Digital Images in the Mathematics Classroom

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Subject: Digital images

Grade Level: 3–12 (Ages 7–18)

Audience: Administrators, technology coordinators, technology integration specialists, technology facilitators, teacher educators, library media specialists, teachers

Standards: *NETS•T* II; *NETS•S* 3–6 (http://www.iste.org/standards/)

Most mathematics teachers agree that technology can be used to promote mathematics teaching and learning. Indeed, the Technology Principle of the National Council of Teachers of Mathematics' *Principles and Standards for School Mathematics* states: "Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning. Electronic technologies—calculators and computers—are essential tools for teaching, learning, and doing mathematics" (p. 24).

The most prevalent technology in mathematics classrooms today is the graphing calculator. Mathematics teachers have embraced the graphing calculator because of its cost; portability; and its ability to help students connect the algebraic, numerical, and graphical representations. Some pedagogically sound software programs are also used widely in mathematics teaching, such as The Geometer's Sketchpad, an excellent tool for helping students visualize mathematical concepts and relationships.

Although mathematics teachers are increasing their use of technology to support student learning, currently most do not use digital cameras in instruction. We believe the digital camera offers many of the advantages of the graphing calculator for mathematics classrooms and that it has great potential to help teachers create real-world context for the teaching of mathematics. Digital cameras can be used both on their own and in conjunction with graphing calculators and computer programs to add to the ways that mathematical ideas and contexts can be represented. Digital photography offers new avenues for classroom teachers working to engage students in challenging and motivating mathematics problem creating and solving. Given the availability of digital cameras, the dreaded, irrelevant "story problem" may become obsolete as students and teachers use visual images to create and solve motivating and realistic mathematics stories.

In this article, we explore several ways digital imagery can support sound pedagogical and curricular goals. These examples follow the framework of acquire, analyze, create, and communicate. We acknowledge that many other uses for digital imagery in mathematics exist and many more uses will be discovered as digital cameras and Internet access become ubiquitous in our schools.

Analyzing Slopes of Rooftops

The concept of slope is important in mathematics. It is first introduced in pre-algebra courses but is further developed in algebra, geometry, and calculus. Although the concept of slope is used in many applied situations, it is too often introduced in schools in abstract and procedural ways that are disconnected from real-world situations (e.g., $\Delta y/\Delta x$). Use of digital imagery can help students bridge the gap between the abstract definition of slope and its concrete applications. The construction of rooftops provides a context for teaching and exploring slope.

Students can acquire a collection of digital images of a wide variety of rooftops by taking their own digital images and by downloading images from the Internet. This collection should include roofs of different types of structures, in a variety of geographic locations. For example, this collection could include an A-frame at a ski resort, a northeastern Cape Cod house, an industrial structure, a school, a ranch-style house, and a southwestern pueblo. These images can be imported into computer programs, such as The Geometers' Sketchpad, for analysis. In Sketchpad, students can anchor their pictures onto a scalable coordinate plane and place data points on the roofs near the eave and near the peak. Using Sketchpad features, they can display the coordinates of each point for use in calculating the slope of the roof, or they can construct a line through the points and display the slope of the line (Figure 1).

Once students analyze their collection of rooftops, they can create a slideshow showing the rooftops, the respective slopes, and the geographic locations of the structures. Students can use their slideshow to communicate how factors such as the environment, building cost, and city codes influence the design of roofs. For example, in areas with large amounts of snowfall, rooflines are often steep so that snow readily slides off. Large commercial structures, such as a Wal-Mart, often use relatively flat roofs because the cost of building a sloped roof over such an expansive building would be too great.

In addition to the activities described above, students can also manipulate their digital images of houses or buildings to see how they would look with different rooflines. At a more advanced level, students can plot data points and determine mathematical functions that model nonlinear roofs (e.g., domes, multitiered roofs) to explore connections between roof designs and cultural and environmental influences. Throughout this work, students are working with images of roofs they have acquired themselves, thus the mathematics they do around these roofs become personal and meaningful.

Finding and Using Vanishing Points

A second interesting application of digital cameras in mathematics comes from the study of art. Prior to the 15^{th} century, most paintings were flat—that is, they did not account for perspective. The results were scenes that do not look realistic. For example, notice that in *The Carrying of the Cross* (1325) by Simone Martini the heads of people in the background are not smaller than those of the people in the foreground (Figure 2).

