A *MATHEMATICS* LESSON FROM THE MAYAN CIVILIZATION

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http://classes.csumb.edu/MAE/MAE637-01/world/Resources/Mayanmath.asp

Mayan ***mathematics***, a significant part of the great civilization of the ancient people, is of true interest to all who admire the monuments, architecture, and art of the great Mayan cities. Among the Maya's multiple accomplishments involving mathematical skills were--

ï building ancient cities, such as Copan, Chichen Itza, Tikal, Tayasol, Quirigua, Tulum, and Palenque;

ï supporting the employment of thousands of construction workers;

ï collecting taxes and developing commerce in a vast geographical area;

ï calculating an accurate calendar with the cycles of the Sun and Moon and of Venus and other planets;

ï developing the astronomical alignments of temples, pyramids, and stelae;

ï inventing the technology of cement and concrete; and

ï creating the geometry used in construction and works of art.

Such major attainments by the Mayan civilization rest in the development of an efficient system of computation. Although many Mayan artifacts that may have provided proof of these accomplishments were burned during the Spanish conquest and colonization (Landa 1938), still remaining is evidence found in inscriptions in stone; in a few surviving Mayan books, such as The Popol Vuh (Recinos, Goetz, and Moreley 1950) and The Book of the Chilam Balam of Chumayel (Mediz 1941); and in ancient customs and traditions that survive among the millions of Maya today.

Mayan *Culture* and Real-Life *Mathematics*

Teachers can infuse ***culture*** into the curriculum and develop students' competence and confidence by using ethnomathematics (D'Ambrosio 1987; Massey 1989; Stigler and Baranes 1988). Ethnomathematics calls for a reconstruction of the ***mathematics*** curriculum to achieve cultural compatibility (Moll and Diaz 1987; Trueba 1988). In this reconstruction, students' cultural and background experiences and vocabulary are used to frame ***mathematics*** problems in the classroom (Henderson and Landesman 1992). When the materials and problems being used originate from the students' daily-life experiences or cultural heritage, we find real-world problem solving at work. In this situation, the problem-solving activity can motivate the students to create mathematical models that may, in reality, become the real object of study (Bohan, Irby, and Vogel 1995).

Kamii (1992) motivates elementary students to rediscover arithmetic with objects of daily life, including material originally designed for game purposes. Research conducted by Doyle (1988), Resnick (1980), Schoenfeld (1985), Wilttrock (1974), and Hiebert and Carpenter (1992) supports reality-based ***mathematics*** teaching. This research advocates the need for problems to be taken from real life and brought into the classroom. Real-life problems involving concrete, as well as semiconcrete, materials can be taken from many of today's students' historical or cultural milieus.

One such cultural and historical event took place more than 5000 years ago in a region named Mesoamerica, where the Maya developed a numerical written system that dealt ingeniously with the relationship between numeral and number (Morales-Aldana 1994). According to Otto Neugebauer, a science historian, the Mayan numeration system with positionality and place value was "one of the most fertile inventions of humanity, comparable in a way with the invention of the alphabet" (Coe 1966, 156).

Mayan ***mathematics*** was characterized by a positional numerical system that had as a base the number 20. The Maya created a symbol for the 0, which had a use similar to that in any other positional numerical system. Furthermore, in addition to their mathematical advances, compared with other civilizations, their system of teaching ***mathematics*** was based on the use of concrete, semiconcrete, and representational materials. Probably, that characteristic expanded the dominant structure's potential to develop numerical computations and also allowed the priests, the academicians, and the religious class of that time to carry out the great astronomical and scientific advances that are still impressive today.

