The Yogurt Shop Task: Bringing Mathematical Modeling Into the High School Classroom

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Abstract

In this mathematical modeling task, Algebra 1 students rely on their real-world and mathematical knowledge to design a shelving layout for a yogurt shop. They must design a layout for the shelves that will be easily accessible, serve the needs of the business, and fit an appropriate number of cups. This article describes the implementation of the task along with examples of student work.
Keywords: algebra, math modeling

When students ask, "When will I ever use this?", mathematical modeling provides one of the most powerful answers. The Yogurt Shop Task is an engaging example of mathematical modeling for Algebra 1 students. It combines designing a frozen yogurt shop with linear equations and spatial reasoning.

Mathematical modeling is the process of using mathematics to represent and analyze real-world situations (Garfunkel & Montgomery, 2019). Unlike traditional word problems with one right answer, modeling tasks are authentic, messy, and open-ended. Students make choices, test ideas, and refine solutions in ways that mirror how mathematics is used outside school. Engaging students in tasks like this invites collaboration, perseverance, and seeing mathematics as a tool for making sense of their world (Livers, 2023).

Describing the Task

The Yogurt Shop Task (Figure 1) begins with a premise: an entrepreneur is opening a frozen yogurt shop, and needs help designing shelving for cups. Students are given the wall dimensions and the locations of obstacles like a counter, TV, and light fixtures, which constrain shelf placement. Their challenge is to design a shelving layout that is accessible, meets the needs of the business, and holds an appropriate number of cups.

Figure 1
The Yogurt Shop Task

Note. Shop interior reproduced with permission of Mindful Design Consulting.

The Yogurt Shop Task engages students in rich mathematics while aligning with the Common Core State Standards for Mathematics. The task asks students to determine how many cups fit on a shelf, convert units, and model the linear relationship between cups and stack height. This work addresses content standards such as creating equations (HSA-CED.A.1), solving equations (HSA-REI.B.3), and reasoning about their validity (HSA-REI.A.1). The task also embodies Standards for Mathematical Practice: students model with mathematics (MP4), persevere in problem solving (MP1), reason abstractly and quantitatively (MP2), construct viable arguments (MP3), and attend to precision (MP6).

Figure 2
Task Standards

Common Core State Standards for Mathematics – Practice Standards
MP1: Make sense of problems and persevere in solving them. **MP2**: Reason abstractly and quantitatively. **MP3**: Construct viable arguments and critique the reasoning of others. **MP4**: Model with mathematics. **MP6**: Attend to precision.
Common Core State Standards for Mathematics – Content Standards
HSA-CED.A.1: Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions. **HSA-REI.B.3**: Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. **HSA-REI.A.1**: Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.

Implementing the Task

This task has been implemented in Algebra 1 classrooms after students learn linear equations. A three-day plan (Figure 3) with 60-minute periods allows students time to think, productively struggle, revise ideas, and strengthen models. Initially, the task was fully open-ended, but students often got stuck, so we added structure. Students receive a slideshow and may present their solution digitally or on paper. Some used draggable shelves in Google Slides, while others created drawings.

Figure 3
Days 1–3

On Day 1 (Understanding the Problem), students are introduced to the scenario and must decide what is important and what assumptions are reasonable. Teachers facilitate a brief discussion of givens and constraints to help groups begin. Teachers can ask, "What do we know for sure? What is missing? What would you need to assume to move forward?" Teachers may also provide physical cups to help students visualize cup stacking and placement of cups on mock shelves. Students decide what "accessible" means, how many cups are "appropriate," and how to handle obstacles. A brief whole-class discussion can also help students consider what might count as a reasonable number of cups based on factors such as demand, staffing, or storage. These decisions push students to articulate assumptions and negotiate what matters most in their design.

Students often rely on their own experiences with frozen yogurt shops to justify choices. Some groups design shelves that hold cups face down, while others make dispensers modeled after real shops. Students may also research the business side of selling frozen yogurt, like which cup size sells most or the average height of an employee. This information helps them logically defend their decisions. Groups typically discussed several possible layouts before agreeing on a design that balanced accessibility, capacity, and the constraints of the space.

Perhaps the most powerful aspect of the task is how it prompts students to talk about mathematics in meaningful ways. One group debated whether they could stack more cups by prioritizing small sizes over large ones. Another group argued about whether shelves could be placed beneath the light fixtures, weighing accessibility against capacity. These conversations, rich with critique and defense, show students engaging in mathematical practices that go beyond getting an answer.

