Lesson 16: Is a Smartphone Smart Enough to Go to the Moon?

Goals

- Use scientific notation to compare quantities in context, and describe (orally) how using scientific notation helps with making comparisons between very large and very small quantities.

Learning Targets

- I can use scientific notation to compare different amounts and answer questions about real-world situations.

Lesson Narrative

In this culminating lesson, students use scientific notation as a tool for making comparisons. Students compare old hardware to new hardware using various digital media as a form of measurement. For example, students compare floppy drives to modern technology by measuring how many floppy drives it would take to store a high-definition film. Students must identify the essential features of the questions and reason qualitatively and abstractly in order to answer them in context (MP4, MP2).

Alignments

Addressing

- 8.EE.A.3: Use numbers expressed in the form of a single digit times an integer power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other. For example, estimate the population of the United States as 3×10^8 and the population of the world as 7×10^9, and determine that the world population is more than 20 times larger.
- 8.EE.A.4: Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Use scientific notation and choose units of appropriate size for measurements of very large or very small quantities (e.g., use millimeters per year for seafloor spreading). Interpret scientific notation that has been generated by technology.

Instructional Routines

- MLR7: Compare and Connect
- MLR8: Discussion Supports

Required Materials

Copies of blackline master

Required Preparation

Print the Old Hardware, New Hardware blackline master. Prepare 1 copy for every 2 students.

Student Learning Goals

Let's compare digital media and computer hardware using scientific notation.

16.1 Old Hardware, New Hardware

20 minutes

Students perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Students use scientific notation and choose units of appropriate size for measurements of very large or very small quantities.

As students work, look for those who use scientific notation to make their calculations and estimations easier. Consider asking them to share their work later.

Addressing

- 8.EE.A.3
- 8.EE.A.4

Instructional Routines

- MLR7: Compare and Connect

Launch

Arrange students in groups of 2. Display or distribute the included blackline master containing computer hardware specifications over time for all to see throughout the activity. Give students 15–20 minutes to work before a brief whole-class discussion.

Student Task Statement

In 1966, the Apollo Guidance Computer was developed to make the calculations that would put humans on the Moon.

Your teacher will give you advertisements for different devices from 1966 to 2016. Choose one device and compare that device with the Apollo Guidance Computer. If you get stuck, consider using scientific notation to help you do your calculations.

For reference, storage is measured in bytes, processor speed is measured in hertz, and memory is measured in bytes. Kilo stands for 1,000, mega stands for 1,000,000, giga stands for 1,000,000,000, and tera stands for 1,000,000,000,000.

1. Which one can store more information? How many times more information?

2. Which one has a faster processor? How many times faster?
3. Which one has more memory? How many times more memory?

Student Response

1977 Desktop:

- Storage is $\frac{28}{15}$ times as much as Apollo
- Processing is $\frac{1}{2}$ as much as Apollo
- Memory is the same as Apollo

2001 Desktop:

- Storage is $2.\overline{6} \times 10^5$ times as much as Apollo
- Processing is 550 times as much as Apollo
- Memory is 32,000 times as much as Apollo

2007 Desktop:

- Storage is $6.\overline{6} \times 10^6$ times as much as Apollo
- Processing is 2,000 times as much as Apollo
- Memory is 10^6 times as much as Apollo

2007 Smartphone:

- Storage is $5.\overline{3} \times 10^4$ times as much as Apollo
- Processing is 200 times as much as Apollo
- Memory is 32,000 times as much as Apollo

2016 Smartphone:

- Storage is $4.\overline{26} \times 10^5$ times as much as Apollo
- Processing is 4,400 times as much as Apollo
- Memory is 7.5×10^5 times as much as Apollo

2016 Desktop:

- Storage is $1.\overline{3} \times 10^7$ times as much as Apollo
- Processing is 6,000 times as much as Apollo

- Memory is 2×10^6 times as much as Apollo

Activity Synthesis

Select students who chose various devices to share their results. A key insight to take away would be how rapidly technology improves and how modern smartphones are much, much more sophisticated than the computer that put people on the Moon.

Access for English Language Learners

Speaking, Listening: MLR7 Compare and Connect. Ask students to create a visual display of their strategy and result for comparing the Apollo Guidance Computer and the device they selected. Invite students to take a tour of the displays and identify "what is the same and what is different about each approach". Draw students' attention to the ways the values were compared using different strategies (e.g., using estimation, calculating differences using scientific notation versus expanded form). In this discussion, emphasize the mathematical language used to make sense of the different strategies to compare the values. These exchanges strengthen students' mathematical language use and reasoning when comparing large and small quantities.
Design Principle(s): Maximize meta-awareness

16.2 A Bit More on Bytes

25 minutes
Students use scientific notation as a tool to understand the relative scale of different units (MP2). They practice modeling skills by identifying essential elements of the problems and gathering relevant information before computing (MP4).

Addressing

- 8.EE.A.3
- 8.EE.A.4

Instructional Routines

- MLR8: Discussion Supports

Launch

Arrange students in groups of 2. Instruct students to first read through the problems and decide on what information they need to solve each problem. Record relevant information for all students to see. Only record information when students have asked for it. Possible information students will ask for include:

- Mai's dad's computer holds 500 gigabytes of storage space.

