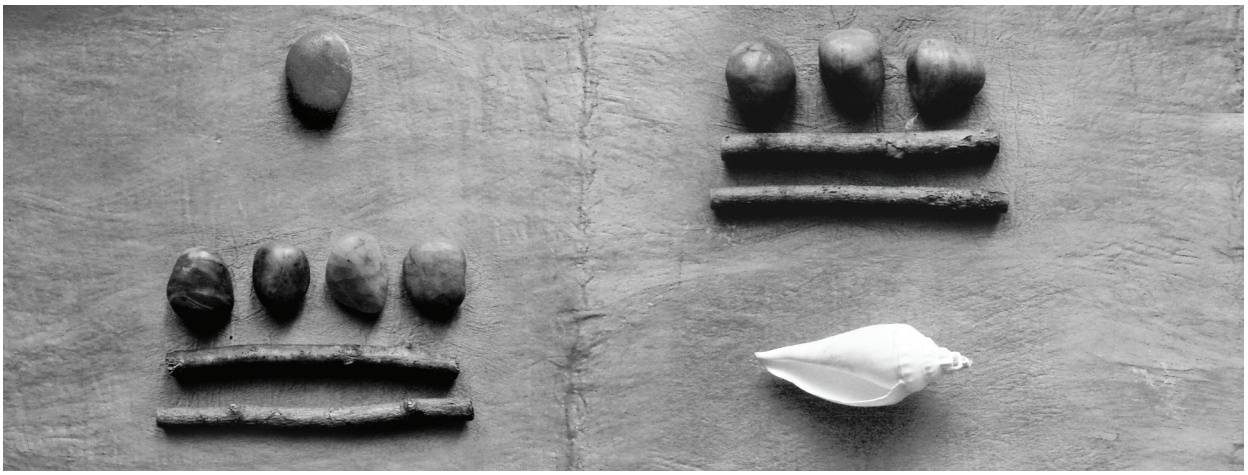
MAYA MATH
MATHEMATICS, GRADES: 5–8

Note to teachers: The most effective way for kids to experience and understand the 20-based Maya number system is to physically manipulate toothpicks, beans and shells or other markers.

> "There's not much point in making wheeled carts if you don't have draft animals to pull them," sniffed Lola. "Besides we were busy inventing the Maya calendar (and) the concept of zero . . ."
>
> **The Jaguar Stones, Book One: Middleworld**, page 209



ESSENTIAL QUESTION:

Was math discovered or invented?

Sub questions:

- How have different cultures have created systems to represent the patterns or relationships of mathematics?
- How does learning Mayan math deepen our understanding of the Arabic system that we use?

MATERIALS:

- Toothpicks, beans and shells, or other markers
- Maya math demonstration video (https://jaguarstones.com/videos/mathdemo.html)
- Math grid and worksheets (provided)
- Access to research materials

OBJECTIVES:

- Develop a working knowledge and understanding of Maya numerals and arithmetic.
- Explain the role of zero in addition, subtraction and multiplication.
- Compare and contrast Maya mathematical concepts with those of other cultures (eg Roman numerals), and discuss the relative strengths and weaknesses of each.

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RATIONALE:

The Maya were advanced mathematicians, and one of the first societies to successfully incorporate the concept of zero into their calculations. Unlike our own culture, which bases its numbering system on the numeral ten (likely because of the ten fingers on human hands), the Maya developed a system based upon the number 20 (fingers and toes). Numerals were represented by a series of dots (1 dot = 1) and bars (1 bar = 5) stacked vertically on top of one another. When the number reached twenty, a dot was moved into a second place value (analogous to our "tens" position), situated directly above the original number. Zero was represented most often by a shell.

KEY VOCABULARY:

Decimal System: method of counting based on the number 10.

Vigesimal System: method of counting based on the number 20.

ACTIVITY 1: THE MAYA NUMBER SYSTEM

NOTE: Before the lesson, prepare the materials and watch the modeled instruction.

Lead/Inquiry: Was math discovered or invented?

Using journaling, Pair/Share or a KWL chart lead the class through a discussion of the development of math and how/why it evolved. Review the term decimal system and how it might have been created.

