Sample Mathematical Practices Lesson-Planning Tool for High School Exponential Functions Unit

Unit: Exponential Functions

Date: Days fifteen through seventeen of the unit

Lesson: Gossip Problem—Comparing Exponential and Linear Functions

Note: Three fifty-minute class periods

Essential learning standards:

As a result of this lesson, students will be able to . . .

- Compare exponential growth to linear growth using tables and graphs
- Build an exponential function given a description of an exponential situation
- Determine that a quantity increasing exponentially will eventually exceed a quantity increasing linearly

CCSS mathematics content standards:

F-LE.1—Distinguish between situations that can be modeled with linear functions and with exponential functions.

a. Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals.

b. Recognize situations in which one quantity changes at a constant rate per unit interval relative to another.

c. Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another.

F-LE.2: Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs.

F-LE.3: Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically, or as a polynomial function. (Limit to comparisons between linear and exponential models.)

(NGA & CCSSO, 2010, pp. 70–71)

Formative assessment: How will students be expected to demonstrate mastery of the learning target during in-class checks for understanding?

1. Students will be required to demonstrate their knowledge of rates of change in patterns to identify linear and exponential functions and their ability to write equations that model these situations while working through the activity on day one and day two.
2. Students should demonstrate their complete understandings during class presentations on day three.
3. Teacher will monitor team progress on tasks using the walk-around formative assessment process tool (figure 2.15, page 99), provide feedback to teams, and use assessing and advancing questions to further their understanding.
4. Students will provide feedback to their team as they work on the multiple representations and presenting to other teams. Students will make revisions based on feedback. Teacher will use personal response system (clickers) for quick checking-for-understanding moments.

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Probing Questions for Differentiation on Mathematical Tasks	
Assessing Questions (Scaffold instruction for students who are stuck during the lesson or the tasks.) 1. Check for understanding of problem: How many students will know the secret before school even starts? Then how many will know at the end of the first hour? Second hour? 2. What type of function is it? How do you know? What should that graph look like? What type of equation should you be trying to write? 3. What are all the different ways to represent a function? Can you try a different representation to help you understand what you are stuck on?	**Advancing Questions** (Further learning for students who are ready to advance beyond the standard during class.) 1. Can you think of a different situation in your life that increases exponentially? Linearly? 2. Why do you think exponential functions increase more quickly than linear functions? 3. Can we find the slope of an exponential function? If not, can you think of a different way to describe how quickly or slowly it grows or decays? How would you describe an exponential function's rate of change?

Targeted Standards for Mathematical Practice: Which Mathematical Practices will be targeted for proficiency development during this lesson?

Mathematical Practice 1: Make sense of problems and persevere in solving them.

Mathematical Practice 2: Reason abstractly and quantitatively.

Mathematical Practice 3: Construct viable arguments and critique the reasoning of others.

Mathematical Practice 4: Model with mathematics.

Mathematical Practice 5: Use appropriate tools strategically.

Mathematical Practice 6: Attend to precision.

(NGA & CCSSO, 2010, p. 6)

Day 1

Activity or Tasks	What Will the Teacher Be Doing?	What Will the Students Be Doing? How will students be actively engaged in each part of the lesson?
Beginning-of-Class Routines Students complete the warm-up problem connecting to prior knowledge.	The teacher manages beginning-of-class routines, making sure students understand how to write the equation of an exponential function given a table of values by reviewing the warm-up, if needed.	Students will work on the warm-up problem independently. Students should respond on personal response systems (if applicable). Students will be reviewing the concept of writing exponential equations during the warm-up.

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Activity or Task 1 Students complete the first page (back and front) of the gossip problem. How will the students be engaged in understanding the essential learning standards? How will the task develop student sense making and reasoning?	The teacher will monitor students as they work in teams, providing help as needed. (See assessing and advancing questions for tips on scaffolding and extending student' learning.) The teacher will push students to compete all or most of the first page today in class and encourage the use of a graphing calculator (Mathematical Practice 5). It is important that students persevere in solving this problem, and if a calculator will help them think about the problem more completely, then they should be allowed to use this tool.	Students will work in their assigned teams of four to analyze the gossip problem and compare the two different situations (Mathematical Practices 1, 2, and 4). Students will be engaged in the essential learning standards with a problem that they can relate with in their world to see how quickly exponential functions increase. To demonstrate their understanding of both situations and the mathematics involved, students will represent each situation as an equation, table of values, and a graph (Mathematical Practice 4). Students will complete the four-way representations for each situation today (front and back of the first page). Students should ensure that they use correct mathematical symbols (Mathematical Practice 6) and structures in the equations, that they label and scale all graphs and tables correctly, and that they have used precise language when answering the extension questions on the back.
Closure Students complete a student-led closure activity and check for understanding of the learning target by answering a clicker question.	The teacher presents a question asking students which section (equation, graph, or table) for which situation (linear or exponential) was most difficult. The data collected on this question will help to guide the instruction tomorrow.	In teams of four, students will discuss the prompt (Mathematical Practice 3) and respond honestly to the question using a personal response system.
Day 2		
Beginning of Class Routines Students complete the warm-up activity connecting to prior knowledge with page 2 of the day-16 flipchart.	Teacher will manage the beginning-of-class routines. Students should understand how to write the equation of a linear function given a table of values by reviewing the warm-up, if needed.	Students will work on the warm-up problem independently. Students should respond on personal response systems (if applicable). Students should be reviewing the concept of writing linear equations during the warm-up.

