Mathematical Modeling

“Mathematical modeling is the link between mathematics and the rest of the world.”
(Meerschaert, M., Mathematical Modeling, Elsevier Science, 2010)

The process of beginning with a situation and gaining understanding about that situation is generally referred to as “modeling”. If the understanding comes about through the use of mathematics, the process is known and mathematical modeling.

Step 1. Identify a situation.
   Read and ask questions about the problem. Identify issues you wish to understand so that your questions are focused on exactly what you want to know.

Step 2. Simplify the situation.
   Make assumptions and note the features that you will ignore at first. List the key features of the problem. These are your assumptions that you will use to build the model.

Step 3. Build the model and solve the problem.
   Describe in mathematical terms the relationships among the parts of the problem, and find an answer to the problem. Some ways to describe the features mathematically include:
   • define variables
   • write equations
   • draw shapes
   • measure objects
   • calculate probabilities
   • gather data, and organize into tables
   • make graphs

Step 4. Evaluate and revise the model.
   Check whether the answers make sense, and test your model. Go back to the original situation and see if the results of the mathematical work make sense. If so, use the model until new information becomes available or assumptions change. If not, reconsider the assumptions you made in step 2 and revise them to be more realistic.

Choices, assumptions, and approximations are present throughout the cycle.

The modeling process is enhanced by:
1) The facilitative skill of the teacher. The teacher must create a positive and safe environment where student ideas and questions are honored and constructive feedback is given by the teacher and by other students. Students
do the thinking, problem solving and analyzing.

2) **The content knowledge of the teacher.** The teacher understands the mathematics relevant to the context well enough to guide students through questioning and reflective listening.

3) Teacher and student **access to a variety of** representations, and mathematical tools such as manipulatives and technological tools (sketchpad, spreadsheets, internet, graphing calculators, etc.).

4) Teacher and student **understanding of the modeling process.** Teachers and students who have had prior experience have better understanding of the modeling process and the use of models.

5) Teacher and student **understanding of the context.** Background information/experience may be needed and gained through Internet searches, print media, video, pictures, samples, field trips, guest speakers, etc.

6) **Richness of the problem** to invite open-ended investigation. Some problems invite a variety of viable answers and multiple ways to represent and solve. Some contrived problems may appear to be real-world but are not realistic or cognitively demanding.

7) **Context of the problem.** Selecting real-world problems is important, and real-world problems that tap into student experience, (prior and future), and interest are preferred.

For discussion purposes:

Student success implementing the modeling process in high school mathematics, college majors and careers should be enhanced if younger students:

* Begin to ask their own life questions and see mathematical processes and skills as an important part of understanding and solving these problems.
  - How do you share a quantity with a group of students?
  - What is the shortest path?
  - What is the best way to package items of similar or different shape?
  - How many of one item will fit inside another?
  - How much will it cost? How long will it take? How fast must you travel?
  - Who will arrive first?
  - How do you create a scale model of an object?
  - How do you make a profit when selling a particular product?
  - How do you make a stronger building, bridge or tower?
  - Which pizza is the best deal? Which size of product is the best value?
  - How is math used in crime scene investigations?
  - What is the best text, phone, or pay-per-view plan?
- Which container holds the most of a quantity?

* Experience the use of different ways to model and understand a problem.
  Experience with manipulatives, graphs, measuring, equations, technology, etc.
  Students should want to use more than one approach to solving a problem.
  Students should know that some problems have a best or most efficient solution and for other problems, “it depends.”

* Provide students with experience asking questions in non-threatening ways to “help me understand your thinking” rather than “prove you're right.”

* Provide examples of real people in real careers using mathematical modeling to solve real problems that utilize mathematics familiar (or mostly familiar) to the students at the particular grade level.

* Explore some rich math problems that span several lessons or days. Possibly keep track of learning through a chart with “What I Know” and “What I Need to Know.”