Mayan ***mathematics***, science, and society were closely linked and, in general, presented an integral focus, which meant that each investigation and each scientific fact had a direct relationship with Mayan society. For example, their study of astronomy was closely related to different cycles for planting corn. Morley (1968) indicates that archeological as well as documental proof shows that the day on which the fields should be burned in preparation for planting corn was chosen with extreme care by the priests. For example, in the city of Copan, Honduras, two pillars of inscribed stone, stelae 10 and 12, rise out of two chains of hills that bank the extremes on the west and east of the Copan valley. The distance between these two stelae is about a mile along a straight line. From stela 12, one can see the sun set directly behind stela 10 on 12 April and 7 September. The first date, 12 April, was precisely the date chosen by the priests for the commencement of the initial step in planting the corn seed. Figure 1 depicts the two stelae and shows the alignment of the stelae at sunset on 12 April, which indicated to the priests the date to prepare the soil for planting (Morley, Brainerd, and Sharer 1983).This real-life mathematical application from history also explains how the Mayan priests were able to share with the people their knowledge, which was used to resolve community problems.

This example illustrates how the Maya combined geometry, knowledge of astronomy, and mathematical calculations, as well as construction skills, to establish the correct date to prepare the soil for planting their most important food--corn. To achieve such developments, Mayan civilization needed an efficient numerical system that allowed its members to handle small numbers and that facilitated their computation.

Mayan Numerical System

The numbers of the Mayan numerical system were written from bottom to top. The historian Esparza-Hidalgo (1976) commented on how the young generation might approach older individuals to ask how to start counting--from up to down or from down to up. The older individual would likely answer without hesitating: "Well, how do plants grow? Then, how would we count?" Given this answer, we see one more example of how the Maya were and continue to be keen observers of their natural environment.

The Mayan numerical system used three symbols: the dot that in real life was a small rock, bean, or any kind of seed; the bar, which represents an open hand; and the symbol of 0, represented by a shell, a closed hand, or a head. When the Maya did calculations, they represented the 0 by an empty box or a shell. With the combination of the dot and the bar, they constructed the first nineteen numbers as depicted in figure 2.

The system for writing Mayan numbers includes three rules:

Rule 1: Combine from one to four dots in each position.

Rule 2: Combine from one to three bars in each position.

Rule 3: Five dots equal a bar.

The numbers 4, 5, and 20 were extremely important. The number 5 formed a unity, the open hand. Today, for example, in the markets of Mayan descendants, we observe purchases in terms of hands, such as a hand of avocados, a hand of oranges, or a hand of cucumbers. The number 4 is important because four units of five equal a person. In other words, the system has four units that include twenty fingers and toes. The number 20 represents a person. In addition, twenty is the base of this numerical system. A 20 unit is represented as a shell with a dot on top, as shown in figure 3.

The number 20 was also important in the Mayan calendar, which had a count of 360 days in some cases and 365 days in others. The priests used multiples of 20 and no fractional notations, since the Maya did not use fractions in their numerical system. This calendar gave each of the 20 days a name, represented by a unique symbol. The 365-day calendar had 5 additional nameless days (18 x 20 + 5 - 365). The numerical system and the calculations were of major use in developing and keeping the Mayan calendar (Coe 1966).

Morley (1968) described the way to add in the Mayan numerical system. Landa (1938) recorded that the Maya carried out their calculations on the floor or in flat places and that they used little rocks and sticks for calculating. Many times, cacao beans were used instead of sticks. Cacao, or chocolate, was a main food staple. See figure 4 for an example of addition in the Mayan system. Rather than use dots and bars, the classroom teacher may wish to use sticks and beans to represent ***mathematics*** more concretely.

Mayan Numbers--Multiples of 20

According to Closs (1986), larger numbers in multiples of 20 in Mayan languages follow a regular pattern up to 380. For example, 1 was called "hun"; 20 was named "kal." One 20 was "hun kal." The number 19 was given the name "bolonlahun"; 380 was 19 x 20; therefore, it was called called "bolonlahun kal." Six powers of 20 were recorded. The number 400, or 20[sup 2], the second power of 20, was given the name "bak"; 8000, or 20[sup 3], the third power of 20, was called "pic." Interestingly, in one Mayan language, Cakchiquel, the word for "pic" is "chuwi," meaning "sack." Cacao beans, which were not only a main food source but also a medium of exchange, were said to have been packed in quantifies of 8000 in each sack.