Procedure:

1. Pass out the Maya Numerals Worksheet to the class. Give the students five minutes as archeologists to decipher the Maya numerals as best as they can using the incomplete key provided. Have students share ideas about how the system works, but do not confirm guesses.
2 Model adding a two-digit number silently using toothpicks, beans and shells on a grid. Have the students volunteer rules that they saw. Ask the students to look for rules as you carefully and silently model a two-digit addition problem without talking. Have them record what they saw. Share responses. Model once again silently. Share more ideas and rules. (Note - key rules are: five dots equals one bar, and four bars equals one dot in a higher place value.) Now model one last problem, explaining rules as you go. Ask for a student volunteer to model and review the Maya numerals from 1-19. Discuss place values in a base twenty system: "twenties", "four hundreds" and "eight thousands".
3. Students break up into small teams. Hand out Maya math grid and markers. Practice another two-digit addition as a group. Have students complete the computational worksheet staying within the Maya system (ie they shouldn't convert Maya numbers into decimal numbers).
4. When students demonstrate mastery have them convert the Maya vigesimal numbers to decimal numbers.

Conclusion:

What method was most helpful to you in learning the Mayan numerals? Why? What is something you learned about our decimal system by exploring the vigesimal system? What is one strength of each system? What is one way the two systems are similar? What is an important difference?

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How practical is the Maya number system? (What if you were an illiterate market trader writing in the dust, using sticks and stones to make your calculations?) Was it easier to calculate within the Maya system, or to convert the Maya numbers to the decimal system?

What are some of the challenges archeologists face as they attempt to interpret ancient civilizations? (For instance, their information is frozen in time- snapshots instead of videos, written communication instead of demonstrated communication.)

ACTIVITY 2: DIFFERING NUMBERING SYSTEMS

Lead/Inquiry:

List as many other number systems as possible: Chinese (base 10), binary (base 2), Babylonian (base 60), Maya (base 20), Egyptian (base 10) etc.

Procedure:

1. Write suggestions on slips of paper, and have teams randomly select assignment to research. How does the number system work? Why was the system based on that particular number? What is the practical application of the system? What are its weaknesses? How does it compare to our own.
2. Students then present their number system to the rest of the class.
3. Divide class into two groups: was math discovered or invented. Have each team think of all the reasons they can to defend their side. Present arguments.

Expansion:

Number systems are not confined to counting and arithmetic. Have the students write a response paper on the other number systems they encounter throughout the day, including telling time, calendar dates, handling money, etc. What number bases do these systems use? Why? How are they similar to or different from out way of counting?

Conclusion:

What are three things you have learned about the process of mathematics? Do you think math was discovered or invented? Explain your answer.

ASSESSMENT:

Students shall be assessed based upon their understanding of the mathematical concepts presented as demonstrated by their completion of written problem sets, group presentations, and their contributions to class discussions.

USEFUL LINKS:

A brief explanation of Maya math: http://jaguarstones.com/maya/mayamath.html

The history of mathematics: http://en.wikipedia.org/wiki/History_of_mathematics

Ancient number systems: http://www.math.wichita.edu/history/topics/num-sys.html

Maya math video demonstration: http://www.youtube.com/watch?v=VmZjPVT2M20

Maya math lesson plan: www.exploratorium.edu/ancientobs/chichen/docs/Mayan_Math.pdf

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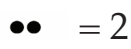
A portion of an Ancient Maya Almanac (The Dresden Codex)

WORKSHEET 1
DECIPHERING MAYA NUMBERS

You are an archeologist who has discovered a Maya Codex covered in glyphs and Maya numbers. Your colleagues have been able to translate a few of the Maya numbers. Using the translated numbers, decipher the rest of the numerals.

TRANSLATED NUMERALS

 = 2 = 8 = 12 = 20 = 33

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a) = _____ b) = _____ c) = _____

d) = _____ e) = _____ f) = _____

g) = _____ h) = _____ i) = _____

j) = _____ k) = _____ l) = _____

m) = _____ n) = _____ o)

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A portion of an Ancient Maya Almanac (The Dresden Codex)

WORKSHEET 1- KEY
DECIPHERING MAYA NUMBERS

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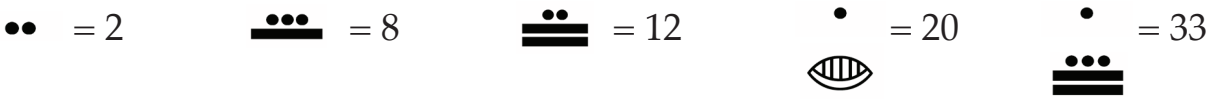
TRANSLATED NUMERALS