Day 2 (Mathematizing the Situation) shifts toward mathematizing early ideas. Some groups generate scale drawings on paper (Figures 4 and 5), carefully converting feet to inches. Others design on computers in a slideshow, dragging and rearranging digital "shelves" and cup stacks to test layouts (Figure 6). As groups decide on shelf placement, some students over-simplify while others get lost in detail. Teacher nudges like, "Does it matter exactly where the shelves go?" or "What areas are accessible?" help students recognize and defend choices. Cup dimensions lend themselves to building equations that model the linear relationship between the number of cups in a stack and the total height. Many groups initially reason arithmetically using tables or repeated calculations before recognizing that an equation provides a more efficient way to represent and generalize the relationship. Students draw scale diagrams, create tables, and use linear equations.

Figure 4
Sketches of Designs: Shop Layout and Cup Stacks

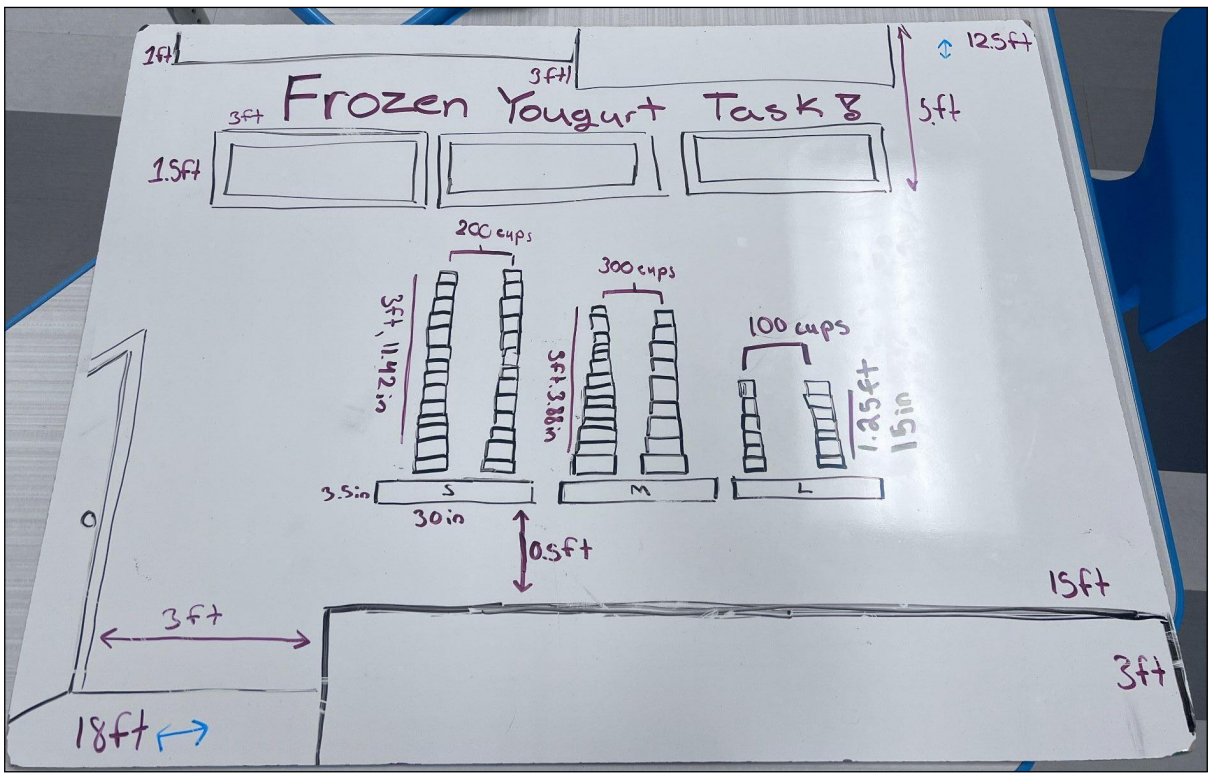


Figure 5
Sketches of Designs: Fitting Cups on a Shelf

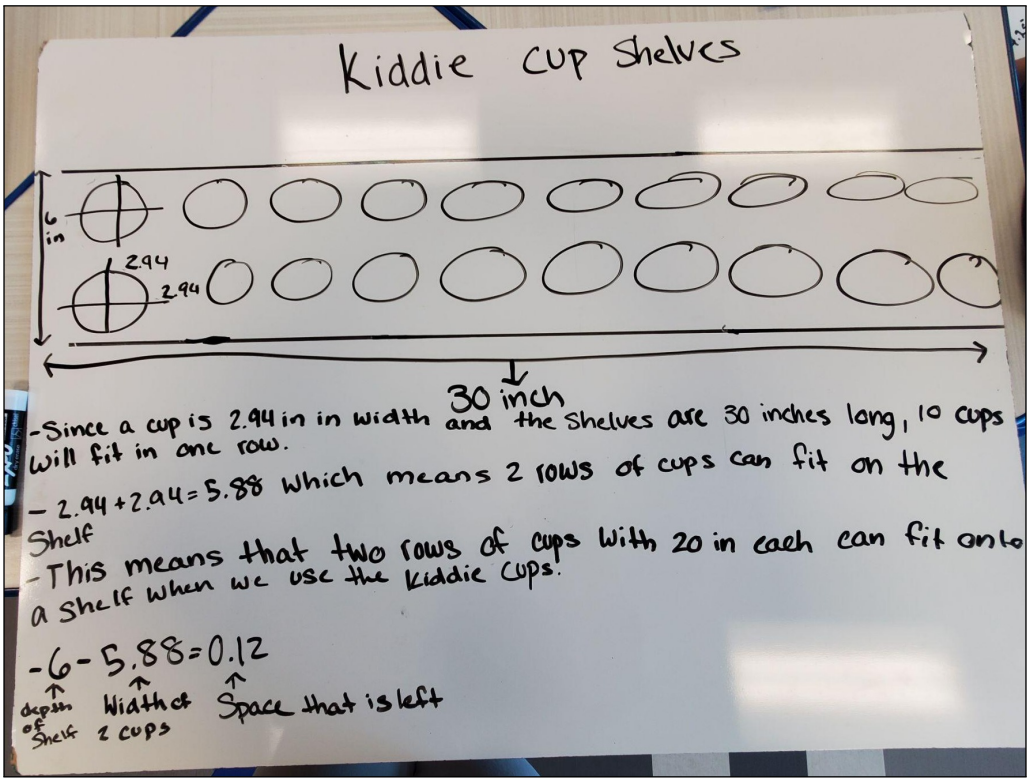


Figure 6
A Digital Design

Note. Shop interior reproduced with permission of Mindful Design Consulting.

When working with the space, units must be converted between feet and inches, shelves sometimes collide with the TV, and calculations that looked promising on paper turn out to be unrealistic. These setbacks encourage perseverance. Students try different approaches, revise assumptions, and sometimes abandon initial designs for new ones.

Teachers can support students on Day 2 by asking, "How can we represent the relationship between the number of cups and the stack height?" or "What's a way to show how many cups fit on a shelf?" Strategic questions like, "How does your table connect to your equation?" or "Does your diagram agree with your calculations?" push students to reconcile different representations and see how mathematics and context align.

Students' mathematical work will vary. One group (Figure 7) defined x as the number of "extra" cups, meaning the total number of cups in the stack plus 1. In contrast, another group defined x as the total number of cups in the stack. The group in Figure 8 illustrates how students considered and calculated multiple stacks on a shelf. Some groups maximize space by substituting the height they are working with and solving for the number of cups, while others determine the number of cups they want to use and then calculate the height. In some cases, groups' calculations led to slope values that required further justification or revision, which created opportunities for class discussion about how slope represents the rate at which stack height changes with each additional cup. These moments often became productive discussion points as students compared methods and refined their models. Regardless of approach, students must apply their knowledge of linear equations and logically defend their design choices. These examples illustrate different ways students represented the situation rather than suggesting a single preferred approach.

