Time-Travel Days: Cross-Curricular Adventures in Mathematics

Irene Percival

A visitor to Carol Pettigrew's grade-three class in North Vancouver, Canada, might be forgiven for skepticism when told that a mathematics class is about to start. The children, most wearing sheets pinned around them like tunics, have their heads down on their desks. Music plays while the teacher's voice quickly leads them back through the highlights of two millennia of history. Finally the music stops and Pettigrew announces, "And here we are, in an Ancient Greek school." Unlike other imaginary journeys that elementary students take, the main purpose of these "Time-Travel Days" is to learn about the mathematics and mathematicians of previous ages. The children revel in the experience.

A Hive of Activity

Later in the day, that same visitor might again express surprise, but this time at the level and variety of the work in progress. In one corner of the room, three girls in the Hypatia group are drawing ellipses by using a string looped around two pins. Later, they outline a parabola by repeatedly folding a sheet of paper. Their questions about these shapes lead to discussions of wide-ranging topics, from planetary motion to the parabolic reflectors found in satellite dishes. Students in the Archimedes group can be seen balancing cardboard triangles on their pencil points, having first discovered which lines they must draw to locate a triangle's center of gravity. Later, they investigate their mathematician's "Law of the Lever," using calculators to explore the data on their activity sheet. They are delighted when the multiplicative nature of the lever principle suddenly becomes apparent, although they are overheard regretting the lack of a teeter-totter on their playground for practical verification.

FIGURE 1

Making a pyramid from four sets of golf balls

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Nearby, some students in the Pythagoras group strengthen their three-dimensional visualization skills by trying to put four sets of golf balls together to make a pyramid (see **fig. 1**). Two other students concentrate on two-dimensional shapes, looking at the numerical patterns formed by the triangular, square, and oblong arrays, which reput-

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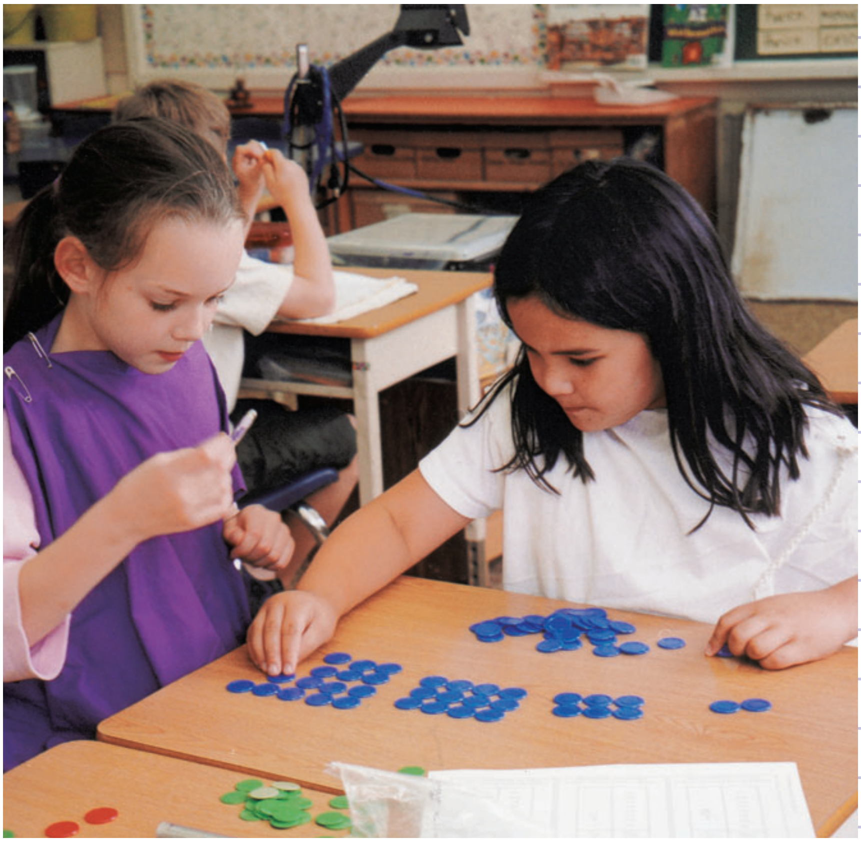
edly intrigued Pythagoras and his followers. Other groups work on ideas related to topics attributed to Eratosthenes, Euclid, and Thales.

