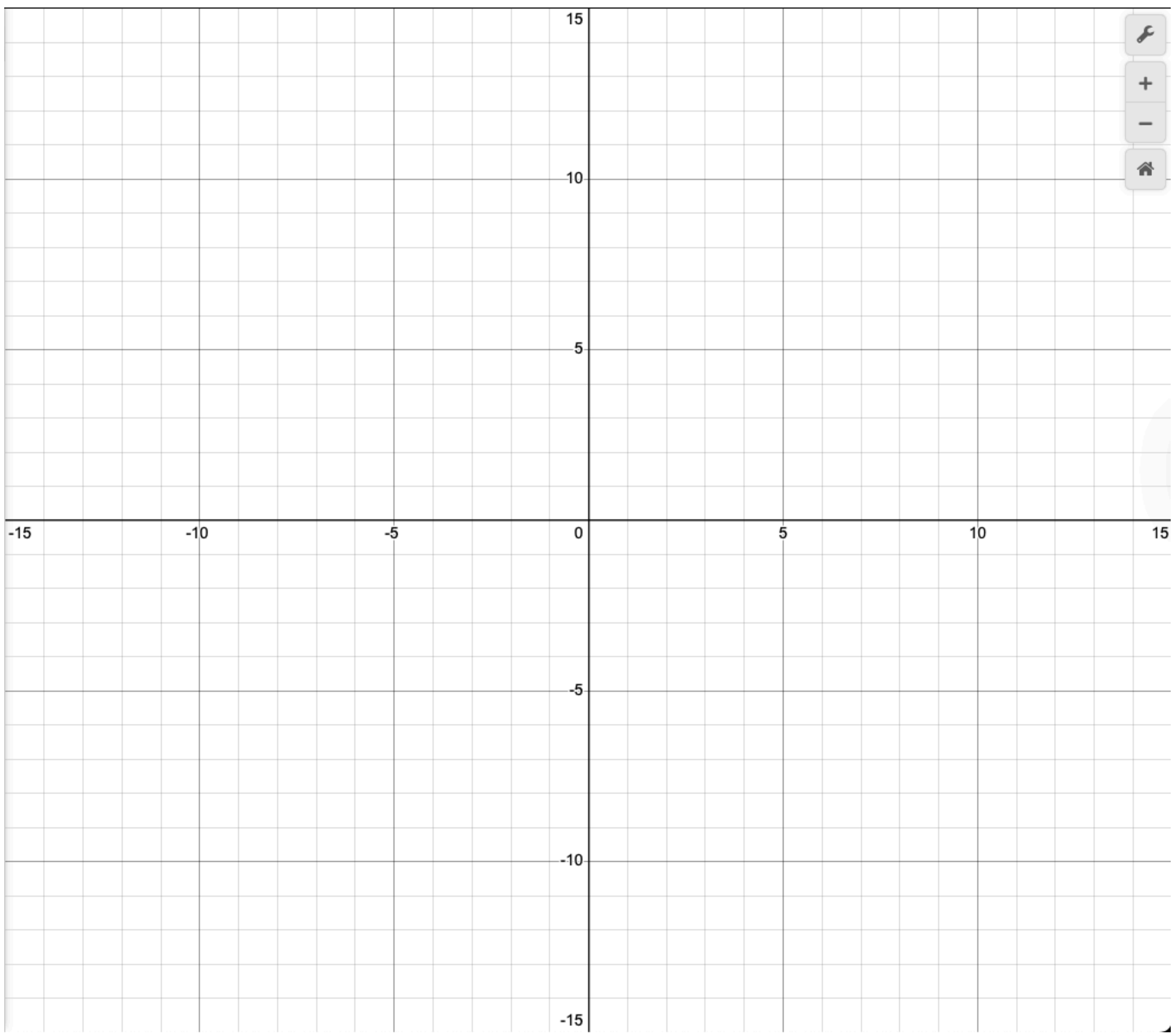
PSET: Linear VS Exponential Growth

Problem 1: Plot the Points

Part I

Plot these points on this graph:

(-1, -3), (-2, -6), (-3, -9), (0, 0), (1, 3), (2, 6), (4, 12)



