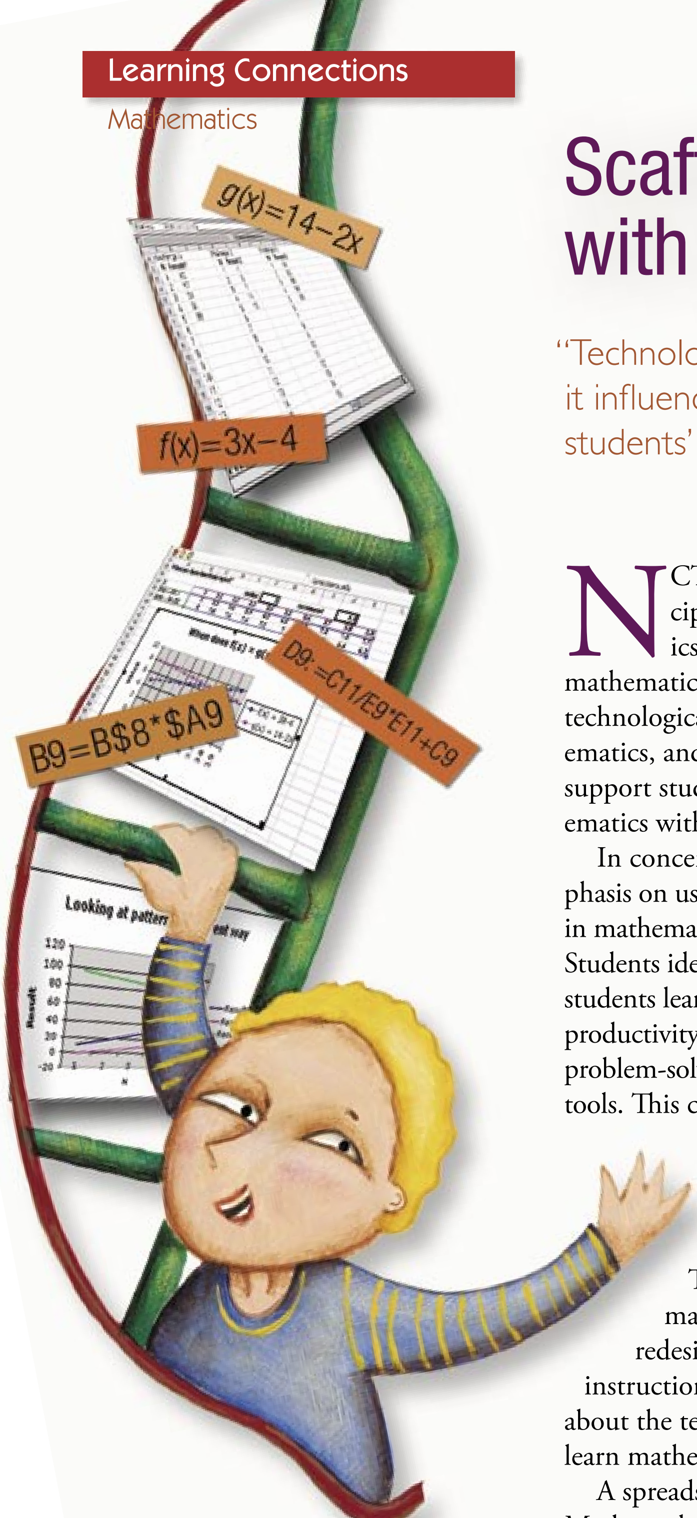
Scaffolding Math Learning with Spreadsheets



"Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning."
—*National Council of Teachers of Mathematics,* Principles and Standards for School Mathematics

By Margaret L. Niess

Subject: Algebra

Grades: 6–12 (Ages 11–18)

Standards: *NETS•S* 3; *NETS•T* II (http://www.iste.org/standards/). *NCTM* Grades 6–9 and 9–12 Algebra (http://standards.nctm.org/document/).

NCTM's "Technology Principle" challenges mathematics teachers to rethink the mathematics they teach, investigate technological tools for learning mathematics, and consider how they can support students in learning mathematics with technology as a tool.