Large numbers were, like the small numbers, depicted in columns. See figure 5. The example first shows 20. Notice that the shell represents 0 and that one dot is in the 20s place, which makes this number 20. For the example of 805, notice that 5 units + 2 x 400 = 805. For 2230, (10 x 1 = 10) + (11 x 20 = 220) + (5 x 400 = 2000) = 2230.

Conclusion

As demonstrated in figure 4, the algorithm of addition in the Mayan numerical system is relatively simple. It can facilitate learning arithmetic operations and develop mathematical skills. The concrete, semiconcrete, or representational materials used by the Maya--beans, rocks, or sticks or graphs with the bars, dots, and shells--make the algorithm easy to understand and operate. Could this method explain the Mayan civilization's incredible performance in ***mathematics*** and astronomy?

Using such examples from a cultural and historical perspective, teachers can offer models of study for abstract concepts of numerals and number or amount. Not only does this approach have the advantage of modeling an abstract concept, it also has implicit ethnomathematical, cultural links that could be used by the elementary school teacher to advance multicultural attitudes in the classroom and assist students of Mayan descent to feel pride in their own ***culture***.

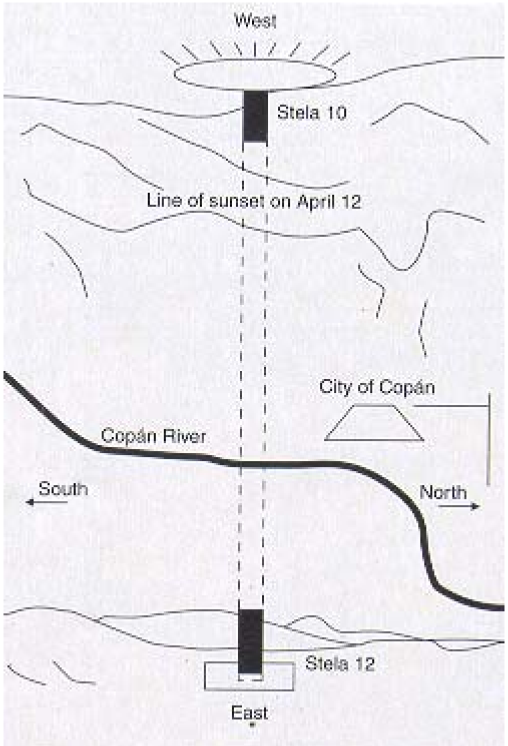

FIGURE 1; Stelae 10 and 12, Copan, Honduras

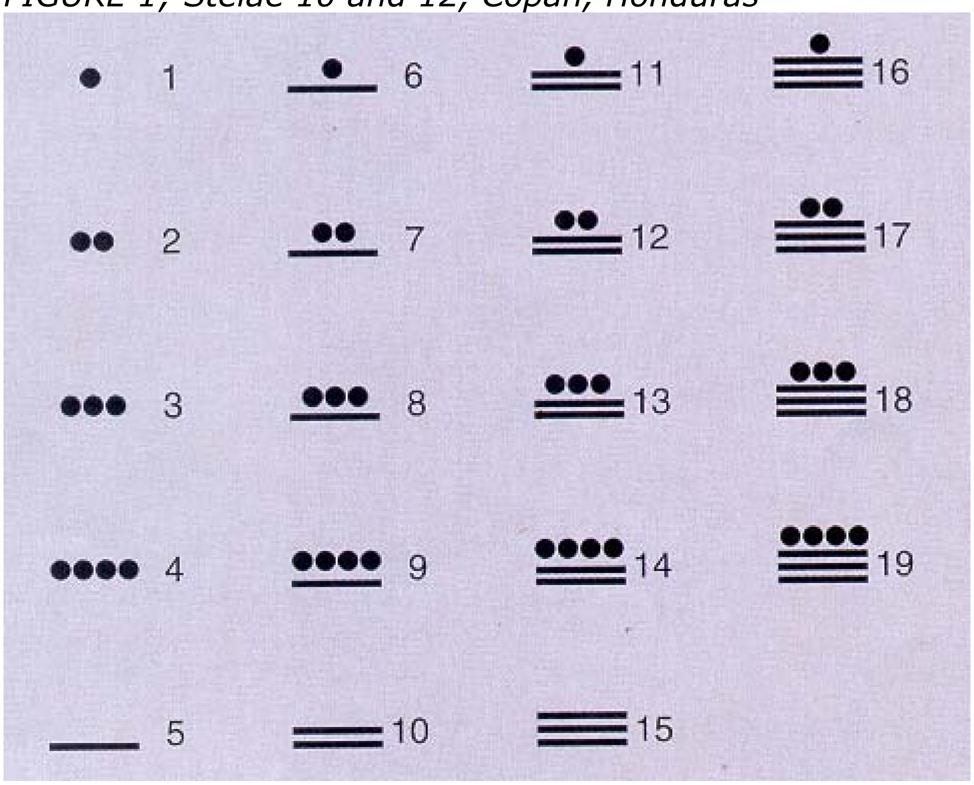

FIGURE 2; Combinations of dots and bars construct the first nineteen Mayan numbers

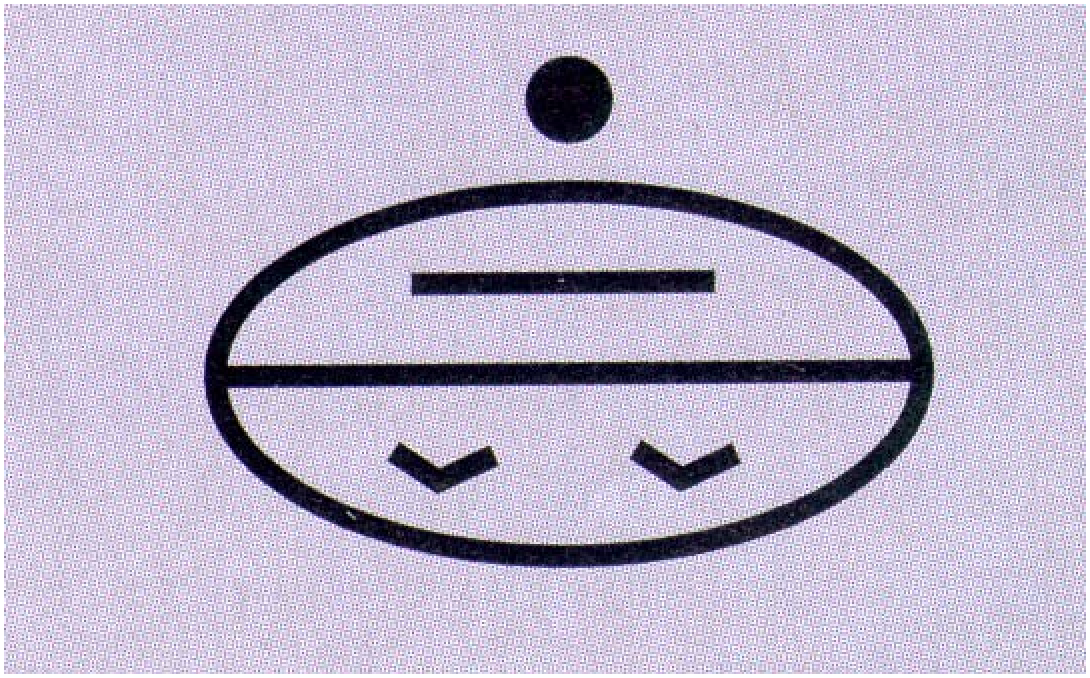

DIAGRAM: FIGURE 4; Example of addition using the Mayan system
DIAGRAM: FIGURE 5; Depictions of larger numbers
PHOTO (COLOR): Photograph courtesy of Carroll Academy, a public magnet school for international studies, Aldine Independent School District, Houston, Texas;

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culturally relevant materials from the Mayan civilization in teaching abstract and concrete mathematical concepts.

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