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a) = 3

b) = 5

c) = 13

d) = 0

e) = 9

f) = 1

g) = 11

h) = 15

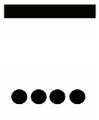
i) = 4

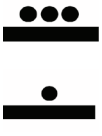
j) = 7

k) = 10

l) = 19

m) = 20

n)  = 104

o)  = 166

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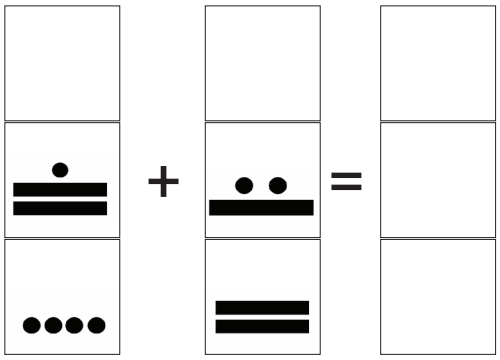
WORKSHEET 2
MAYA ADDITION & SUBTRACTION

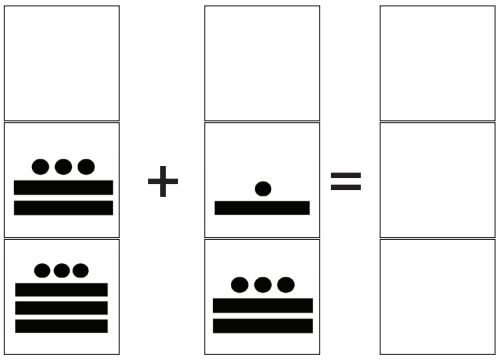
Set up and solve the following equations using the provided materials.

A)



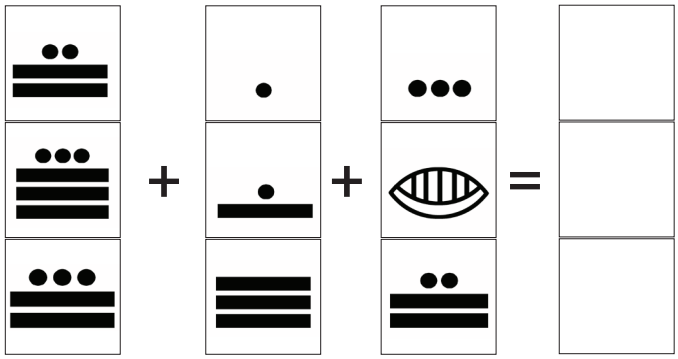
_____ + _____ = _____

B)



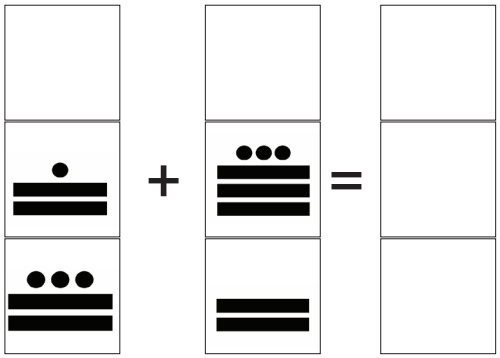
_____ + _____ = _____

C)



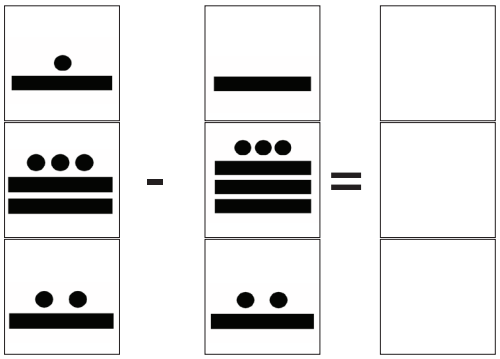
_____ + _____ + _____ = _____

D)



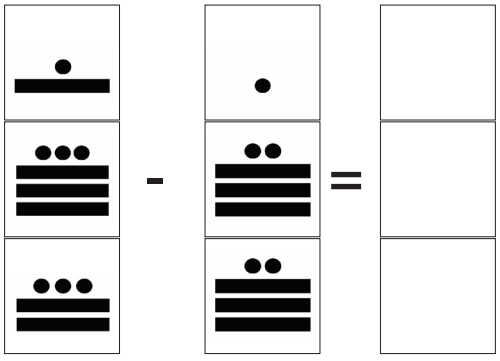
_____ + _____ = _____

E)



_____ - _____ = _____

F)



_____ - _____ = _____

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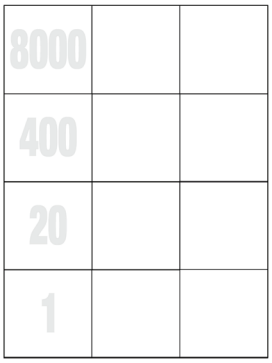

WORKSHEET 2 - KEY
MAYA ADDITION & SUBTRACTION

Set up and solve the following equations using the provided materials.

