

DMT INSIGHTS

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RETHINKING THE TEACHING OF AREA AND PERIMETER

Dimensions, units, and the measurement of length and surface

Introduction

Students often confuse area and perimeter. Both measurements relate to the same geometric figure, but they describe different attributes. Perimeter measures the length of a boundary, while area measures the amount of surface covered. Understanding these distinctions requires students to identify the attribute being measured, select an appropriate unit, and explain how those units are iterated or structured. Research on measurement suggests that students benefit from instruction that makes these relationships explicit (Clements & Sarama, 2014; Lehrer, 2003).

Dimensions provide a way to examine what is being measured, which units are appropriate, and how those units are used.

Understanding Dimensions, Units, and Measurement

Measurement begins by identifying the attribute being measured. A point identifies a location but has no length, area, or volume. One-dimensional measurements involve length, including height, width, distance, and perimeter. These quantities are measured using linear units such as inches, centimeters, and meters.

Two-dimensional measurement involves area, which describes the amount of surface covered. Area is measured in square units. For a rectangle, length and width are each measured in linear units, while the area represents the number of square units that cover the surface.

Three-dimensional measurement involves volume, which describes the space a solid occupies and is measured in cubic units.

Dimension	What it represents	What we can measure	Units and tools
0D: point	A location with no length, area, or volume	Location, not a measurement of extent	Points, vertices, coordinates
1D: linear	Length along a line, segment, or path	Length, height, width, distance, perimeter	Inches, centimeters, meters, feet; rulers, string, tape measures
2D: surface	Extent across two dimensions	Area of rectangles, triangles, and composite figures	Square inches, square centimeters, square meters; square tiles, grids
3D: space	Extent across three dimensions	Volume of solids	Cubic inches, cubic centimeters, cubic meters; unit cubes

Length, height, and width are one-dimensional measurements even when they describe a two-dimensional figure or a three-dimensional object. Consider a rectangle 6 cm long and 4 cm wide (Figure 1). Each side is measured in centimeters. The perimeter is the total length of the boundary: $6 + 4 + 6 + 4 = 20$ cm. The area is the number of square centimeters that cover the surface: 4 rows of 6 square centimeters, or 24 cm^2 . The units differ because perimeter measures length along the boundary, while area counts square units covering the surface.

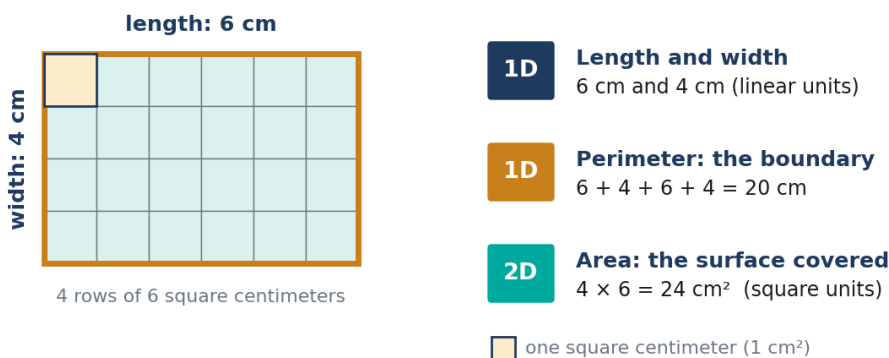


Figure 1. Length, width, and perimeter are measured in linear units; area is measured in square units.

These distinctions provide a mathematical framework for understanding measurement. Students can examine how units are iterated, composed, and structured to measure different attributes. Lehrer (2003) described several ideas students develop in measuring length and area, including iterating equal units, recognizing that units must cover a surface without gaps or overlaps, and understanding how units are structured. Battista (2004) examined how students structure square units to determine area, including using rows and columns to move beyond counting individual units. Clements and Sarama (2014) describe learning trajectories for length and area that show how these ideas develop over time.

When students must interpret a diagram, identify the measurement attribute, select units, and apply a procedure, several demands are placed on their attention and working memory. Clear explanations, appropriate representations, and practice can help students coordinate these demands. Cognitive load theory offers a useful perspective on

instructional design (Sweller et al., 2011), though it does not explain why a particular student confuses area and perimeter.

Key Idea • The dimension of a measurement determines the type of unit needed. Length and perimeter use linear units; area uses square units; volume uses cubic units.

Common Area and Perimeter Errors

Teachers and researchers commonly observe several kinds of responses when students measure area and perimeter:

- **Formula swapping:** Using length $\times$ width to find perimeter, or adding side lengths to find area.
- **Area-perimeter conflation:** Assuming that a figure with a greater perimeter has a greater area, or that figures with equal areas have equal perimeters.
- **Grid-counting errors:** Counting the squares along the edge of a figure, rather than the lengths of its edges, to find perimeter, or counting grid points rather than units.
- **Composite figures:** Difficulty determining the area or perimeter of a composite or non-rectangular figure without a familiar formula.

