How Are Students Performing without Intervention?  

The following problems are extracted from a pre-intervention baseline assessment administered to students in California and Pennsylvania. The California data represents 4th, 5th, and 7th-grade students in a private philanthropic school in southern California, while the Pennsylvania data represents 7th-grade students in an urban public school in Pennsylvania. The National Assessment of Educational Progress (NAEP) data represents a national sample (http://nces.ed.gov/nationsreportcard/).

### Selected Problems

1. Students were asked to measure the length of the line segment with the ruler under various measurement conditions.
   - **Problem 1:** How long do you think it is?  
   - **Not correct:** How did you get your answer?

2. The line segment is divided into 8 equal-length Mark Blocks. Is this the line segment?
   - **Problem 2:** Is this the line segment?
   - **Not correct:** How did you arrive at that answer?

3. Jen and her friends invented their own units to measure length. Jen named her unit "jip," Tyler measured her unit as "yip," and Scott measured her unit as "gasp!" They all measured the same length as 10. How many "jips" and "gaps" are in 1 "yip"? Is it a fraction of a "gasp"? If so, how many "gaps" are there in 1 "jip"?
   - **Problem 3:** How did you arrive at that answer?

4. Do you think these could be a fraction between 0 and 1?  
   - **Problem 4:** Is it a fraction between 0 and 1?

5. What is the relationship between 3 square inches and 9 square inches?  
   - **Problem 5:** How did you arrive at that answer?

6. If you want to make an equilateral triangle, which of these triangles could work?
   - **Problem 6:** Which of these triangles could work?

7. How many squares are there in 1 square inch? How many squares are there in 1 square foot? How many squares are there in 1 square yard?  
   - **Problem 7:** How many squares are there in 1 square yard?

8. This rectangle is 5 square inches. How many 1 square inches are in the red rectangle?
   - **Problem 8:** How many 1 square inches are in the red rectangle?

Results showed that students gained in accuracy and fluency in generating correct graphs and equations from word problems, graphs from equations, and equations from graphs. These gains were preserved after a 2-week delay.

### Measurement and Fractions

- **Unit 1:** Partitioning & Iterating  
  - **Problem:** Students are asked to identify the extent of the created unit.

- **Unit 2:** Properties of Measurement Systems  
  - **Problem:** Students are asked to relate iteration and partitioning to the measurement of linear extent in units of continuous extent.

- **Unit 3:** Inverse Relationships between Sides of Units & Measured Quantities and Measurement as Proportional Comparison of Two Quantities

- **Unit 4:** Relating Partitioning & Iterating to Denominators & Numerators in Fractions, Equivalent Fractions

- **Unit 5:** Relating Attributes of Measurement Units to Attributes of Measured Quantities

- **Unit 6:** Relating Measurement to Multiplication and Division through an Analysis of Quantities & Units

### Areas for Improvement

- **Areas for Improvement:** Students have significant difficulty with mathematical concepts and procedures related to measurement and fractions.

- **Areas for Improvement:** Important conceptual and operational connections between measurement and fraction concepts are inadequately developed in the 4th-grade curriculum. Measurement yields continuous (as opposed to discrete) quantities, and rational numbers are typically needed to create and represent measured quantities.

### Research Objectives and Learning Units

The goal of this project is to help students develop a fluid integrated mathematical knowledge base in which the domains of measurement and fractions are meaningfully connected to each other and to core concepts of multiplication, division, ratio, and proportion. Six units described below will be developed as supplemental curricular resources to fortify and integrate these mathematical domains and concepts.

### Units Overview

- **Unit 1:** Partitioning & Iterating
  - **Description:** Students are asked to identify the extent of the created unit.
  - **Materials:** Subdividing and combining units for measuring linear extents with precision.

- **Unit 2:** Properties of Measurement Systems
  - **Description:** Students are asked to relate iteration and partitioning to the measurement of linear extent in units of continuous extent.
  - **Materials:** Developing units to measure length.

- **Unit 3:** Inverse Relationships between Sides of Units & Measured Quantities and Measurement as Proportional Comparison of Two Quantities
  - **Description:** Students are asked to understand the relationship between iteration and partitioning to measurement of linear extent in units of continuous extent.
  - **Materials:** Using measurement systems to develop measurement units.

- **Unit 4:** Relating Partitioning & Iterating to Denominators & Numerators in Fractions, Equivalent Fractions
  - **Description:** Students are asked to understand the relationship between iteration and partitioning to measurement of linear extent in units of continuous extent.
  - **Materials:** Using measurement systems to develop measurement units.

- **Unit 5:** Relating Attributes of Measurement Units to Attributes of Measured Quantities
  - **Description:** Students are asked to understand the relationship between iteration and partitioning to measurement of linear extent in units of continuous extent.
  - **Materials:** Using measurement systems to develop measurement units.

- **Unit 6:** Relating Measurement to Multiplication and Division through an Analysis of Quantities & Units
  - **Description:** Students are asked to understand the relationship between iteration and partitioning to measurement of linear extent in units of continuous extent.
  - **Materials:** Using measurement systems to develop measurement units.

### Results

- **Results:** Students have significant difficulty with mathematical concepts and procedures related to measurement and fractions.

- **Results:** Important conceptual and operational connections between measurement and fraction concepts are inadequately developed in the 4th-grade curriculum. Measurement yields continuous (as opposed to discrete) quantities, and rational numbers are typically needed to create and represent measured quantities.

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