Making Connections Using Embedded Software

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The NCTM's *Curriculum and Evaluation Standards for School Mathematics* (1989) calls for increased attention to "connecting mathematics to other subjects and to the world outside the classroom." Often, these connections are made with interdisciplinary projects and through the study of mathematics in a real-world situation. We can also make connections by using software created for practical, real-world applications in the mathematics classroom.

Design Your Own Home

Can students draw a bird's-eye view of their house or apartment building and the land it takes up? Can they draw an accurate map of the interior? We found this exercise to be interesting for students and adults. Students are particularly intrigued by drawing "dream houses" and can easily do so with a program such as Abracadata's Design Your Own Home software. Issues of scale, area, ratio, angle and perimeter are naturally confronted in this task. In designing a dream house, students move from the computer to the drawing board or three-dimensional models. They make decisions about the appropriate scale for the particular medium, confront transformations as they flip and rotate elements in their design, and measure area and perimeter and experiment with different models for a fixed area.

For an interesting problem, have all the students in a class create the blueprint of a 1,500–square-foot house. As different designs emerge, many mathematically rich questions arise:

- How does this space compare with that in your own home?
- Which design will be the most expensive to build? The easiest to heat? Why?

To begin another problem that can branch in many different directions, give the class a map of a town, real or contrived. Divide the students into groups and by lottery assign each group a plot of land. Each group's task is to build dwellings on its assigned plot. Group members may choose to live in one house, in a multidecker house, in separate houses and so on. Rules can be established for the use of space, such as that no building may be within 100 feet of a street. This task can be simplified by giving everyone the same-plot on which to build and comparing building decisions. Or it can be expanded by discussing real issues that architects must address—sunlight, building-code restrictions and so on. Once the space is designed, the teams can present their designs.

Having the groups examine their use of space by designing the interior may be very revealing. This design can be done with a drawing program such as Aldus SuperPaint or with Design Your Own Home: Interiors. When asked to create house interiors, many adults do not demonstrate a good sense of space; they often can fit 10 bathtubs into their bathrooms, sometimes none at all!

Bridgebuilder

If students are exploring the mathematics of bridges, they can experiment with building truss bridges on Bridgebuilder software, in which they use triangles and symmetry to create a stable bridge. They can tweak and refine their design for efficiency using data about bridge members that are furnished by the software. As students manipulate the data, the idea of isolating variables is likely to emerge as an efficient and important strategy.

Physics Explorer

Mathematics has been called the language of science, and science can be an effective lens through which mathematical relationships can be observed and recorded. The school's science department may be able to supply software environments rich with mathematical data. For example, students can explore relationships between numerical input and bouncing balls as they experiment with a billiard table built on Physics Explorer software. They can learn to narrow and focus their investigation, look for counterparts, find different patterns, and recognize dead ends. In the example shown in Figure 1, students enter

a number for upward thrust and a number for right thrust. Clicking "GO" launches the ball on the path determined by these numbers. Given the freedom to explore, some students note the geometric shapes composed, others focus on the numbers and paths, and some focus on both. When asked to predict the outcome before launching a ball, students create many conjectures, such as that shown in Figure 1.

Figure 1

Conjecture: the number of bounces needed to move from the centre and back to the centre is the sum of the UP and RIGHT numbers
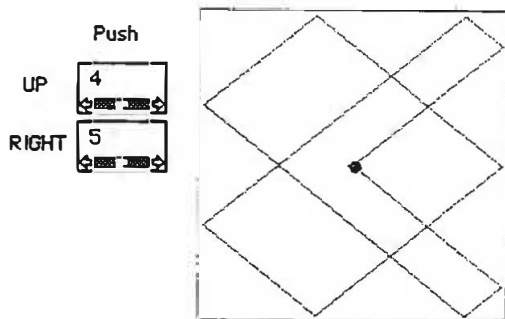
Aldus SuperPaint

Although Aldus SuperPaint is a software program worthy of discussion in detail, only one of the applications found to be of value in mathematics classrooms is presented here. Mathematics textbooks often include activities in which students explore the mathematics of quilt designs. Indeed, many quilters use computers to create their designs. How do they do it? What are the essential elements? Aldus SuperPaint and any number of paint and draw programs give the opportunity to explore color variations (combinatorics), composition (Why do some squares make more patterns than others when put together in a quilt?), geometric shapes (What shapes are formed if these squares are put together?), and continuity (How can I connect the line segments in this square to line segments in other squares?).