Figure 7

Linear Equations and Cup Calculations: Defining the Variable

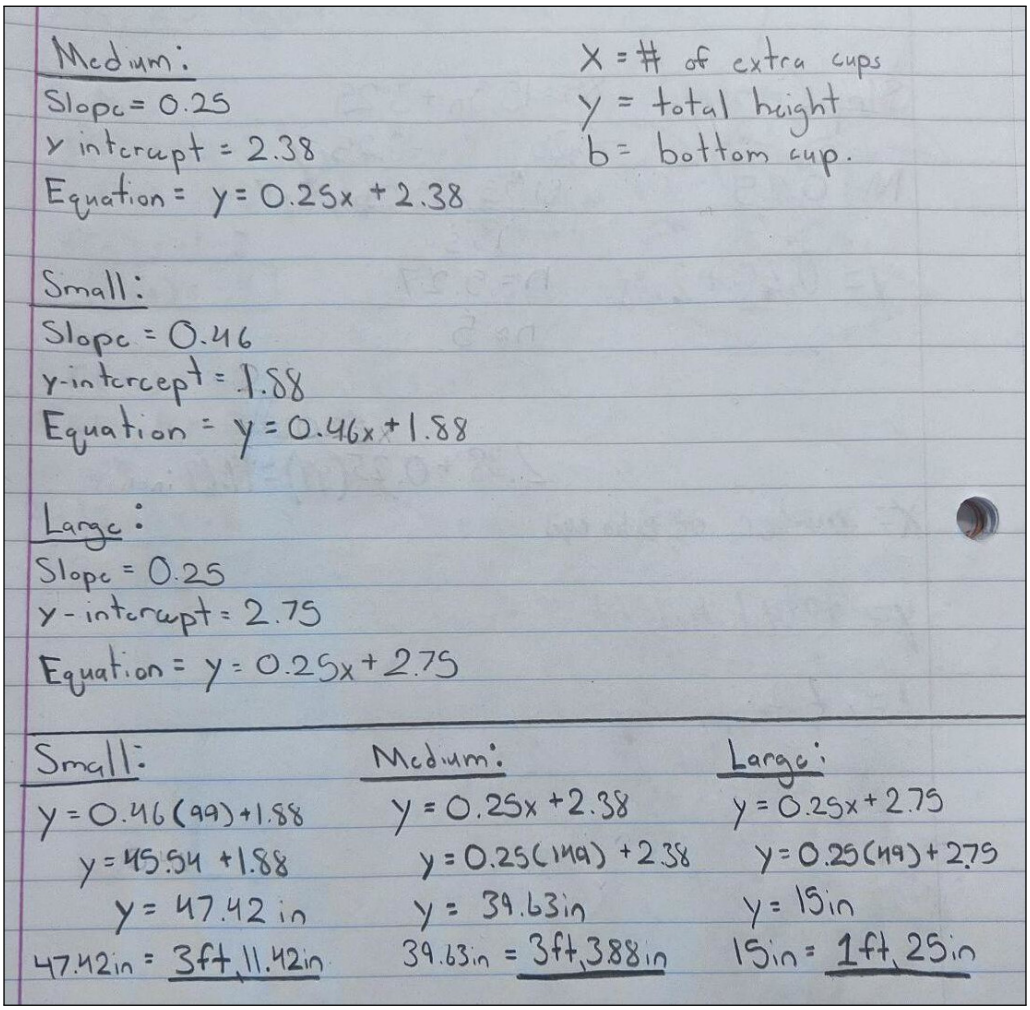
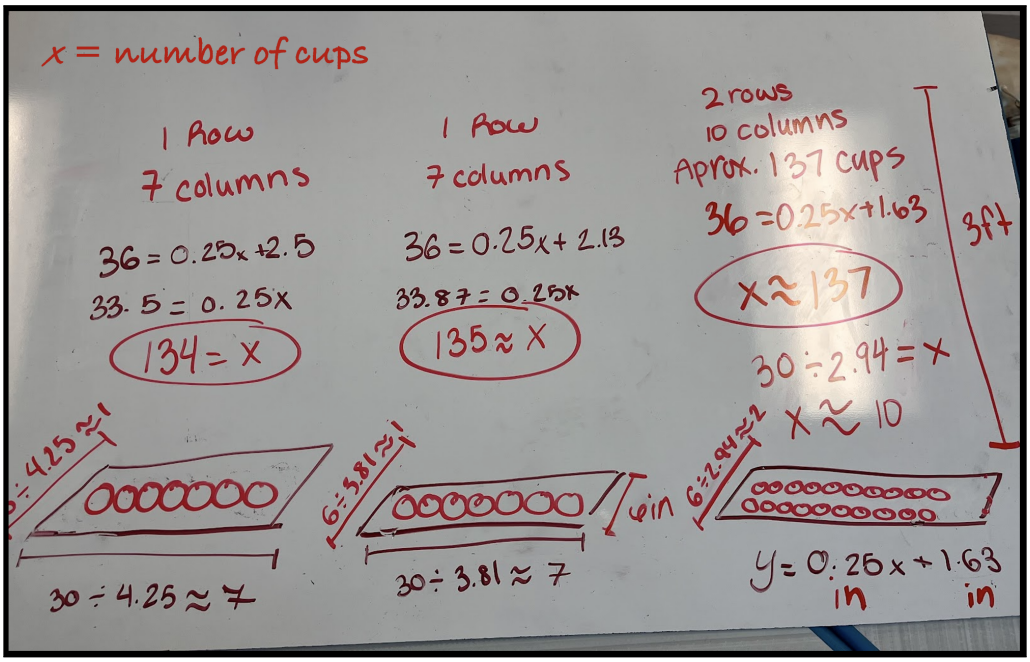
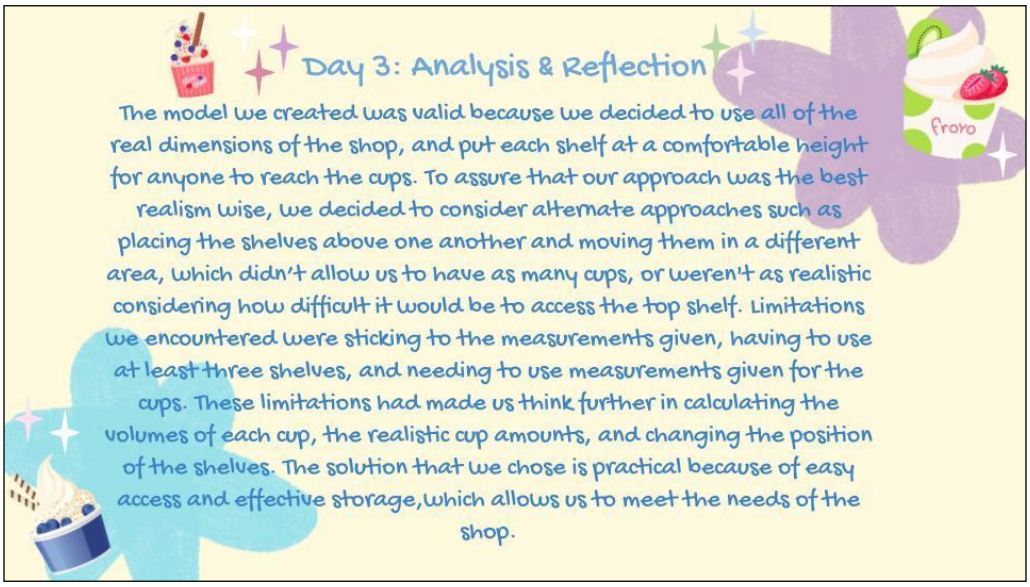