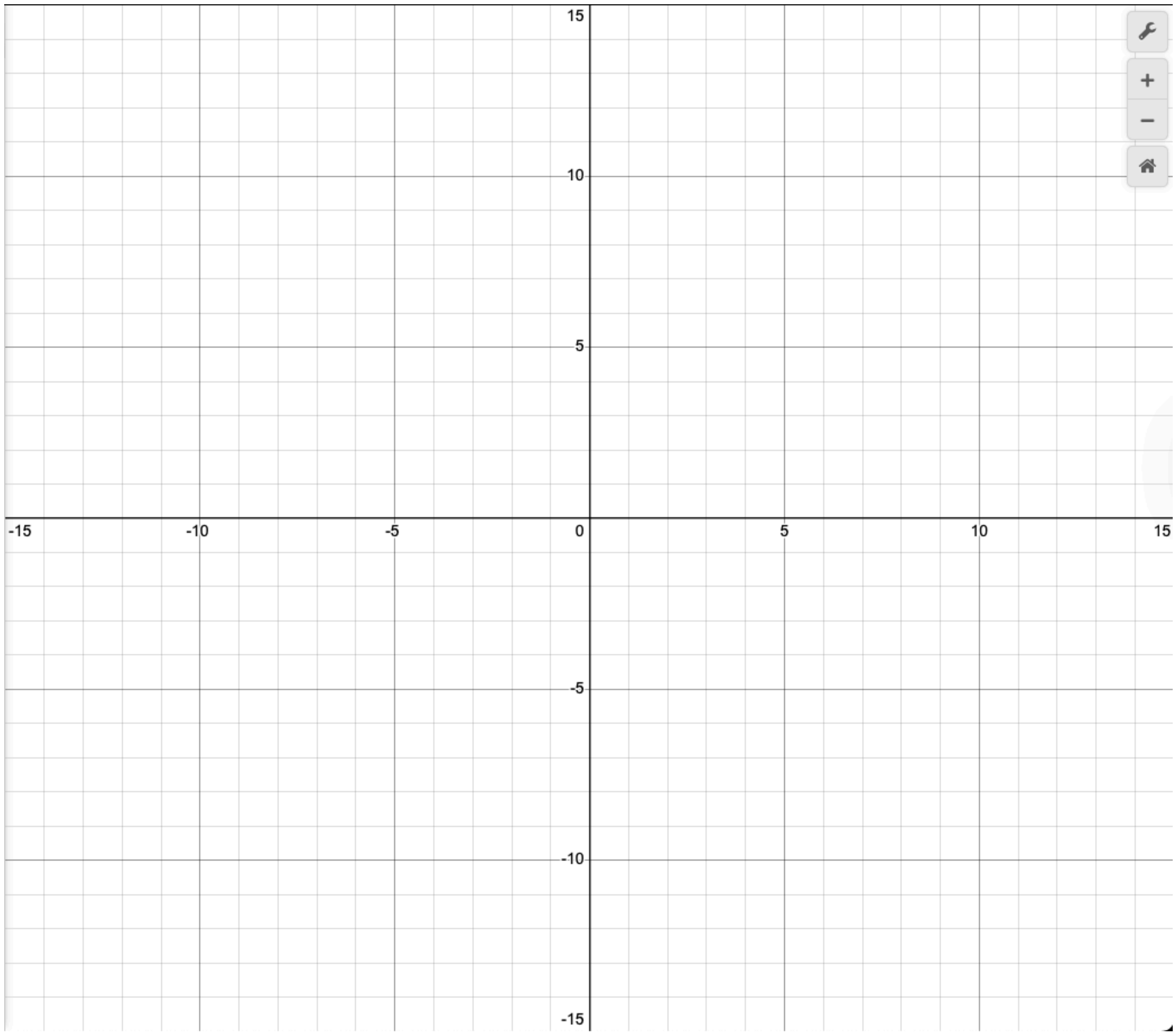
Is this linear or exponential growth?

Why?

Part II

Plot these points on this graph:

(-1, 0.5), (0, 1), (1, 2), (2, 4), (3, 8)



Is this linear or exponential growth?

Why?

Problem 2: Real Applications

Part I

Read each scenario carefully. Circle whether the growth described is linear or exponential. Then, briefly explain your reasoning in one sentence.

1. A scientist puts one bacterium in a jar. Every hour, the number of bacteria doubles.
    a. Linear or Exponential Growth?
    b. Why?

2. You start a job where you earn $50 more each week than the week before.
    a. Linear or Exponential Growth?
    b. Why?

3. A new social media app is shared by each user with 3 new people every day.
    a. Linear or Exponential Growth?
    b. Why?

4. Your book club decides to read 25 more pages each week than the last.
    a. Linear or Exponential Growth?
    b. Why?

5. Each time you fold a paper in half, its thickness doubles.
    a. Linear or Exponential Growth?
    b. Why?

6. A small crack in a tank causes it to leak 2 gallons of water per hour.
    a. Linear or Exponential Growth?
    b. Why?

7. A video starts with 100 views. Each day, it gets twice as many views as the day before.
    a. Linear or Exponential Growth?
    b. Why?

Part II

Come up with two real-life scenarios.

Linear Growth Example:

Exponential Growth Example: