IN THE CLASSROOM

# Mathematical Modeling: Part 1 of Series

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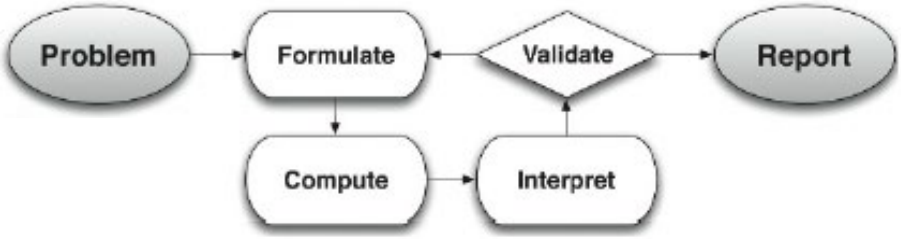
*Modeling, model*, and *models* are words that appear multiple times in the Colorado Academic Standards (Common Core State Standards). They can be found across all grade levels and strands in phrases such as visual fraction model, concrete models, mathematical models, modeling situations, area models, probability models, physical models, model a linear relationship, descriptive modeling, modeling context, model periodic phenomena. These examples, however, fail to capture the essence of mathematical modeling as called for in Math Practice 4: Model with Mathematics. Furthermore, these examples do not capture the description of modeling in the conceptual category of modeling in the high school standards. More recently, the Guidelines for Assessment and Instruction in Mathematical Modeling Education (GAIMME), released in April 2016, provides specific guidance and support to teachers as they incorporate the practice of mathematical modeling into classroom instruction.

## Modeling Defined

Beginning with Math Practice 4 (excerpted below), key student actions for engaging in this Practice are:

> Mathematically proficient students can **apply the mathematics they know to solve problems arising in everyday life, society, and the workplace**. Mathematically proficient students who can apply what they know are **comfortable making assumptions and approximations** to simplify a complicated situation, realizing that these may need revision later. They are able to **identify important quantities in a practical situation and map their relationships using such tools** as diagrams, two-way tables, graphs, flowcharts and formulas. They can **analyze those relationships mathematically to draw conclusions.** They routinely **interpret their mathematical results in the context of the situation** and **reflect on whether the results make sense, possibly improving the model if it has not served its purpose.** (CCSSI, 2010, p. 5)

Further, the modeling cycle (CCSSO, p. 72) in the high school standards provides a visual representation of the modeling cycle and actions captured in Math Practice 4.




In addition, the GAIMME report provides a succinct definition of mathematical modeling that captures the essence of Math Practice 4 and the modeling cycle, "Mathematical modeling is a process that uses mathematics to represent, analyze, make predictions or otherwise provide insight into real-world phenomena" (GAIMME, 2016, p. 8). This definition clearly communicates that an essential element is a real-world context or situation. In addition, mathematics is used in the process to explore and investigate the real-world context or situation. Math Practice 4 describes specific student actions to be used as they explore and investigate the context or situation. Students make assumptions or approximations, identify important quantities and relationships, analyze the relationships and make conclusions and interpret these in terms of the context. If the conclusions do not make sense in terms of the context, students begin the exploration and investigation again and refine their model in doing so.

An important caveat to note is that a word problem is not necessarily a modeling problem. A modeling problem, as described in the GAIMME report, has the following characteristics:

- relevant and important context for students,
- open in the beginning: multiple entry points and question definition,
- open in the middle: multiple mathematical approaches,
- open in the end: multiple solutions,
- questions are inspired and assumptions are required, and
- useful solutions.

## Examples of Modeling Problems YOU Can Use and Help CCTM Colleagues Delve Deeper

So what are examples of modeling problems? Let's look at a task from grades K–5, grades 6–8, and high school. In each example, consider how the task is open in the beginning, in the middle, and at the end. What information would students need? What assumptions would they need to make?

- Grades K–5 Task: Class Party

Our class is planning a party. Several students have suggested we buy pretzels for the party. How many bags of pretzels should we buy? (adapted from GAIMME)

- Grades 6–8 Task: Stray Dogs

Your class has decided to recommend to your city council that stray dogs be fed. How much dog food would the city council need to buy to feed all the stray dogs in your city for one year? (adapted from GAIMME)

- High School Task: Gas Station Problem

Is it worth it to drive a little farther to a gas station that has cheaper gas? What would make it worth it? (Pahler, 2016)

*Teachers are encouraged to use one of these problems with students and send student work or reflections on using these problems to Cathy Martin (cathy_martin@dpsk12.org). The next article in this series will dive deeper into GAIMME and recommendations for classroom implementation of mathematical modeling.*

## References

National Governors Association (NGA) & Council of Chief State School Officers (CCSSO). (2010). Common Core State Standards Initiative (CCSSI).

Garfunkel, S. & Montgomery, M. (EDs). (2016). GAIMME: Guidelines for Assessment & Instruction in Mathematical Modeling Education. Consortium for Mathematics and Its Applications (COMAP) & Society for Industrial and Applied Mathematics (SIAM).

Pahler, L. (April 2016). Guidelines for Assessment & Instruction in Mathematical Modeling Education. Presentation at NCTM.