Each of these responses can be interpreted through the dimensional framework. Instruction can make the distinction between attributes less clear in several ways:

- **Formulas without units:** When $A = l \times w$ and $P = 2(l + w)$ are used without attention to the units each represents, students may treat them as interchangeable procedures.
- **Unnamed units:** When square tiles or grids are used for both measurements without distinguishing the edge of a square from its face, the unit being used may be unclear.

Student Responses as Evidence

Student responses provide evidence of how students may be interpreting the measurement task. When students interchange area and perimeter formulas, teachers can investigate whether they have identified the attribute and unit being measured. Errors when counting grid squares may suggest difficulty distinguishing square units from linear units. When students struggle with composite figures, teachers can examine how they compose and decompose shapes and whether they recognize that area and perimeter are preserved or changed in different ways. These responses should guide further questioning and instruction rather than serve as definitive diagnoses.

Key Idea • A student's response is evidence to investigate. Ask what the student is measuring, which unit the student is using, and how the units are counted or combined.

Understanding One- and Two-Dimensional Measurement

Research on learning trajectories describes how students develop understanding of length and area measurement (Clements & Sarama, 2014; Lehrer, 2003). Lehrer, Jenkins, and Osana (1998) followed children's reasoning about space and measurement across the early elementary grades. For area and perimeter, the central distinction is between linear and square units:

- **1D (length and perimeter):** Iterating a linear unit along a path or boundary. Lengths are combined by addition.

- **2D (area):** Covering a surface with square units without gaps or overlaps, and structuring those units into rows and columns so the number of units can be determined by multiplication.

Asking “Are we measuring the length of the boundary or the surface it covers?” helps students identify the attribute and the unit. These ideas describe important relationships in measurement, rather than a required instructional sequence.

Aligning Tools and Units with Dimensions

Measurement tools can make the attribute and the unit visible:

Dimension	Attribute	Tools and units	Purpose
1D	Length, width, height, perimeter	Rulers, string, tape measures; inches, centimeters, meters	Iterate a linear unit along a path or boundary.
2D	Area	Square tiles, grid paper; square inches, square centimeters	Cover a surface and structure square units into rows and columns.

Square tiles can help students examine both area and perimeter when teachers make the measurement unit explicit. For area, students count square units covering a surface. For perimeter, they measure the boundary segments using linear units. Teachers should highlight the difference between a tile's face and the length of its edge (Figure 2).

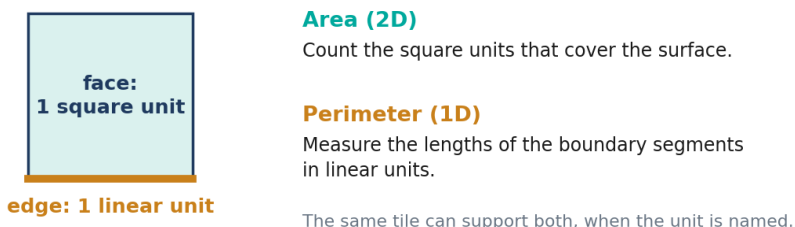


Figure 2. The face of a square tile represents a square unit; its edge represents a linear unit.

Instructional Considerations

The following considerations can guide instruction. They describe ideas to develop, not a sequence every class must follow:

- **Identify the attribute and unit.** Ask what is being measured and what represents one unit.
- **Develop unit iteration and structure.** Iterate linear units along a boundary, and structure square units into rows and columns.
- **Connect representations.** Connect diagrams, tools, language, and equations to the attribute and unit being measured.
- **Compare figures.** Examine figures with equal areas and different perimeters, or equal perimeters and different areas.
- **Develop efficient formulas.** Develop and practice formulas while connecting them to the quantities represented: $P = 2(l + w)$ combines side lengths, and $A = l \times w$ counts square units in rows and columns.

- **Compose and decompose.** Extend reasoning to composite figures by composing and decomposing them, and by examining which measurements are preserved or changed.

Each consideration includes explicit instruction, feedback, and practice. Conceptual understanding and procedural fluency develop together as students use formulas accurately and explain what they represent.

Key Idea • Formulas provide efficient ways to calculate measurements. Students should be able to use them accurately and explain the units and mathematical relationships they represent.

Summary

Understanding area and perimeter requires students to distinguish the attribute being measured, identify the appropriate unit, and explain how the quantity is determined.

Perimeter involves measuring and combining lengths along a boundary. Area involves measuring a surface using square units arranged in rows, columns, and other patterns.

Explicit instruction, representations, feedback, and practice help students develop accuracy, efficiency, and an understanding of the mathematical relationships involved.

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