The students' first task was to read stories about the mathematician assigned to them, then write a list of ten interesting facts based on this material. Some children, however, took the social studies and language arts links a step further. The Archimedes group rehearsed a skit, which they performed later in the week with costumes and stage props. Through their re-enactment of the famous "Eureka" story of the king's crown, the performers and their classmates not only learned about Archimedes' discovery but also developed a better understanding of life in ancient Greece.


Photograph by Irene Percival; all rights reserved

Background Information

Most of the Greek activities were selected from the *Historical Connections in Mathematics* series (Reimer and Reimer 1992, 1993, 1995). Pettigrew's resources included many other books on historical and multicultural mathematics, some of which are listed at the end of this article. The idea for "time-travel days" grew out of her love of history, her wish to make mathematics fun for her students, and her recent realization that mathematics can be taught from a historical perspective. She talks enthusiastically about the need to integrate all subjects, including mathematics, and has spent many hours collecting information for the students' trips back in time. The actual time-travel days occur once each month, but the mathematical ideas that they generate often spill over into the following days or weeks.

The excursion to ancient Greece was not the students' first time-travel adventure. Pettigrew planned a series of ten trips that started in the Stone Ages, progressed through thousands of years of civilization, and ended with a questioning look at "Math of the Future." The structure of the trips varied considerably: Some focused on the work of individual mathematicians and others looked more generally at the mathematics in use at the time. Several activities contained material not usually found in a grade-three curriculum but were included for their value in developing skills in communication, problem solving, and reasoning (NCTM 2000). This article shows how Pettigrew's concept came to life. It gives details of the first five expeditions to distant times and places and summarizes the later ones.

Stone-Age Mathematics

Looking at the mathematics of the Stone Age was perhaps the biggest challenge because the only pieces of physical evidence that remain are notched bones, which seem to record ancient attempts at tallying. Before mentioning these, Pettigrew initiated a brainstorming session about early humans' need for mathematics and possible ways that they could record numbers. Then she gave the students "bones," taken from plastic Halloween skeletons, on which she had drawn notches. But most of the students ignored the marks and spent their time putting the skeletons together in a spontaneous science lesson (see **fig. 2**). The focus on numbers returned later in the day when the students looked

FIGURE 2

Mathematics takes second place to science as students assemble a skeleton.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more closely at the bones as well as at pictures of a wolf bone (Wortzman 1996) and the Ishango bone (Zaslavsky 1999). Pettigrew had marked notches in groups of five, in imitation of the wolf bone. The marks on the Ishango bone are in groups of various sizes and have been interpreted either as a calendar or as number patterns, suggesting that their maker had knowledge of doubling and prime numbers. The students were able to spot some of these patterns and enthusiastically discussed the significance of their discoveries.

Mathematics in Mesopotamia

During a visit to the "Fertile Crescent," Pettigrew gave her class a new appreciation of the need for numerical records by playing the role of an unscrupulous trader. Dividing her class into several "villages," she traded one group's sheep for another group's goats. Without a written record of the number of animals traded, she was able to cheat the villagers by reporting fewer animals than she had actually received. The Sumerians stopped such fraud by placing into a clay container tokens representing the number of sheep. The vendors then sealed the container and the buyers broke it open (Ifrah 1998). Using Plasticine, a modeling clay, the students discovered how these physical counters were eventually replaced by "written" symbols simply by making imprints of them in clay.

Quickly moving ahead several thousand years, the children used a "stylus" (a suitably carved chopstick) pressed into a "clay" (plasticine) tablet to practice writing the Babylonian cuneiform number system that was derived from the earlier number shapes (see **fig. 3**). Pettigrew had used these symbols on the class calendar since the beginning of the month, and most of the students had figured out the system in the thirty-day period before time-travel day (see **fig. 4**).

FIGURE 4

Babylonian symbols represent the date.