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Activity or Task 1 Students complete the gossip problem and extension questions. How will the task develop student sense making and reasoning? Students complete the gossip problem for homework (if needed).	Before students complete their work on the gossip problem, the teacher goes back and provides some hints and tips on the section that students voted was most difficult in the closure activity yesterday. Then, the teacher monitors students as they work in teams, providing help as needed. See the assessing and advancing questions for tips on scaffolding and extending student learning. Teachers should push students to compete the entire problem today in class. Whatever is not completed in class will be assigned as homework.	Students will work in their assigned teams of four to analyze the gossip problem and compare the two different situations (Mathematical Practices 1, 2, and 4). Students will be engaged in the essential learning standards with a problem that they can relate with in their world to see how quickly exponential functions increase. To demonstrate their understanding of both situations and the mathematics involved, students will represent each situation as an equation, table of values, and a graph (Mathematical Practice 4). Students will complete the four-way representations for each situation today. Students should use correct mathematical symbols (Mathematical Practice 6) and structures in the equations, label and scale all graphs and tables correctly, and have used precise language when answering the extension questions on the back (Mathematical Practice 6).
Activity or Task 2 Students check work with neighboring teams (Mathematical Practice 3). How will the task require student conjectures and communication?	Teacher will assign teams one box (section) or one question. Team members will be responsible to present to the class. Allow teams approximately five minutes to partner with a neighboring team to compare answers on their assigned part.	Student teams should partner with other teams nearby (three stay, one stray activity) to compare their solutions to the section of the problem they will present. Students should grade another team's section while the other team grades their work (Mathematical Practice 6).
Closure Students lead closure and check for understanding of the learning target.	At closure, the teacher asks students to make up a question to ask another student from his or her assigned section. Use student questions to test students' knowledge when presenting tomorrow.	Students will create a question they can ask (and would be able to answer) based on their section of the problem. They should submit their completed question in text format on their personal response system before leaving class.
Day 3		
Beginning-of-Class Routines Students complete the warm-up activity connecting to prior knowledge.	The teacher will complete beginning-of-class routines, and allow students to have five to ten minutes to prepare their presentations. Teachers will remind student teams that the goal in presenting is to make sure the rest of the class is an expert on the section that they are presenting. They will need to not only present answers, but explain the what, why, and how of their work. Each team will have about three minutes to present.	Students should organize in their teams from the day before and begin discussing how they plan to present their section (Mathematical Practice 3). Students should be prepared with the correct answer and be able to explain the what, why, and how of their work.

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Activity or Task 1 Students give their presentations. How will the task develop student sense making and reasoning? How will the task require student conjectures and communication?	As students present, the teacher prompts the class about whether students agree or disagree with the team's findings. The teacher should facilitate a discussion, if needed. The teacher might choose to use some of the student questions developed the previous day during closure to assess students' knowledge and help extend the class knowledge.	Students will present their assigned material. The audience should determine whether the class agrees or disagrees, and hopefully some mathematical conversations should follow (Mathematical Practices 3 and 6).
Closure Students lead closure and check for understanding of the learning target.	The teacher will ask students to use clickers to answer the closure question.	Students submit their answers to the closure question after working independently (Mathematical Practice 2).

Materials Needed	**Technology Tips**
• Days 15–17: Sorting Out the Change • Day 15: Exponential Functions Agenda • Day 16: Exponential Functions Agenda • Day 17: Exponential Functions Agenda	Encourage struggling students to use their graphing calculator as a tool. They can pull the table values from the calculator if they are struggling with basic mathematics.

Source for standards: NGA & CCSSO, 2010, pp. 6, 70–71.

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