In concert with the NCTM's emphasis on using technology as a tool in mathematics, ISTE's NETS for Students identifies the importance of students learning to use technology as productivity, communication, research, problem-solving, and decision-making tools. This challenge, however, carries with it the requirement that students learn the basic operations and concepts of technology. Thus, more and more, mathematics teachers must redesign their curriculum and instruction to help students learn about the technology they will use to learn mathematics.

A spreadsheet is one of these tools. Math teachers are challenged to think about scaffolding students learning about spreadsheets while they are also learning mathematics. This learning can begin at least by middle school (if not earlier).

Consider these examples of scaffolding learning mathematics with spreadsheets. These problems lead students to explore linear functions using spreadsheets. This exploration requires that students are able to enter user-defined and spreadsheet-defined formulas, copy formulas, and graph data. But, without these specific skills, learning about the spreadsheet overshadows the mathematics. These mathematical problems help them gain the needed skills, one at a time as they also work with mathematics.

Problem 1: Hit the target number of 13 using each of these numbers only once: 1, 4, 6, 8.

This is an "order of operations" problem that prepares students for working on similar problems using spreadsheets. Which of these possible solutions results in the target of 13?

a. $1 + 8 / 4 - 6$ b. $6 \times 2 - 8 + 4$
c. $6 \times 2 + 8 / 4$ d. $8 / 4 \times 6 + 1$
e. $8 + 4 + 1^6$

Answer: Both "d" and "e," though there are probably others. Collect the students' ideas, asking them to explain how they result in the target.

After this warm-up, demonstrate Problem 1 using a spreadsheet to the whole class. Show them how to enter one of the formulas using the cell labels. For example, solution "d," is demonstrated by entering this formula in cell D9: =C11/E9*E11+C9, as in Figure 1.

Rather than having students laboriously type the cell names, show them how to select the cells and enter the needed operations. The "return" results in a display of the target number. The formula bar shows the formula that was entered, and cell D9 displays the target of 13. Students working in pairs at the computer can complete this spreadsheet and in the process learn about using cell names to enter formulas. The activity gives them a chance to work on both order of operations and using spreadsheets in solving mathematical problems.

Problem 2: Solve this mystery to find the 100th value in this pattern!

N	Pattern
1	7
2	9
3	11
…	…
100	?

The pattern in this problem seems obvious; the numbers are increasing by two each time. But this method for finding the 100th value is not particularly efficient. If they insist, however, change the problem to require that they tell you the 1000th value. The challenge is to find a formula based on the value of N.

Once students have the idea, you can use a spreadsheet to engage them in entering a formula and copying that formula to other cells in the spreadsheet. Ultimately, this activity reveals that spreadsheets use a "relative" reference when copying formulas. The formula is changed "relative to" its particular row and column in the spreadsheet. Figure 2 shows N incremented by one. Rather than entering the values in each cell, students can simply enter the formula =A5+1 in cell A6, then copy it. They enter the pattern 2N+5 as =2*A5+5 in cell B5 and then copy it. Investigation of the formulas in the spreadsheet shows that each formula has been shifted for the appropriate row and column.

More work with patterns unveils more mathematics as well as more about spreadsheets. Students can begin to visualize patterns using the spreadsheet charting capabilities. At the same time they have more opportunities to become familiar with copying formulas from cell to cell. Figure 3 provides a set of three different patterns. What can students learn from these patterns?

Use the spreadsheet chart wizard to explore these patterns (Figure 4). All three are linear. The mathematical question is, "What does that mean about the patterns?" This problem leads to an exploration of linear patterns and looking at how lines are expressed symbolically. In the process, however, students have found out more about graphing in the spreadsheet and how to add data to charts.