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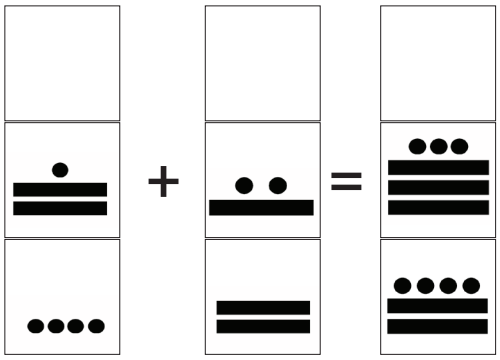
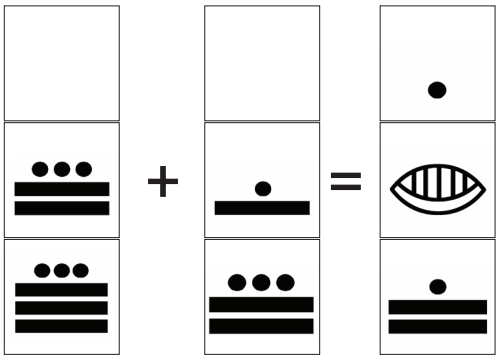


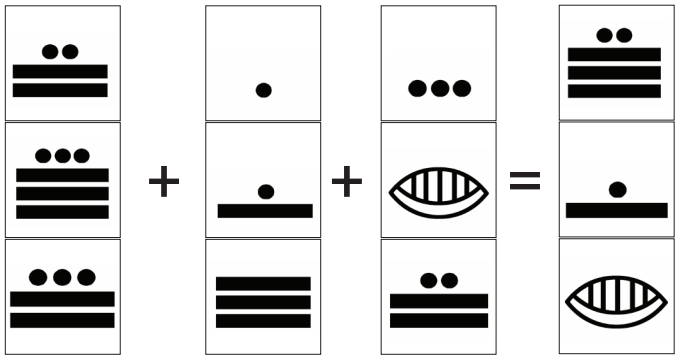
224 + 150 = 374

B)



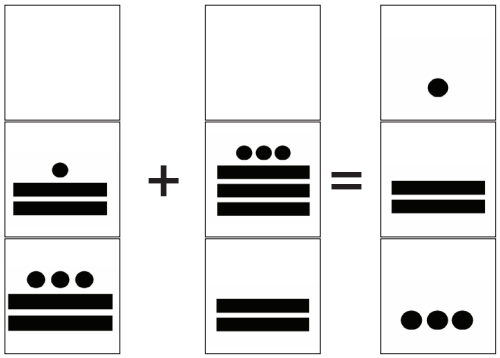
278 + 133 = 411

C)



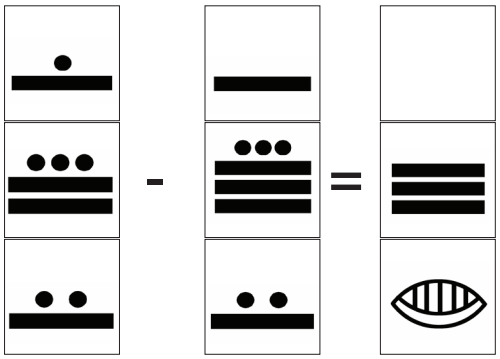
5,173 + 535 + 1,212 = 6,920

D)



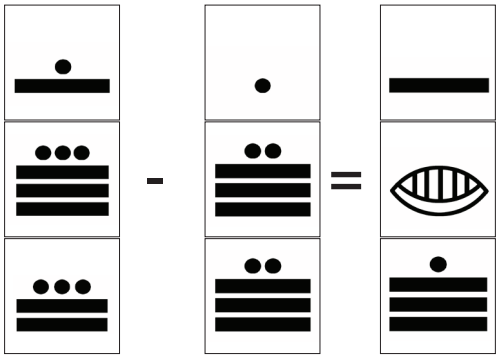
233 + 370 = 603

E)



2,667 - 2,367 = 300

F)



2,773 - 757 = 2,016

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