



"The **STELLA** software is one of the most powerful, innovative math modeling programs for high school students that I have seen in the 12 years I have used computers in teaching."
 --Diana Fisher, Franklin High School

Case Study

Barriers and Opportunities

The typical mathematics curriculum is packed with material to cover. In high school and in college courses, there is precious little time for "smelling the roses."

Because you have so much ground to cover, your students can have barely enough time to complete textbook exercises, much less to develop a deep appreciation for the underlying concepts. And, of course, the inherently abstract nature of mathematical representations can easily compound student difficulties. Translating word *problems* into the appropriate equation *form*, for example, often entails a conceptual leap that challenges even the better students.

The **STELLA**® software is a tool that can dramatically increase learning within the mathematics curriculum. The **STELLA** software's diagrammatic interface makes it easy to visualize mathematical relationships. As you or your students add detail to the relationships represented in a **STELLA** diagram, the concepts involved will be stated more rigorously and precisely than is possible using words or stick figure diagrams. Then, the **STELLA** software's simulation capabilities allow you to see the mathematical solution unfold.

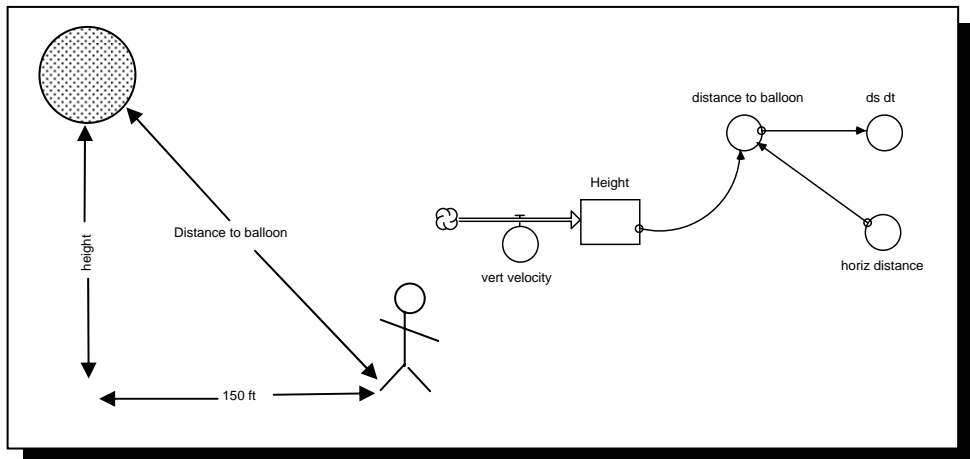
The **STELLA** software thus provides you with an intermediate stepping-stone between the words that describe a mathematical concept or problem, and the formal representation of the concept. By using the **STELLA** software, you can cover more material, in a shorter period of time, *achieving a deeper level of student understanding.*

The Setting: A suburban high school in Northern VA
The Topic: Pre Calculus/Calculus
The Challenge: Making related rate problems real

Background: A key unit in any pre-calculus or calculus course covers the topic of related rates. The difficulty in this unit is the conceptual abyss that many students perceive between the stick figure depiction of a story problem, and the mathematical expressions needed to solve it. Since the thinking skills acquired in the unit on related rates are essential to subsequent progress in the math curriculum, it is essential that students learn to navigate this abyss. Math teachers at a Northern Virginia high school decided that the **STELLA** software would be an excellent tool to help their students move from words and stick figures to mathematics. The teachers began by using the **STELLA** software in the classroom to help solve some sample problems with related rates.

Step 1: Map. The students were given the following problem statement: *A balloon sits on the ground, 150 feet away from an observer. The balloon is launched, rising vertically at a rate of 8 feet per second. How fast is the balloon moving away from the observer when it is at a height of 50 feet?*

The teachers worked with the students to develop a simple stick figure sketch of the problem. Once the students got a sense of the situation, the teachers worked with the class to translate the drawing into a **STELLA** diagram. Both are shown below. As the diagram shows, a stock was used to represent the vertical position of the balloon. A flow represented the constant rate at which the



balloon was rising. Converters and connectors indicated the distance from observer to balloon (*distance to balloon*) and the rate at which the balloon was moving away from the observer (*ds/dt*).

Step 2: Model. After the basic map had been laid out, the next task was to define the distance from observer to balloon, and the rate at which the balloon was moving away from the observer (*ds/dt*). As the figure at right shows, these calculations were straightforward. In fact, the calculation for *ds/dt* gave the teachers an opportunity to cement in the minds of their students the concept of a limit as well as the fundamental theorem of calculus.

Step 3: Simulate. Once the **STELLA** software had yielded a solution to the problem as stated: students found it easy (and fun) to explore a wide range of alternative assumptions for the related rate problem. It even was possible for students to investigate cases in which the balloon was rising at a variable rate, and in which the observer was moving relative to the balloon. This exploration enabled students to understand, at a much deeper level, the meaning of the mathematics associated with related rate problems.

Step 4: Celebrate! The teachers in the math department report that the **STELLA** software has greatly improved their teaching productivity. The integration of **STELLA** models into the curriculum has provided students with a rigorous, yet intuitive, means to step from story problems and the associated stick-figure sketches to the underlying mathematics. As an added bonus, the teachers find that the students are much better prepared to assimilate concepts presented in other courses in the natural sciences.