FIGURE 3

Babylonian-style "writing"

Egyptian Mathematics

On arrival in Egypt, the time-travelers were eager to share their knowledge of the country and its most famous monuments, the pyramids. Pettigrew seized the opportunity to reinforce the previous week's geometry unit by asking about the number of faces, edges, and vertices on the structure, thereby strengthening the children's vocabulary. She then gave the students small blocks to build their own pyramids. This project gave valuable insight into the students' level of understanding of three-dimensional shapes. Although the students could describe a square pyramid, none of the groups actually made a square base on which to build their monument, confirming the claim that "the study of geometry in grades 3–5 requires thinking *and* doing" (NCTM 2000, p. 165).

Arithmetic followed later in the day. The students solved a puzzle to determine Egyptian number symbols (see **fig. 5**), and subsequent comparison of the Egyptian and modern number systems provided a useful review of the present place-value structure. The "real-life" origins of the number symbols (Burnett 1999) generated an interesting discussion. The children were delighted when they discovered the meaning of the hieroglyph for "walking," a pair of legs, which the Egyptians incorporated into their mathematical vocabulary to mean addition or subtraction according to which direction the legs were pointed (see **fig. 6**). Students enthusiastically wrote their own mathematical sentences, often using much greater numbers than are commonly encountered at the grade-three level. Pettigrew's requirement that they translate their work into modern symbols encouraged the students to discover how to express such numbers

FIGURE 5 An Egyptian number puzzle

EGYPTIAN NUMBER SYMBOLS

Use the clues at the top of the page to decode the Egyptian numbers. When you know the value of a symbol, draw it in the box at the bottom of the page.

CLUE 1: The Egyptians were good astronomers and knew how many days there are in a year.

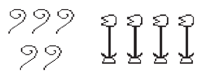
CLUE 2: Nârmer captured one hundred twenty thousand prisoners.

CLUE 3: Some Pharaohs lived for many years, but King Tutankhamen died when he was eighteen years old.

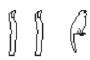
CLUE 4: The Great Pyramid of Khufu was built in 2500 B.C. It took one hundred thousand people twenty years to make it, and they used two million, three hundred thousand stone blocks.

▲ King Tutankhamen was only  years old when he died.

▲ The Egyptian year was  days long.

▲ Khufu's pyramid was built about  years ago.

▲ It contained  stone blocks.

▲ Nârmer took  people captive.

1	=
10	=
100	=
1,000	=

10,000	=
100,000	=
1,000,000	=

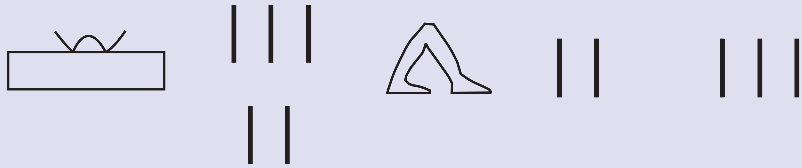
in our place-value system, and the Egyptian tally-like representation of numbers helped the students understand the "regrouping" process that often is necessary in calculations.

To end the day, Pettigrew read Egyptian myths to the class. The myths included the story of the god Horus, whose eye was torn into six pieces in battle but was united by Thoth, the god of wisdom. The students identified the numerical pattern in the values of the fraction symbols derived from the Horus-eye symbol (see **fig. 7**), then developed their understanding of the fractions by answering questions, using Egyptian units of measurement (Burnett and Irons 1996).

Activities continued throughout the week. The students made sheets of "papyrus," using strips of construction paper glued together in a crosswise fashion. They used these to write their own Egyptian documents, which contained mathematical sentences and their names spelled out in hieroglyphics. They also explored "Senet," a board game seen in the wall paintings of ancient tombs. A precursor