Scaffolding continued on p. 48

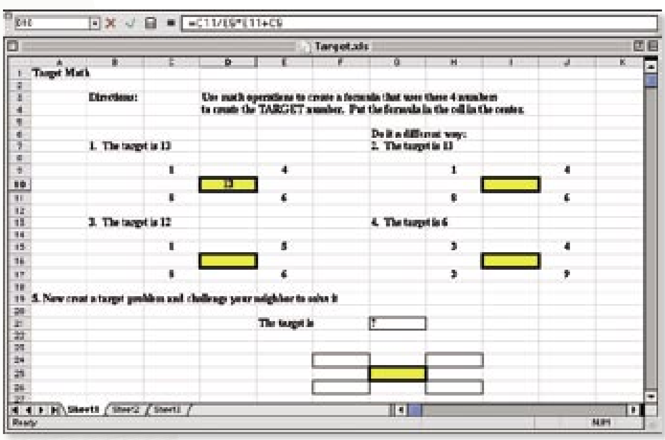


Figure 1.

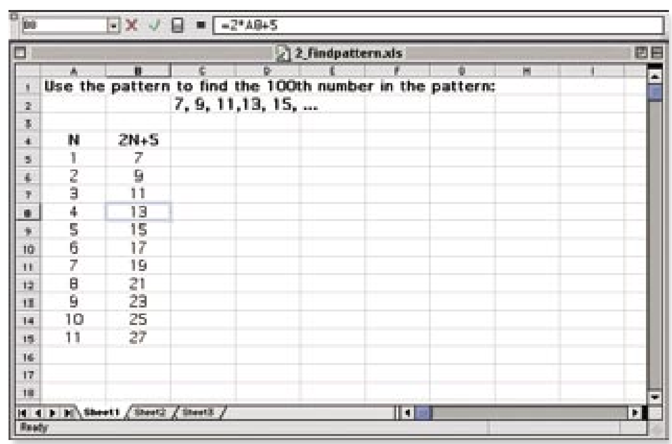


Figure 2.

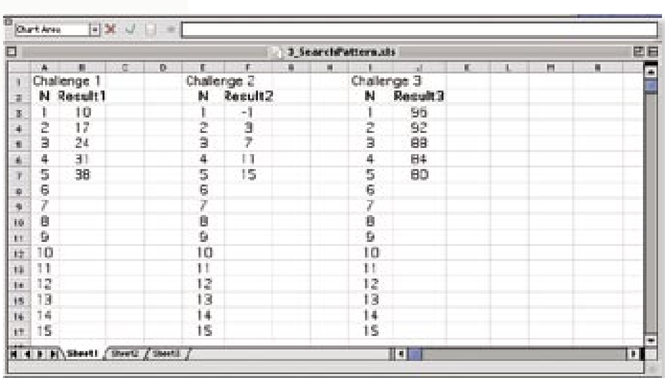


Figure 3.

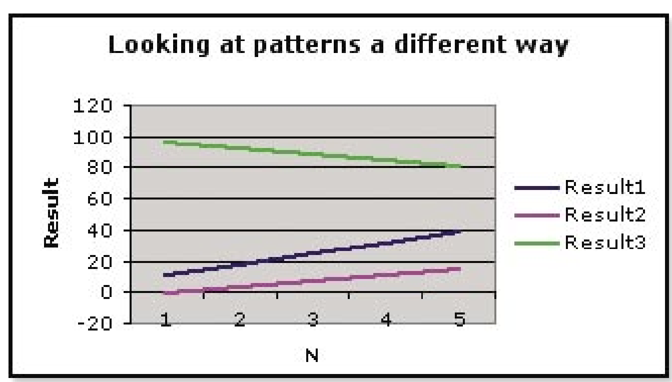


Figure 4.

Note: This work is partially supported by the National Science Foundation under the grant IRT-0324273 and by the EUSES Consortium (http://eecs.oregonstate.edu/EUSES/).

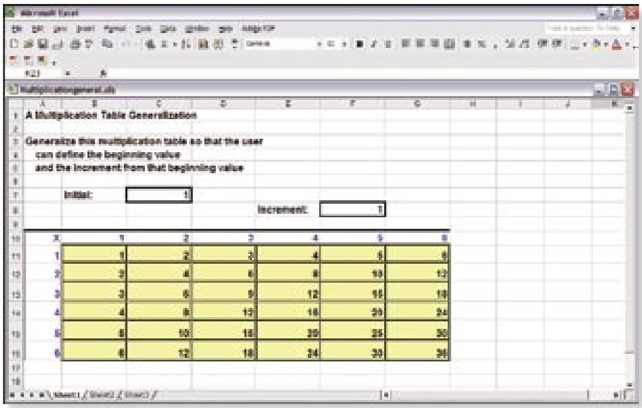


Figure 5.