Figure 8
Linear Equations and Cup Calculations: Multiple Stacks on a Shelf



On Day 3 (Presenting and Refining the Model), students communicate and defend their designs in writing and oral presentations. They analyze their model by describing alternative approaches they considered, evaluating its validity, and identifying its limitations. Figure 9 shows one example in paragraph form, though some students explain these three items separately.

Figure 9
Model Analysis



Before students present, teachers can act as the "client" and ask, "Why should I approve your design?" or "I need more of the popular size cups. How will that change things?" Modeling presentations are an opportunity to receive feedback from both peers and the teacher to revisit assumptions, make adjustments, and strengthen designs. Prompting peers with, "What questions do you have for this group?" shifts the critique to the class, creating authentic mathematical discourse.

Across all three days, teachers act as facilitators of thinking. Strategic questioning keeps students in productive struggle without overwhelming them. Across the three days, students move from defining the problem to mathematizing it and refining their models. By the end, each group produces a model that reflects its assumptions and constraints. To extend this task, students could choose the type of shop they are designing for.

Conclusion

In The Yogurt Shop Task, students balance practicality with precision, wrestle with assumptions, and defend their choices. In doing so, they experience what it means to model with mathematics. For teachers, the three-day structure provides a manageable way to model, allowing time for students to think, struggle, revise, and share. Along the way, they collaborate, represent ideas in multiple ways, persevere through challenges, and engage in meaningful mathematical argument. The variety of solutions reveals mathematics as a creative sense-making endeavor that helps students see themselves as capable problem solvers.

Acknowledgments

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Joseph DiNapoli researches the nature of perseverance in problem solving and the methods by which it can be supported and nurtured — work that advocates for learning mathematics with understanding. He studies perseverance across undergraduate, secondary, elementary, and early-childhood classrooms and in professional development with in-service teachers, examining factors such as conceptual scaffolds, translanguaging in bilingual settings, mathematical software, and curriculum materials.