During the Renaissance, artists began incorporating a sense of perspective into their work. This gave their paintings a more realistic look. One way they incorporated perspective was through the use of a *vanishing point;* that is, the point of a painting where parallel lines intersect. Notice in the image of da Vinci's *The Last Supper* (1498), imported into The Geometer's Sketchpad, how the use of a vanishing point gives the painting a sense of realism (Figure 3). In this painting, the parallel lines (highlighted with Sketchpad lines) in the ceiling tiles and along the walls all intersect at a single point on the head of Christ, the focus of the painting.

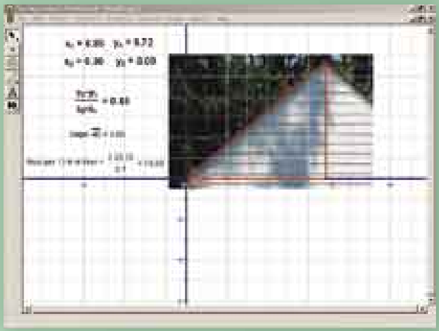

Figure 1. A rooftop with a slope of 0.83.

Figure 2. *The Carrying of the Cross* (1325) by Simone Martini.

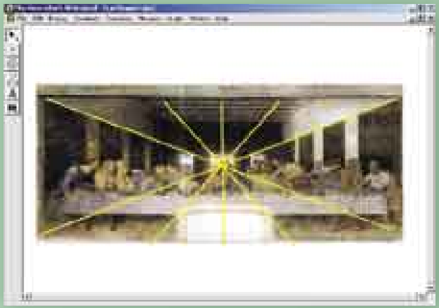

Figure 3. *The Last Supper* (1498) by Leonardo da Vinci (imported into The Geometer's Sketchpad).

Figure 4. How tall was Garrett at the time this picture was taken?

Students can acquire digital images of art that incorporate vanishing points or use their own digital photographs of scenes that contain parallel elements. As in Figure 3, they can use Sketchpad to analyze their images by constructing parallel lines that identify the location of vanishing points. After developing an understanding and appreciation of the use of vanishing points, students can design their own templates with parallel lines and vanishing points in order to create perspective drawings.

Such experiences with perspective drawings allow students to communicate at a deeper level how to best distinguish between perspective and non perspective drawings, how to determine the components of the drawing the artist wanted to feature, and how to use a vanishing point as a starting point for constructing a perspective drawing. Once again, the use of the digital camera creates an opportunity for students to use mathematical concepts in real-world situations and use these concepts to create a product.

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Providing a Context for Problem Solving and Proportional Reasoning

A third application of the digital camera in the mathematics classroom relates to word problems, sometimes called story problems. One function of word problems is to assess how well students can use the mathematical concepts and procedures they are learning to solve realistic problems. Too often, however, mathematics word problems are far from realistic and students do very little in the way of authentic problem solving when working with word problems. Digital images can provide personal and meaningful contexts for word problems in ways that promote the use of problem solving skills. Consider the problem posed in the caption for Figure 4.

For this problem, the picture is a crucial element in the solution process. Students are encouraged to acquire images that can provide the basis for an interesting problem solving experience. In the example, Garrett provides a picture of himself and some clues about his height. In addition to acquiring the image, Garrett has created a word problem around the image. Although his fellow students may come up with a variety of solution methods, all the methods require some analysis of the picture. For example, some students may use the hypothesis that the paper posted on the wall beside Garrett is 11 inches long. Using this assumption, students could take measurements of the images of Garrett and the piece of paper (using Sketchpad or the line tool in programs such as Word) and set up ratios that lead to an approximation of Garrett's height. As part of the problem-solving experience, students can communicate their ideas about the role of the picture in the solution process, the accuracy of their results, and how digital images and proportional reasoning can be used to solve other applied measurement problems (e.g., how a criminologist might use the video from a bank's security camera to determine a suspect's height). Once students gain experience working with these types of word problems, they can create more complex problems based on a series of digital images that they acquire themselves. Their digital story problems can be based in their experiences and interests.

Taking Future Steps

In this article, we have provided teachers with several examples of how digital images can be incorporated into mathematics teaching. Our examples show how digital images can be used as an essential part of the mathematical content of the lesson as opposed to just "dressing up a lesson" with nice pictures. We believe that digital imagery can help students develop a strong sense of authenticity in their mathematics learning. We also suggest that digital cameras have many of the same features that allowed graphing calculators to become an integral part of mathematics teaching and learning. We look forward to more research to determine uses for digital cameras that promote the learning of mathematics.

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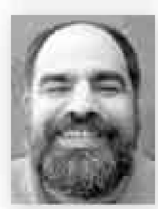

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