SPICE | Science Projects Integrating Computing and Engineering

Expanded Mathematics

Brief

SRI Education

Digital Promise

VANDERBILT SCHOOL OF ENGINEERING

UNIVERSITY of VIRGINIA | SCHOOL of EDUCATION and HUMAN DEVELOPMENT

Mathematical concepts in SPICE

In SPICE, students program a computer model of water runoff and use it to test their engineering designs. Such a model must necessarily specify the amounts of water using numerical values and use computational concepts such as variables and expressions (which are mathematical in nature). As a result, there is a specific set of mathematical concepts that students must use in order to develop the runoff model.

SPICE is designed to minimize the amount and complexity of mathematics needed for students to be successful. Because mathematics topics and standards at specific grade bands vary from one district or state to another, there may be specific topics that particular students may lack experience with. This brief summarizes the main mathematical concepts in the SPICE unit and provides a few suggestions for supporting students with these concepts, should they encounter difficulties with them.

1. **Interpreting a bar graph.** In Lesson 2, students are asked to interpret a bar graph of monthly rainfall events. The graph supports students by explicitly including the height of each bar as a numerical value on each bar. To support students who may struggle with the graph, it may help to prompt students to compare the relative heights of the bars, or to re-represent the information in a form they are more familiar with (such as a table).

2. **Measurement.** Measuring the amount of water (such as rainfall, absorption, or runoff) is a central idea throughout the unit. In SPICE, water is measured in inches, as if using a rain gauge, and this idea is introduced in Lesson 2. To support students further in understanding inches as a measure of amount of water, a physical demonstration with a rain gauge or glass beaker and a ruler may help illustrate the concept.

3. **Comparing quantities.** The water runoff model requires students to compare the amount of rainfall to the amount of water the surface material can absorb (the “absorption limit”). The SPICE materials avoid the use of the “<” and “>” symbols and instead use written language to express “is greater than”, “is less than”, and in some cases “is equal to.” Alternative representations such as pictures showing whole-part relationships or number lines could support students in making these comparisons.

4. **Decimal number system and place value**. In order to be reasonably accurate, the computer model expresses numerical values to one decimal place (tenths). Students must perform simple operations (such as comparisons and subtraction) on decimal numbers. To support students in reasoning about decimal numbers, it can be helpful for students to think of these numbers using a numerical system they are already familiar with, such as fractions or a rain gauge, ruler, or number line.

5. **Writing mathematical expressions**. A mathematical expression is a meaningful string of numbers, operations (such as +, –, <, or =), and possibly variables. Students may be familiar with expressions used as formulas (e.g., a formula for finding the area of a rectangle of length L and width W is L x W.) In SPICE, students are asked to write mathematical expressions that they will later program into their computer model, such as total runoff = total rainfall – total absorption. Expressions involving variables can be difficult, so students may find it helpful to think about specific numerical examples first, then generalizing to variables afterward (e.g., “If there are 2 inches of rainfall, and 1.5 inches are absorbed, how would you figure out how much runoff there is?”) In addition, it may be helpful for students to articulate expression in everyday language before using mathematical symbols.