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Helping Kids Learn – Post #15 5/11/20

STEM: Mathematics – Place Value & Labels

Most of the amounts or quantities we deal with in everyday life are represented by "labeled" numbers. We learn early that 2 is less than 9. But, when 2 is actually *2 dollars* and 9 is actually *9 cents*, 2 represents something greater than 9. That's because the labels *cents* and *dollars* give additional information and meaning to the numbers. Understanding place value and labeled numbers is essential to solving problems in the real world. For ways to adapt this lesson, see **Lift the Level** below.

Be a Mathematician – Number Sense

We write numbers (numerals) using a system that assigns value based upon the quantity a digit represents and where the digit is placed, a ***place value*** system. Not all number systems work that way. The Ancient Romans assigned a value to a letter and that didn't change. "I" was always 1. "V" was always 5. If you put a letter with a smaller value *after* a letter with a greater value, everyone understood that it added to the value.

I = 1 V = 5 VI = 6, VII = 7, VIII = 8

However, if you put a letter with a smaller value *before* a letter with a greater value, everyone knew that it took away from the value.

I = 1 V = 5 X = 10 IV = 4, IX = 9

Why not VIIII for 9? It's harder to read and makes greater numbers toooooooo longgggggg!

In our place value system, the value of a digit depends upon several things:

- Relative magnitude – how much it stands for compared with other digits
- It's place in a number
- How the number is *labeled*

Ask if you need help cutting

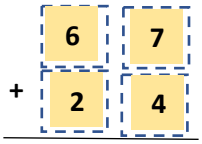
Investigation 1: You'll need a copy of the worksheet on page **5,** a pencil, a pair of scissors and, possibly, a crayon or marker.

Turn the Worksheet face down. If you can see the numbers (digits 0-9) through the paper, color the back of the yellow and orange squares. Turn the sheet face up and cut out the yellow squares. If you are playing with a partner, they will cut out the orange squares.

Put the squares in order in a single row with 0 at the left and 9 at the right. The digits stand for quantities (amounts) – 6 is more than 4, for example. All by themselves the numbers can represent anything from popcorn kernels to blue whales.

Turn the squares face down and mix them around. Pick one square. Look at the addition problem at the top of the Worksheet. The object of the game is to put the number squares in the *tens place* or the *ones place* on the addition problem so you make the greatest possible sum. Once you put down a number square, you can't pick it up again. Draw and place number squares 3 more times. Add your numbers and write the sum (answer) under the line. (Leave space to write more sums underneath the first one.)

Suppose this was your first game:



The sum is **91.** Is this the greatest sum you could make with these four numbers? How could you have placed the numbers to get a greater sum? Put the number squares back. Mix and play again. Don't erase sums, just cross out and write below.

If you are playing alone, your goal is to get the greatest possible sum with the four number squares you choose. If you play with a partner, your goal is to get a greater sum than your partner. (See **Solutions**.)

Investigation 2: Use the same squares as Investigation 1. Use the subtraction problem at the top of the Worksheet. Play as in Investigation 1. Now you are finding the difference between two 2-digit numbers. If you get a greater number on the bottom (subtrahend) and you don't know how to do that subtraction, put the number squares back and play again.

In this game your goal is to get the greatest difference (answer). If you're playing with a partner, try to get a greater difference than they do.

In Investigations 1 and 2, the place where you put the digit matters. Why? (See **Solutions** below.)

Investigation 3: Putting a label on a number gives the reader a lot more information than showing a number alone. Some labels help the reader: "27 goats" paints one picture in our minds; "27 super tankers" gives us a different image. Other labels are absolutely essential! 27 inches is completely different from 27 miles.

In this investigation you will choose numbers and a label. You can play with a partner or play against yourself. The goal is to get the greater length.

Cut out the squares at the bottom of the Worksheet. They are abbreviations for lengths:

in. stands for *inches*.....ft. stands for *feet*.....mi. stands for *miles*

12 inches = 1 foot
5,280 feet = 1 mile
63,360 inches = 1 mile

Make sure you can't read through the new squares. Keep the yellow and orange squares separate. Also, keep the length squares separate from the numbers. If you're playing with a partner, you'll have 2 bunches of squares face down. If you're playing against yourself, you'll have 4 bunches.

Choose a number square and put it in one of the two blank squares on the Worksheet. Then choose another number square to put in the remaining blank. Next, choose a length square to go in the green square. The goal is to get the greater length. So,

21 x 12 = 252 in.
Yellow gets a point.

The labels make all the difference! Without them, orange wins; with them, yellow is the clear winner.

Lift the Level You can make this lesson deeper and/or suitable for older students by any of the following. The last two suggestions strengthen number sense. You many find the links in **STEM Online** below useful.

