Lesson 1.2.1: Whose Footprint Is Bigger?
Theme: Citizenship

Specific Objectives

Students will understand that
- the magnitude of large numbers is seen in place value and in scientific notation.
- proportions are one way to compare numbers of varying magnitudes.
- different comparisons may be needed to accurately compare two or more quantities.

Students will be able to
- express numbers in scientific notation.
- estimate ratios of large numbers.
- calculate ratios of large numbers.
- use multiple computations to compare quantities.
- compare and rank numbers including those of different magnitudes (millions, billions).

Problem Situation 1: Comparing Populations

In your out-of-class experience, you read about a “water footprint.” In this lesson, you are going to compare the populations of China, the United States, and India. You will go on to look at the water footprint for each nation as a whole and per person (“per capita”) to make some comparisons and to consider what this information might mean for the planet’s sustainability—that is, the Earth’s ability to continue to support human life. While there is no one definition of sustainability, most agree that “sustainability is improving the quality of human life while living within the carrying capacity of supporting eco-systems.” Carrying capacity refers to how many living plants, animals, and people the Earth can support into the future.

You will begin by thinking of various ways you can compare different countries’ populations. Scientific notation might be a useful tool because it is a way to write large numbers. A number in scientific notation is written in the form: $a \times 10^n$ where $1 \leq a < 10$; and $n$ is an integer.

Examples
- 28,930,000 can be written in scientific notation as $2.893 \times 10^7$.
- In 2011, the population of the world was approximately 6.9 billion people. You can write this as 6,900,000,000 or you can use scientific notation to write it as $6.9 \times 10^9$ people.

(1) In 2011, the population of the United States was 311,000,000. The Earth’s population was about 7 billion. Write these numbers in scientific notation.

(2) What are some other ways you could compare the population of the United States to the population of the Earth? Think about forms of comparisons using both estimation and calculation.

(3) In 2011, the population of China was 1.341 billion. Calculate the proportion of the world population that China had in 2011. Write your answer as a percent and as a fraction. Consider how many decimals to give in your final answer.

(4) Calculate how many times larger the population of China is compared to the United States.
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Problem Situation 2: Comparing Water Footprints

The population of the United States is smaller than many other major countries in the world. However, the people who live in the United States consume (or use up) a larger percentage of some natural resources, such as water. This means that the United States has a large “water footprint.”

According to the website www.waterfootprint.org, “People use lots of water for drinking, cooking, and washing, but even more for producing things such as food, paper, cotton clothes, etc. The water footprint is an indicator of water use that looks at both direct and indirect water use of a consumer or producer. The water footprint of an individual, community, or business is defined as the total volume of freshwater that is used to produce the goods and services consumed by the individual or community or produced by the business.”


<table>
<thead>
<tr>
<th>Country</th>
<th>Population (in thousands)</th>
<th>Total Water Footprint* (in ( 10^9 ) cubic meters per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>1,257,521</td>
<td>883.39</td>
</tr>
<tr>
<td>India</td>
<td>1,007,369</td>
<td>987.38</td>
</tr>
<tr>
<td>United States</td>
<td>280,343</td>
<td>696.01</td>
</tr>
</tbody>
</table>

(5) Notice that the countries are listed in the table above from highest to lowest population. Using the data on Total Water Footprint, rank the countries (from highest to lowest) according to their total water footprint.

(6) Rank the countries in order of water footprint per person (“per capita”) from highest to lowest. Be careful with the units on your numbers and final answer.

(7) How many times larger is the population of China compared with the population of the United States? Write your answer in a sentence. (You may want to refer back to Question 4.)

(8) Calculate how many times more water the average person in the United States uses compared to the average person in China.

(9) Write a sentence to explain the meaning of your answer to Question 8. (Remember Writing Principle 1: Use specific and complete information.) Someone who reads what you wrote should understand what you are trying to say, even if they have not read the question or writing prompt.

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Making Connections
Record the important mathematical ideas from discussion.

Further Applications
(1) According to the data in this lesson, the per-person water footprint for the United States for 1997–2001 was 2,482,709 cubic meters per year per person.
   (a) Write a sentence explaining what this number means.
   (b) Find the current population of the United States. One good site is www.census.gov/main/www/popclock.html. Use this information and the given water footprint to estimate the current total water footprint of the United States.
   (c) Compare this number with the U.S. water footprint given in this lesson. How many times larger is it now?