FIGURE 6

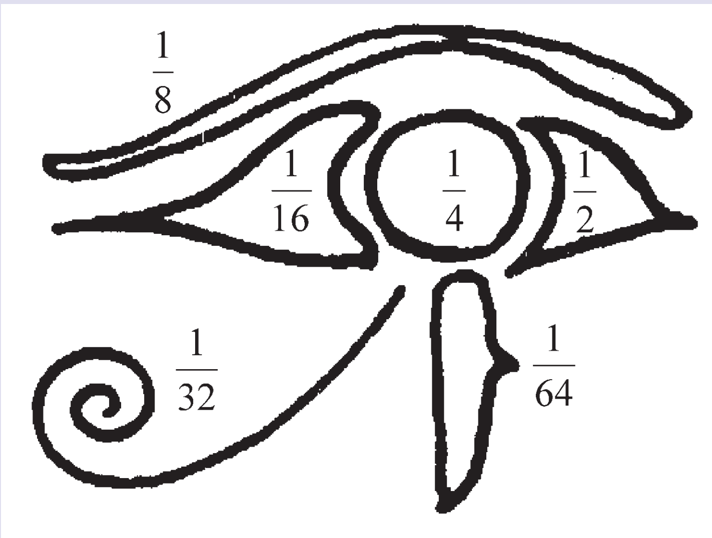
Egyptian addition



(reading from right to left)
"Three" "two" "is added" "five" "is the answer"

FIGURE 7

Horus-eye fractions



to many modern games, Senet involves two players who move their counters around a board. The winner is the first to get all of her or his pieces to the final square. The students constructed their own boards and had many contests. They developed strategies to improve their chances of winning.

Chinese Mathematics

The next destination of the time-travel machine was another "Cradle of Civilization," China. Pettigrew planned this trip to coincide with the Chinese New Year, so the students already were immersed in Chinese culture. They explored two calculating tools: the abacus (see **fig. 8**), which was familiar to some of the students, and the counting board, an earlier device that also employed a base-ten positional system and led to the development of written "stick numerals" (Zaslavsky 2001). The children used toothpicks to imitate the bamboo rods with which the Chinese physically represented their numbers on the counting board. Pettigrew's request that her students explain verbally how and where the sticks should be placed not only gave them valuable practice with spatial language but also provided yet another way to reinforce their understanding of place value.

Later in the day, Pettigrew read *Grandfather Tang's Story* (Tompert 1990) to the class and the students made their own set of tangram shapes by folding and cutting paper. This method, taken from the book *Mathematics: A Way of Thinking* (Baratta-Lorton 1977), is more time-consuming than is simply cutting out shapes from a suitably marked square. However, it led to a rich discussion of geometrical language and gave the students useful practice in carefully following verbal instructions, both of which are important in developing students' ability to communicate mathematically (NCTM 2000). The day ended with "Lo Shu," an ancient Chinese depiction of a magic square. Once again, Pettigrew introduced the new topic through storytelling (Irons and Burnett 1995). She described the Chinese legend of the turtle that came out of the river Lo to reveal the puzzle to the Emperor (see **fig. 9**). In a class discussion of the illustration, students identified the numerical significance of the patterns of dots and commented on the placement of odd and even numbers. A few students noticed the common sum of the square's rows and columns and suggested that this property explained why the squares were considered "magic." The students then constructed their own magic squares, based on the principles that they had discovered.

The Last Five Time-Travel Days

The students' next time-travel trip took them to Rome to learn about Roman numerals and the abacus on which the Romans did their calculations. Later that day they traveled to India, where they discovered the origin of the Hindu-Arabic numbers that are used today and explored some of the mathematics known to the Hindu priests.

The timeline fastened above the class notice boards had to be scrolled over many centuries to reach the next destination, Europe toward the end of the Dark Ages. Fibonacci, the thirteenth-century Italian who introduced the Hindu-Arabic numbers to Europe, was the featured mathematician. The children enjoyed exploring his famous series of 1, 1, 2, 3, 5, 8, . . . and were able to demonstrate their understanding of its pattern both verbally and by writing more numbers in the series. Magic tricks based on this series added to the day's fun.

Pettigrew divided the class into six groups for a visit to the Renaissance era. Each group studied a mathematician selected from *Historical Connections* (Reimer and Reimer 1992, 1993, 1995). The class could choose from a wide variety of activities, the most popular of which was "Plot and Swat" (Reimer and Reimer 1995). This exercise in coordinate geometry produced the picture of a fly, a reference to the story that Descartes invented his coordinate system while watching a fly crawl around his ceiling. The Galileo group was excited by "that hooky thing," their name for the square-root sign, which they needed unexpectedly for one of their pattern-recognition activities. The square-root concept was new to them but they were eager to understand it, and they enthusiastically explained the meaning of the symbol to the rest of the class.