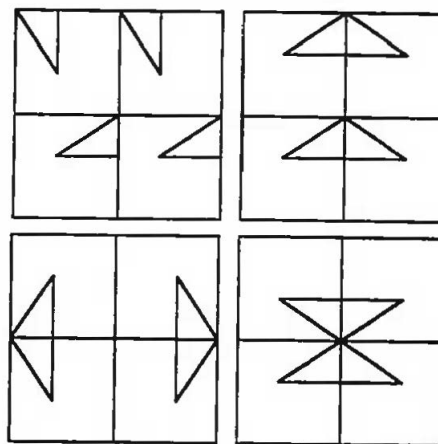**Figure 2**

Escher's Two-Line–Segment Drawings

Perhaps students would like to emulate Escher in his musings by creating a two-line–segment pattern (Figure 2) in a square and exploring the squares created by putting four of the two-line–segment squares together (Figure 3) (Schattschneider 1990). Which two-line–segment patterns create the largest number of different squares? If they find a pattern they like, they can scale down their four-square pattern, copy it, and make the whole quilt by putting together as many squares as they like. In the process, they may compose or reveal other geometric shapes.
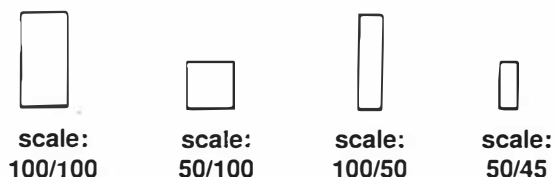
Figure 3

Four-Square Patterns Composed from the Two-Line–Segment Drawings

Paint-and-draw programs offer a new medium for exploring existing geometry activities. Ibe (1987), in the article "Mathematics and Art for One Shape," asks readers to rotate and translate a square, adding to the preimage, to create different figures. The Replicate function in Aldus SuperPaint allows students to translate this problem to the screen. Replicate also allows users to rotate and dilate simultaneously to create spirals. Scaling can be done so that each axis is scaled by a different amount. New problems emerge, for example, can students scale a rectangle and turn it into a square? Distorting different figures by scaling the axes unevenly gives a good visual sense of what happens when the scales on a graph are changed (Figure 4).

Figure 4

scale: 100/100 scale: 50/100 scale: 100/50 scale: 50/45

Rescaling can also be played in reverse by giving a starting and ending state. Can students resize the shirt on the right in Figure 5 to its original size on the left? Are more than one series of rescalings possible?

Figure 5

Sprout

Start with the familiar pen or garden problem. Students are given a length of fence. What it the biggest garden or pen they can make? To extend the investigation, use Sprout software and have students choose and plant vegetables and collect data about the number of people that can be fed vegetables. A case might be made against cultivating the greatest area for the greatest production, depending on how the rows are planted and what crops are grown.

ET-MITT (Empowering Teachers—A Mathematical Inquiry Through Technology) is a National Science Foundation–funded project in which graduate courses for middle school teachers are being developed at Bolt, Beranek and Newman in collaboration with the University of Massachusetts, Lesley College and EDCO Collaborative. The focus of the project is the use of technology to foster an inquiry approach to teaching and learning mathematics, as demonstrated in this article.

Incorporating these software programs into a mathematics classroom makes a quiet statement in and of itself. It states that art, architecture and science belong in the realm of mathematics and that mathematics can be found in the worlds of art, architecture and science—and in the art class and the science class, too.

References

Ibe, M. D. "Mathematics and Art from One Shape." In *Geometry for Grades K–6: Readings from the Arithmetic Teacher*, edited by J. M. Hill, 61–62. Reston, Va.: NCTM, 1987.

NCTM. *Curriculum and Evaluation Standards for School Mathematics*. Reston, Va.: Author, 1989.

Scattschneider, D. *Visions of Symmetry: Notebooks, Periodic Drawings and Related Works of M. C. Escher*. New York: Freeman, 1990.

List of Software

Aldus SuperPaint. Silicon Beach Software, PO Box 261430, Sandiego, CA 92196-1430.

Architecture: Design Your Own Home. Abracadabra, PO Box 2440, Eugene, OR 97402; phone (800) 451-4871.

Bridgebuilder—Preengineering Software. 1266 Kimbro Drive, Baton Rouge, LA 70808; phone (504) 769-3738.

Physics Explorer: One Body. Sunburst Communications, 101 Castleton Street, PO Box 100, Pleasantville, NY 10570-0100; phone (800) 321-7511.

Sprout, Abracadata, PO Box 2440, Eugene, OR 97402; phone (800) 451-4871.