This activity can be used by students whether or not they have had hands-on experience with physical algebra tiles. Most students, especially tactile learners, benefit from manipulating physical tiles. This activity offers a similar model, using Sketchpad tiles to represent polynomials.

If your students have experience with physical tiles, you might have them use custom tools to construct arrangements that will update dynamically as students drag sliders for *x* and *y*. If so, students should use page "Explore More," rather than page "Frame," to complete the worksheet. Students who do not have experience with physical tiles will need to work with the Sketchpad tiles before they can effectively use the custom tools.

INTRODUCE

Project the sketch for viewing by the class. Expect to spend about 10 minutes.

1. The first page of the student worksheet—"Get Ready"—can be done in class the day before students use computers, assigned as homework, or used as a warm-up. If your students have never used algebra tiles, you should introduce them, as explained in the next step, *before* assigning Get Ready. In any case, you should review the Get Ready questions before starting the activity. Ask for volunteers to explain their answers. Emphasize the relationship between dimensions and area.
2. Open **Tiling in a Frame.gsp** and go to page "Tiles." Make sure that the dimensions are showing. Drag tiles next to other tiles to compare their dimensions. Explain that tiles are named after their areas and make sure students can identify all the names. Drag the *x* and *y* sliders to show that the area expressions match the dimensions for all values. Explain that this activity uses rigid tiles, but that students can explore dynamic tiles in the Explore More.
3. Go to page "Example 1" (or go to page "Frame" and make up your own examples). Enlarge the document window so it fills most of the screen. Explain, ***Today you're going to use Sketchpad to create rectangles using tiles. First you'll drag tiles from the stacks to the outside edges of the frame. Here you can see $x + 2$ along the top and $x + 3$ along the side. These are the dimensions of the rectangle.*** Students should pay attention to how these *dimension tiles* are represented on the frame—along the top and outside left edges of the frame, and separated by like terms.

4. Explain, ***You'll drag tiles from the stacks into the frame to create rectangles. The tiles should be arranged so that there are no gaps or overlaps.*** Press *Show Tile Area.* Explain that the dimensions of this rectangle match those along the outside of the frame. The "seams" in the completed rectangle create straight segments that extend the entire length or width of the rectangle and are aligned with the "seams" in the dimension tiles. Press *Show Blueprint Lines* if you want to emphasize this, but students will not have blueprint lines for the problems on the worksheet. You can show the blueprint lines and tile areas simultaneously to demonstrate that rays constructed from the dimension tiles overlap every seam without going through the interior of any of the tiles.

5. Ask, ***What is the area of the completed rectangle?*** Then use a text caption, or use the board, to write the multiplication problem.

$$\textit{length} \times \textit{width} = \textit{area}$$

$$(\text{or, } \textit{base} \times \textit{height} = \textit{area})$$

$$(x + 2)(x + 3) = x^2 + 5x + 6$$

   Ask what each polynomial represents. Make sure that students know their basic multiplication terminology and notation. They should know what *factors* are and that a product can also be symbolized using only parentheses (without the $\times$ symbol).

6. If you wish to give more guidance, go to page "Example 2." You might review the example together with the class, ask student pairs to review it on their own, or mention it to student pairs only if they need support.

DEVELOP

Expect students at computers to spend about 30 minutes.

7. Assign students to computers and tell them where to locate **Tiling in a Frame.gsp.** Distribute the worksheet. Tell students to work through step 14 and do the Explore More if they have time. Encourage students to ask their neighbors for help if they are having difficulty with Sketchpad.

8. Let pairs work at their own pace. As you circulate, here are some things to notice.

   - Make sure students are placing tiles so that they match both dimensions along the outside of the frame. In particular, make sure students are not using 3 unit tiles as the equivalent of an x tile.

- If a student pair is really struggling, you might show them how to construct blueprint lines by using the **Ray** tool to click on the intersections of the adjacent tiles along the outside of the frame.
- In worksheet steps 6–9, remind students to press *Reset* to return all of the tiles to the stacks after each problem.

SUMMARIZE

Project the sketch. Expect to spend about 5 minutes.

9. Gather the class. Students should have their worksheets with them. Ask, ***How did you multiply polynomials today?*** Establish as a class that multiplying polynomials can be represented by the multiplication equation *length* × *width* = *area* (or, *base* × *height* = *area*), where the dimensions correspond to the factors and the area corresponds to the product.
10. ***How did you decide which tiles to use to build a rectangle? How did you determine which tile goes in each place?*** Students should understand that every tile is a product of two dimension tiles, one on each side of the frame, and that they have to consider both dimensions when choosing their area tiles.
11. ***Are there shortcuts to multiplying? Do you always have to use tiles to multiply polynomials?*** Students should be able to make a multiplication table with dimensions that correspond to the factors and predict the quantity and type of tiles that belong in each region.
12. If time permits, discuss the Explore More. Let students show arrangements they made using the custom tools and how the arrangements adjust to the values of the sliders. You may consider giving all students the chance to work with the dynamic tile tools on another day.

