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Learning & Teaching
PK 12

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Growing Problem Solvers: Modeling with Mathematics in the Moment

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Mission Statement

The National Council of Teachers of Mathematics advocates for high-quality mathematics teaching and learning for each and every student.

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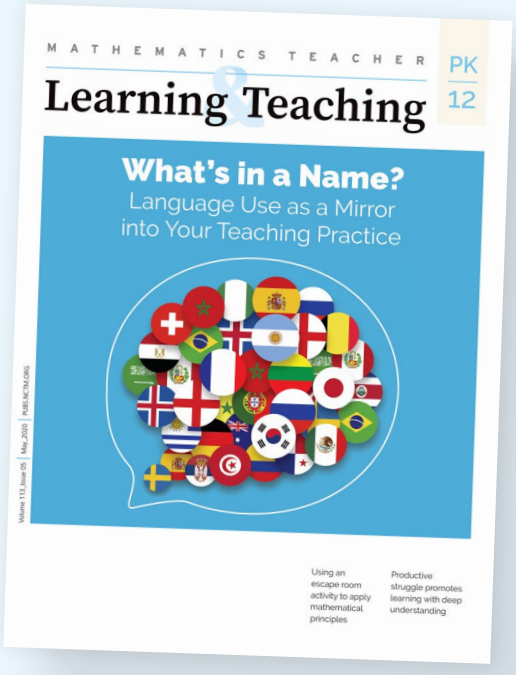


NCTM NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

GPS: Modeling with Mathematics in the Moment

Growing Problem Solvers provides four original, related, classroom-ready mathematical tasks, one for each grade band. Together, these tasks illustrate the trajectory of learners' growth as problem solvers across their years of school mathematics.

Thomas Roberts, Jonathan D. Bostic, and Gabriel T. Matney

The purpose of these four classroom-tested tasks is to engage students in modeling with mathematics. Modeling with mathematics, the fourth of the Standards for Mathematical Practice (SMP 4) from the Common Core State Standards (NGA Center and CCSSO 2010), characterizes behaviors and habits associated with problems that arise from everyday life, the workplace, and society. Problem solvers engaging in SMP 4 are expected to use mathematics to solve a real-life problem and communicate a solution that recognizes the limitations and assumptions of their solution (Bostic and Matney 2016; NGA Center and CCSSO 2010). Solving problems that are connected with the real world or students' lived experiences promotes using mathematics to mathematize situations (Bostic 2015; COMAP 2019; NGA Center and CCSSO 2010).

In the **PK–2** task, students are presented with information about a new elementary school in their neighborhood and are asked to use their knowledge of shapes to design it. While completing the task, students can offer multiple correct solutions from two-dimensional (2D) sketches to three-dimensional (3D) models where multiple 3D shapes are used to create the model. The task requires students to reason about the size of the school in relation to how many people it can accommodate. This task uses geometry knowledge, including modeling the real world. Relationships between shapes and composite shapes identify and describe 2D shapes and 3D figures.

The **grades 3–5** task was inspired by a Marilyn Burns story (2008). Students work to create an arrangement of tables, which meets their space (area) needs and the principal's preference, using as few tables as possible. Students could propose several mathematically correct solutions, and their solutions should explain how each student's space needs are also addressed. As they reason about potential table sizes with only an area given to them, students could map the relationships using diagrams, two-way tables, and area formulas. This task uses knowledge of factors and geometric measurement concepts such as area and relating area to multiplication and addition.

In the **grades 6–8** task, students use ratios, proportions, volume, and money to find the cost of filling four raised garden beds. They work in small groups and request information from the teacher. Available information is written on note cards for students

to retrieve (see the supplementary material). If the information is not available, then they return to their group to request different information. After getting information, students use that information, judging whether it is necessary to solve the problem, and deliver a solution indicating how many different bags of soil are needed and the final cost for all materials.

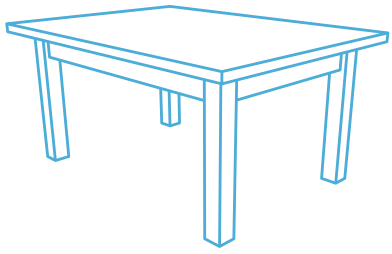
In the **grades 9–12** task, students are presented with a problem of determining location(s) to take a picture of two friends on the theme park ride. While problem solving, students will likely become aware that numerous mathematical solutions exist; however, the map of the park suggests limitations to the locations to take the photograph. The teacher should prepare a number of tools for the students to strategically select, including protractors, compasses, snap cubes, straight edges, and geometry software. Students engaging in this task need to analyze angle positions in relationship to a square structure (the Power Tower) while maintaining the real-world context of photography. Note: You can find a map of Cedar Point online. The task invokes the use of mathematical concepts of angles, triangles, squares, circles, chords, perpendicular bisectors, trigonometric ratios and proportions, and geometric constructions, as students figure out all possible locations where one might stand to take the picture.