Pettigrew set aside one day to teach her students about selected female mathematicians. Again, she chose activities from *Historical Connections*, but the anecdotes about the women's lives made the greatest impact on the students. These not only showed the difficulties that girls who wanted to study mathematics had encountered but also gave the students examples to challenge the view, still prevalent today, that "girls don't do math."

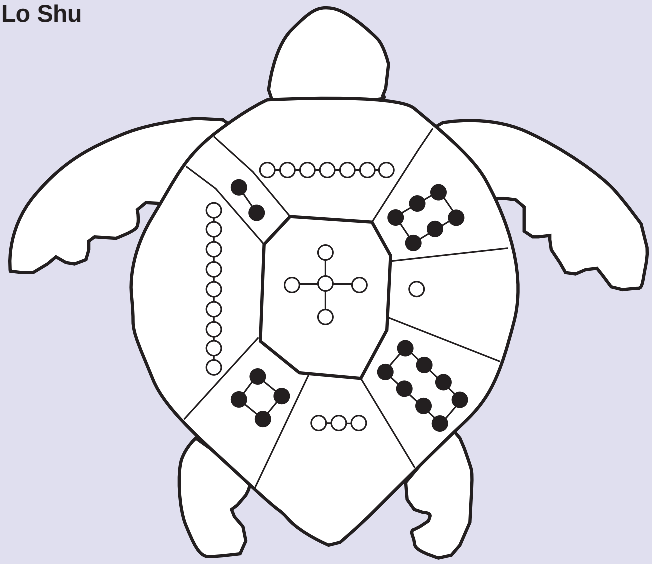
Pettigrew called her last time-travel day "Math of the Future." Although some of the mathematics that they discussed is already several decades old, the fractal pictures that she showed the children had a futuristic look. A visiting high-school teacher demonstrated the graphing calculator, a tool that is likely to be part of the students' future studies.

FIGURE 8

Calculating with an abacus

FIGURE 9

Lo Shu



Reflections

Much has already been written about the benefits of teaching mathematics by using historical or multicultural material (Fauvel 1991, Zaslavsky 1996), but the following points seem particularly relevant.

Time-travel days highlight three important perspectives of mathematics. First, they show mathematics as a human endeavour. Through investigating, or even acting out, incidents in mathematicians' lives, the students come to see the creators of mathematics as real people. Next, learning about mathematics in other countries helps fulfill multicultural goals and enables students who have visited other countries to share their experiences. Third, time-travel days allow mathematics to be part of the present focus on cross-curricular connections. Locating each destination on a time chart and world map are obvious historical and geographic links, but the mathematical topics also led to discussions of the lifestyles of earlier times and motivated many art and language arts activities.

The most visible advantage of this novel approach to mathematics was the high degree of motivation that the students exhibited. The "make believe" element of the trips captured the children's imaginations and mentally prepared them to encounter new ideas, several of which stretched their minds to explore higher levels of mathematics than are normally encountered in the grade-three curriculum. The enthusiasm with which the students seized such concepts suggested confidence and a lack of concern about "wrong answers."

On their travels, the students encountered mathematics questions that appeared without reference to any specific curriculum topic, allowing true problem-solving experiences to occur. The mathematics was placed in a cultural context. Although teachers could use these activities without the pretense of time travel, many of the activities are so closely related to particular civilizations that not acknowledging this connection would be unfortunate.

Does Pettigrew expect the children to remember all the details of their time travels? Of course not, although end-of-year interviews with the students showed that some of the material had made a big impression on them. The important point of these excursions is that the children began to realize that mathematics has been explored and used since the dawn of civilization by people from all over the world. If students retain this view of mathematics, they might be able to see beyond the boredom of the basic facts of arithmetic, algebra, and geometry that are subject to so much drill in our school system. Time-travel days can encourage students to imitate the mathematicians of the past, to ask "why," and to enjoy the pursuit of an answer rather than just its attainment.

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