EXTEND

1. Ask, ***What are some limitations of building rectangles with algebra tiles? Do the limitations still exist with multiplication tables?*** Limitations include the inability to represent negative values, nonlinear dimensions, or variables other than x and y, and the lack of enough pieces for large polynomials. Multiplication tables do not have these limitations.

2. Ask, ***If the product of two polynomials can be represented by the area of a rectangle, how could you represent the product of three polynomials?*** The product of three polynomials can be represented by the volume of a rectangular prism.

ANSWERS

Get Ready

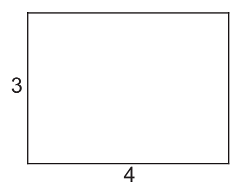
A. $EF = 7$, $BC = 7$. The height of a rectangle is constant.

B. $2x^2 + xy + 3x + 2y + 3$

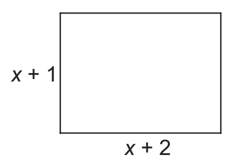
C. $2x + 2y + 4$; $4x + 4$; $4x + 2y + 6$

D. $2 \times 5 = 10$; $6 \times 7 = 42$; $a \times b = ab$

E.



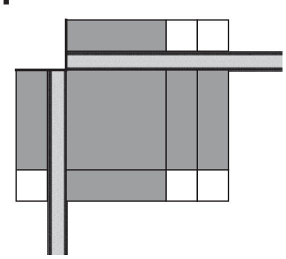
F.



Answers for area will vary. Students should communicate that they understand that $x + 1$ and $x + 2$ should be multiplied.

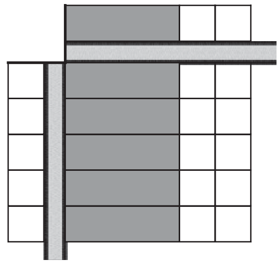
Explore

4.



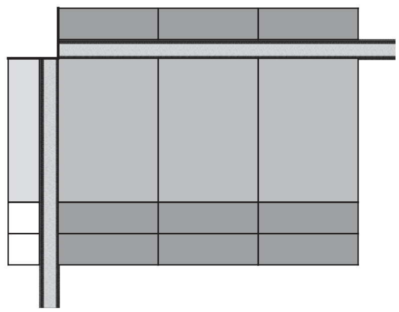
$(x + 1)(x + 2) = x^2 + 3x + 2$

6.



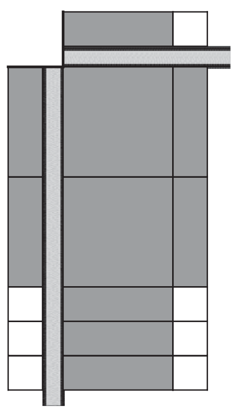
$(5)(x + 2) = 5x + 10$

7.

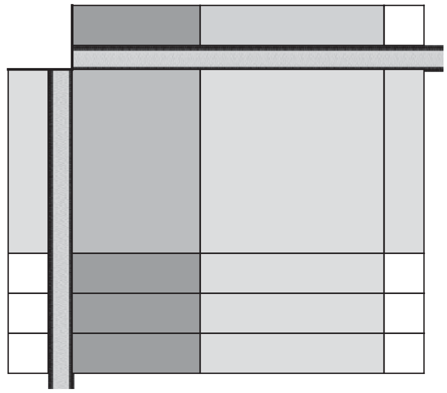


$(y + 2)(3x) = 3xy + 6x$

8.



$(2x + 3)(x + 1) = 2x^2 + 5x + 3$

9. 

$(y + 3)(x + y + 1) = xy + y^2 + 3x + 4y + 3$

10. Building the rectangle would require 40 tiles. (6 x^2 tiles, 22 x tiles, and 12 unit tiles)

11. The red points appear wherever like terms are separated in the dimension tile.

12.

	$3x$	2
$2x$	$6x^2$	$4x$
6	$18x$	12

$(2x + 6)(3x + 2) = 6x^2 + 22x + 12$

13.

	x	y
$4x$	$4x^2$	$4xy$
7	$7x$	$7y$

$(4x + 7)(x + y) = 4x^2 + 4xy + 7x + 7y$

14.

	x	y	1
y	xy	y^2	y
3	$3x$	$3y$	3

$(y + 3)(x + y + 1) = xy + y^2 + 3x + 4y + 3$

The number of rows and columns correspond to the number of terms in each of the factors.