PK–2

A new elementary school will be built in your neighborhood. Using your knowledge of shapes, create designs for the new elementary school that would serve the needs of your neighborhood. As you design the elementary school, think about how many students should be able to attend the school and the needed width, depth, and height of the school to accommodate all the students. Identify the shapes you used and the positions of the shapes in each model.

3–5

Ms. Chapman, the school principal, is planning an ice-cream party for students. She anticipates having up to 54 students at the party. On average, each student requires 3 square feet of space at a table. Each student also requires space at the edge of the table. The rectangular tables in the cafeteria have an area of 28 square feet. Ms. Chapman wants to use the fewest tables possible. What could be the dimensions of the tables? Do the tables need to be identical? How could the tables be arranged for all students to participate in the ice-cream party while using the fewest tables possible?



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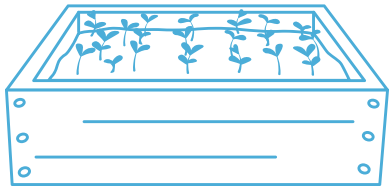
6–8

Jonathan wants to fill his new raised bed gardens with a mixture of peat moss, vermiculite, and compost. The ratio of each is 1:1:2. The garden beds currently have nothing in them. How much will it cost to fill four raised garden beds to a depth of eight inches?

What information do you want to solve this problem?

You may ask your teacher for up to five specific pieces of information to help you. Record your selections. Your teacher will supply you with this information, if it is available. Your teacher will let you know if the information is not available. After considering the information you receive, you will get a second chance to ask for up to four additional pieces of information. After getting this information, your group should formulate your solution with the tools and information available to you. Your group may not "scout" other groups' attempts.



Selection Group 1

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Selection Group 2

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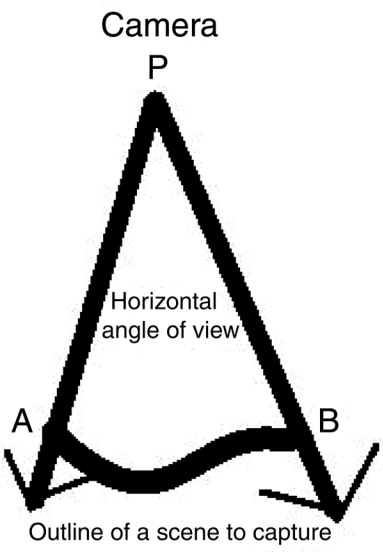
9–12

See the figure for a picture of this phenomenon.

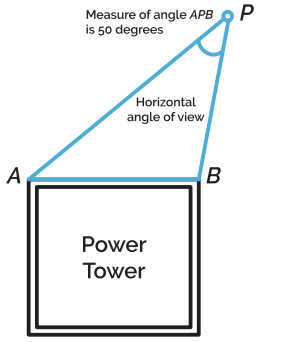
Jason, a photographer, wants to photograph his friends on the Power Tower ride at Cedar Point Amusement Park. His friends are seated on two adjacent legs facing outward in the same direction (i.e., points *A* and *B*). The Power Tower sits on a flat plot of land. He wants a level shot of the full width of the Power Tower so that he can get all his friends in the same shot before the ride starts. A level shot has zero angle of elevation. He does not care whether the full height of the Power Tower is captured. The width of the Power Tower must not be cut off in the picture. Given a viewing angle of 50 degrees, he has found one spot that will work as indicated by point *P*. He believes that he could stand elsewhere in that park to photograph his friends on the Power Tower, albeit from a different perspective.



1. Your task is to figure out all the possible locations where Jason can stand to take the picture with a fixed 50 degree camera angle.

The horizontal viewing angle in photography describes the angular extent of a captured screen such that the vertex is the camera lens.

Viewing the Power Tower from above



2. How can you use your tools to help you make sense of and justify where these points should be? Be prepared to explain and justify your solution(s).

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