1. The games in Investigation 1 and 2 are played "without replacement," once a number is drawn and placed it cannot be used again during that round. How would the game change if you allowed a number square to be drawn, recorded and then put back in the pile to, possibly, be drawn again?
2. Play the games in Investigations 1 and 2 with the goal of achieving the smallest sum or difference. Then develop a general rule for how to maximize or minimize the sum or difference.
3. Our number system is the Hindu-Arabic system. Research its origins and create a short slide show. Include a slide listing advantages and disadvantages of the system.
4. Besides on ancient monuments in Europe, you'll see Roman numerals in use even now on some older buildings or as movie copyright dates. L = 50, C = 100, D = 500 and M = 1,000. Write the date for this year and the year you were born. Speculate: why don't we use the Roman system now? (See **Solutions** below.)
5. Our place value number system isn't the only one in history. Research the Babylonian system and make a poster summarizing it. Include the numerals used, how numbers less than and greater than 59 were written, the value of each place, and how computation (adding, subtracting, multiplying, dividing) worked. At the bottom of your poster include a speculative conclusion about why we don't use the Babylonian system today.
6. There are many essential labels for numbers. Some involve words, such as ounces or meters; others involve numbers, such as "4 squared" 4^2. Create a chart of essential labels with an example and equivalences.
7. To develop relative magnitude of numbers in young children, play Applesauce: Think of a number between 0 and 9. As the child guesses your number, respond with "apple" if your number is greater than the number guessed, "sauce" if your number is less and "applesauce" when they guess the exact number. You many want to write down each guess and the response at first but make the game mental math only (and more portable) as skills develop. Use the game in suggestion 7, Pico Fermi, for strengthening place value concepts.
8. The mental math game, Pico Fermi Donuts, is great for strengthening place value concepts and mental math acuity. It helps to think of "pico" as "a little bit right," "Donuts" as similar to "zeros," and "fermi" as "firm." You may want to write down the guesses and responses at first but transition to mental math only as soon as everyone is comfortable with the game. Think of a two-digit number, initially with each digit different. As each person guesses your number, your replies are "pico," "fermi" or "donuts." When the actual number is guessed, respond "Pico Fermi!"

   For example, suppose your number is 37. I guess 21. Neither digit in your number is guessed so you reply "donuts." (That should ultimately encourage guessers to eliminate "2" and "1" but allow strategies to develop; don't suggest them.)
   Next guess: 75. There is a 7 in your number but it is in the ones place, not the tens.

So there's something a little right about the guess; reply "pico." The guesser won't know which digit is in your number but they'll have a useful clue.
Third guess: 39. There's a 3 in your number and it's in the same place (tens) as the guess. Reply "fermi."
Continue guesses until 37 is guessed with a reply of "Pico Fermi!"

Pico Fermi Donuts can be played with 3-digit numbers or greater. If your number is 265, for example, and the guess is 506, the response is "pico pico." You aren't signaling every digit but indicating that there are two of the three digits in your number.

STEM Online

These are suggestions only and no endorsement is implied. Although they have been screened for appropriateness before posting, parents should vet the websites their children use as they may change over time.

Hindu-Arabic number system https://www.britannica.com/topic/Hindu-Arabic-numerals

Roman numerals https://en.wikipedia.org/wiki/Roman_numerals

Babylonian number system https://www.basic-mathematics.com/babylonian-numeration-system.html

NJ Student Learning Standards

Mathematics Standards 1.NBT.B.2, 1.NBT.C.4; 2.NBT.B.5; 3.OA.D, 3.NBT.A.2; 4.OA.C.5, 4.NBT.A, 4.MD.A.1; 5.OA.B.3; MS and HS - Mathematical Practices 2, 7; HS-N-RN.B.3

Solutions/Suggestions

Investigation 1: Greatest sums are achieved by placing numbers of greater relative magnitude in the tens place of each addend.

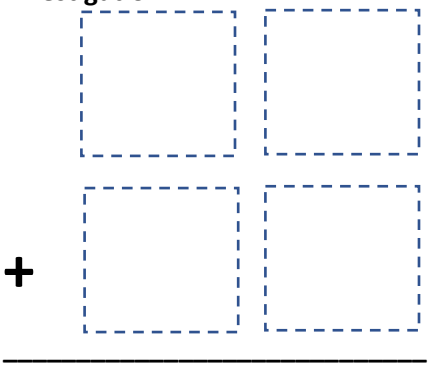
Investigation 2: You want the number of greatest relative magnitude to be in the top (minuend) tens place and the lease relative magnitude to be in the bottom (subtrahend) tens place.

Lift the Level 1: Without replacement, there are 10 ways to fill the first square, 9 to fill the second and so forth; with replacement, there are many more choices (10^4), lessening the chance of winning.

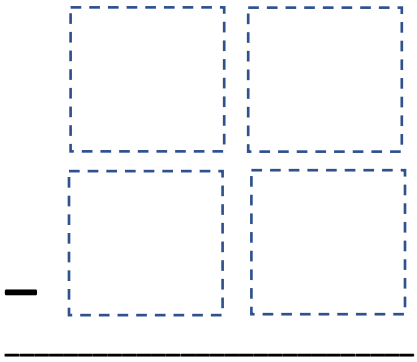
Lift the Level 3: 2020 is MMXX.

Worksheet

Investigation 1



Investigation 2



Investigation 3

Use with Investigations 1, 2, and 3

0	1	2	3	4	0	1	2	3	4
5	6	7	8	9	5	6	7	8	9

Use with Investigation 3

in.	ft.	mi.	in.	ft.	mi.