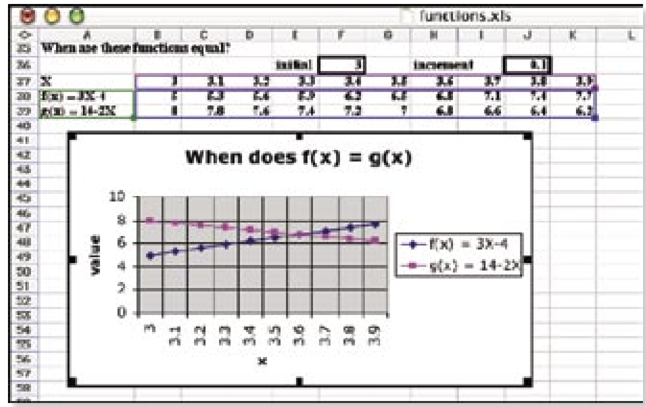


Figure 6.

Scaffolding continued from p. 25

Problem 3: Use a spreadsheet program to create a multiplication table for 1–6.

This problem extends the idea of entering formulas. The product of 1 and 1 needs to be calculated in cell B11. Of course there is a catch. Students need to place a formula in cell B11 that uses cells B10 and A11. The answer seems obvious as =B10*A11. But if you copy this formula across the multiplication table, the changes in the formula do not work correctly. The "relative" copy feature of the spreadsheet is the problem. For this copy to work, cell A11 needs to remain A11. Now is the time to introduce the "$" for use in a formula. If students place a $ in front of the A, then the column will remain and will not be changed. Unfortunately, if you copy the formula down column B, a similar problem occurs, requiring students use a $ again. Cell B9 needs to be =B$8*$A9. When students copy cells down and across the table, the products are correct as shown in Figure 5.

Problem 4: Extend the multiplication table spreadsheet for a variety of numbers.

Students probably think this multiplication table is not particularly interesting in that they are already familiar with these products. However, the table can be generalized using the capabilities of the spreadsheet. First, the values to be multiplied can be generalized. This problem requires the use of the $ for the "increment" value when copying the formula across row 10. When students are able to solve this problem, they are displaying their understanding about "relative" versus "absolute" referencing of cell values when copying formulas. This is an important characteristic of spreadsheets, and one that can be hard to teach in isolation.

Problem 5: Exploring Linear Functions. Juan and Sylvia each have a cell phone, and they want to see who has the better deal. Juan's company charges 20¢ for making a call and then charges 60¢ for each minute of the call. Sylvia's company charges 30¢ per minute, but charges 80¢ for making the call. How many minutes can they talk on the phone such that the charges are equal?

After working with Problems 1–4, students have become familiar with the spreadsheet as a tool for solving this problem. They can set up the problem and graph it to determine that each company charges the same amount at two minutes. They can also see that Sylvia's company offers a better plan if the calls are longer than two minutes. On the other hand, Juan's plan is better for calls shorter than two minutes. The solution to this problem is shown clearly by the resulting graph and the table of values.

Give the students two functions where the equality is not as immediately obvious as in the cell phone problem:

$f(x) = 3x - 4 \quad g(x) = 14 - 2x$

This problem can be solved more easily using the "initial" and "increment" ideas from Problem 4. The table in Figure 6 reveals the solution to be 3.6.

The Importance of Scaffolding

Math teachers often find that they must also teach students to use technology tools, such as spreadsheets. Problems such as those presented here can help your students gain skills with the spreadsheet in a piecemeal fashion, in a way that keeps the activity's focus on the mathematics. The challenge for you is to identify the spreadsheet skills students need to work on the problem you pose. Then you need to look for places in your curriculum where you can help students add to their spreadsheet knowledge and skills. Careful planning results in students being comfortable using the spreadsheet as a tool for learning mathematics because they have learned to learn mathematics with the tool.

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