- A kilobyte is 1,000 bytes, a megabyte is 1,000,000 bytes, and a gigabyte is 1,000,000,000 bytes.
- 1 character is roughly 1 byte.
- An emoji is roughly 4 bytes.
- A full-length, high-definition film is around 8 gigabytes and runs 2 hours.
- A person sleeps about 8 hours in a night.

Give 15–20 minutes of work time before a brief whole-class discussion.

Access for Students with Disabilities

Representation: Internalize Comprehension. Activate or supply background knowledge of working with very large numbers. Allow students to use calculators to ensure inclusive participation in the activity.
Supports accessibility for: Memory; Conceptual processing

Student Task Statement

For each question, think about what information you would need to figure out an answer. Your teacher may provide some of the information you ask for. Give your answers using scientific notation.

1. Mai found an 80's computer magazine with an advertisement for a machine with hundreds of kilobytes of storage! Mai was curious and asked, "How many kilobytes would my dad's new 2016 computer hold?"

2. The old magazine showed another ad for a 750-kilobyte floppy disk, a device used in the past to store data. How many gigabytes is this?

3. Mai and her friends are actively involved on a social media service that limits each message to 140 characters. She wonders about how the size of a message compares to other media.

   Estimate how many messages it would take for Mai to fill up a floppy disk with her 140-character messages. Explain or show your reasoning.

4. Estimate how many messages it would take for Mai to fill a floppy disk with messages that only use emojis (each message being 140 emojis). Explain or show your reasoning.

5. Mai likes to go to the movies with her friends and knows that a high-definition film takes up a lot of storage space on a computer.

   Estimate how many floppy disks it would take to store a high-definition movie. Explain or show your reasoning.

6. How many seconds of a high-definition movie would one floppy disk be able to hold?

7. If you fall asleep watching a movie streaming service and it streams movies all night while you sleep, how many floppy disks of information would that be?

Student Response

1. 500 million kilobytes. Mai's dad's computer can hold 500 gigabytes, which is 500×10^9 bytes. A kilobyte is 10^3 bytes, so his computer holds $\frac{500 \times 10^9}{10^3}$ or 500×10^6 kilobytes.

2. 0.00075 gigabytes. A floppy drive holds 750 kilobytes, which is 750×10^3 bytes. As a fraction of a gigabyte (10^9 bytes), divide $\frac{750 \times 10^3}{10^9} = 750 \times 10^{-6} = 0.00075$.

3. About 5,000 messages, because:
$$\frac{7.5 \times 10^5 \text{ bytes per floppy}}{1.4 \times 10^2 \text{ bytes per message}} \approx 5 \times 10^3 \text{ messages.}$$

4. About 1,250 messages. Emojis take up 4 times as much storage as a character, so there will be 4 times fewer messages. $\frac{5{,}000}{4} = 1250$.

5. About 10,000 floppy disks, because:
$$\frac{8 \times 10^9 \text{ bytes per movie}}{7.5 \times 10^5 \text{ bytes per floppy}} \approx 1 \times 10^4 \text{ floppy disks.}$$

6. 0.72 seconds. A 2-hour film is 120 minutes, which is 7,200 seconds. Therefore,
$$\frac{7.2 \times 10^3 \text{ seconds per movie}}{10^4 \text{ floppy disks per movie}} = 7.2 \times 10^{-1} = 0.72 \text{ seconds.}$$

7. About 40,000 floppy disks. Eight hours is equivalent to 4 movies, which is 40,000 floppy disks.

Are You Ready for More?

Humans tend to work with numbers using powers of 10, but computers work with numbers using powers of 2. A "binary kilobyte" is 1,024 bytes instead of 1,000, because $1{,}024 = 2^{10}$. Similarly, a "binary megabyte" is 1,024 binary kilobytes, and a "binary gigabyte" is 1,024 binary megabytes.

1. Which is bigger, a binary gigabyte or a regular gigabyte? How many more bytes is it?

2. Which is bigger, a binary terabyte or a regular terabyte? How many more bytes is it?

Student Response

1. A binary gigabyte is about 74 million more bytes (74 megabytes) than a regular gigabyte. A binary gigabyte is equal to 1,024 binary megabytes, which is equal to 1,024 binary kilobytes, which is equal to 1,024 bytes. So, a binary gigabyte is $1{,}024^3$ (or 1,073,741,824) bytes.

2. A binary terabyte is about 100 billion more bytes (100 gigabytes) than a regular terabyte. A binary terabyte is 1,024 times a binary gigabyte, so a binary terabyte would be $1{,}024^4$ (or 1,099,511,627,776) bytes.

Activity Synthesis

In a whole-class discussion, ask students what they might have found surprising or interesting when comparing different digital media and different hardware. If time permits, discuss how scientific notation helps to make those comparisons.

Access for English Language Learners

Speaking: MLR8 Discussion Supports. As students explain what they noticed about the differences in digital media and hardware, press for details in students' ideas by requesting that students challenge an idea, elaborate on an idea, or make explicit their process for calculating or comparing the values. Revoice student ideas to model mathematical language use in order to clarify, apply appropriate language, and involve more students. This will help students produce and make sense of the language needed to communicate their own ideas.
Design Principle(s): Support sense-making; Optimize output (for explanation)
