Games and Puzzles that Reach the Kids and Teach the Standards

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Resources for Math Teachers

by Bill Lombard and Brad Fulton

Successful Mathematics through Conceptual Layering

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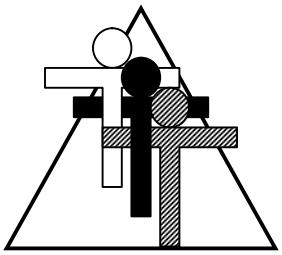
http://tttpress.com/index.html
http://www.mrlsmath.com/



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Summary of Presentation

Bill will share some of his favorite games and puzzles:

KenKen, Backwards Math, Neighbors, Bingo, Number Yoga, Hoppy

and show how to use them in the classroom to build number sense and algebra skills.

Files to download at the Mr. L's Math website:

http://www.mrlsmath.com/download-materials/

Games and Puzzles that Reach the Kids and Teach the Standards
High Performing Teachers B
Pedagogy Practices of Mr. L

Some of these activities are from Teacher to Teacher Press books:

Simply Great Math Games
Simply Great Math Activities: Algebra Readiness
Simply Great Math Activities: Number Sense

Put these activities, puzzles, games, and ideas into regular practice, you will find increased skills and motivation in your students and more joy in your teaching.

Best wishes,

Bill Lombard (a.k.a. Mr. L)

Puzzles and Games

- from mrlsmath.com

Puzzles and Games are a great way to build **enthusiasm, excitement, and skills** in a math classroom. When these are used properly, there is always an underlying mathematical theme that is being explored or reinforced. Students learn the value of **logical thinking, proper planning, and long-term focus**.

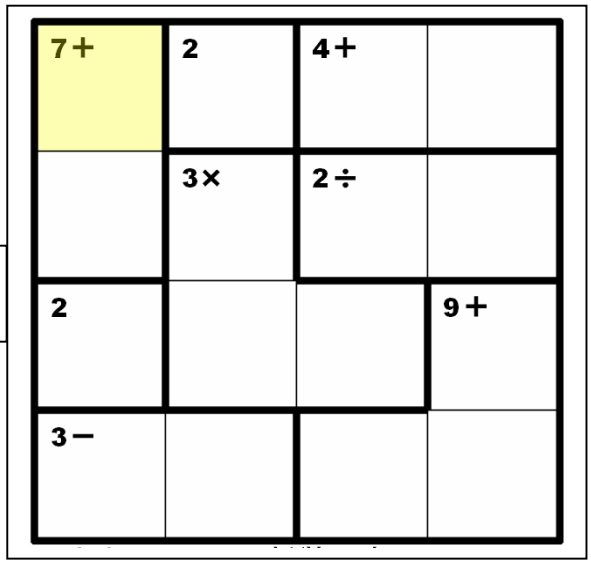
Many of these puzzles build spatial sense and geometrical visualization and allow students to create conceptual models. Research says that **problem solving abilities increase** when students gain spatial reasoning skills, and doing so in such a creative way brings joy to the students and the classroom.

Mathematical games can develop a lot of **creativity and number sense** in students. Many times a game or puzzle at first looks overwhelming, but becomes manageable after focusing on the key concept. Motivation is almost always inherent in a game or puzzle; this creates **conceptual emotion** which is a key to successful learning.

Opportunities for **transitioning from number sense to algebra thinking** abound with puzzles. Number properties show their strength in supporting algebra throughout puzzle activities. It's always a pleasure to watch the enthusiasm and skills grow in students!

4x4 KenKen Samples

E



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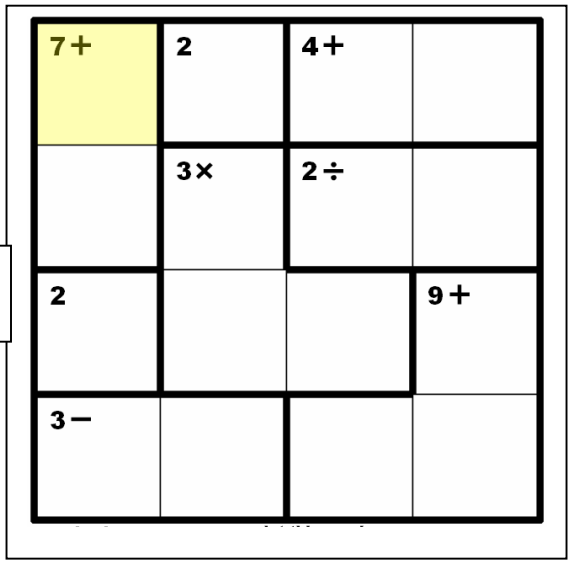

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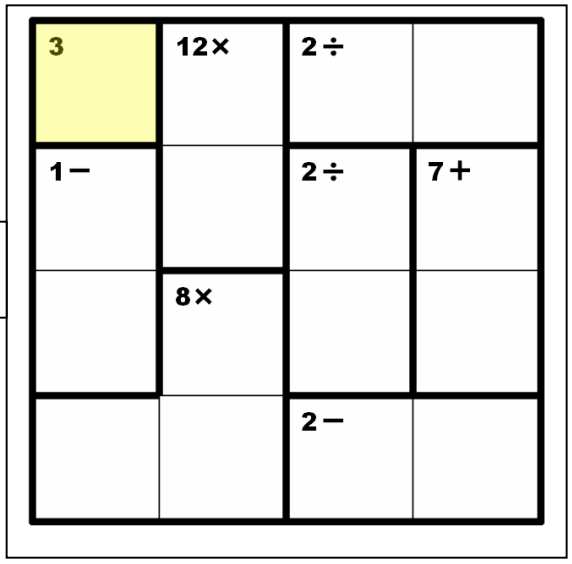

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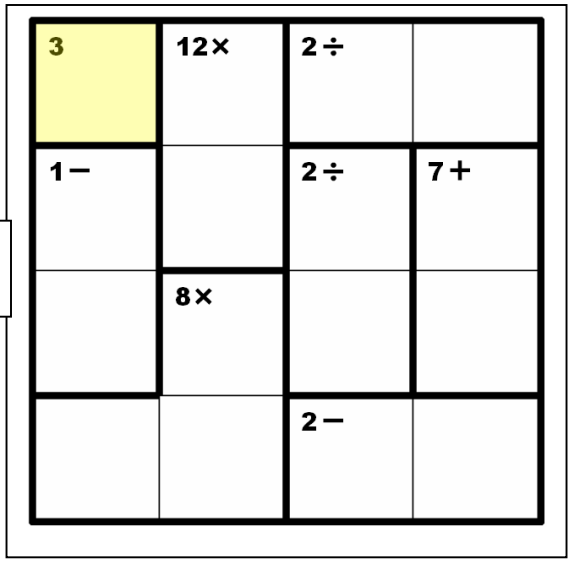

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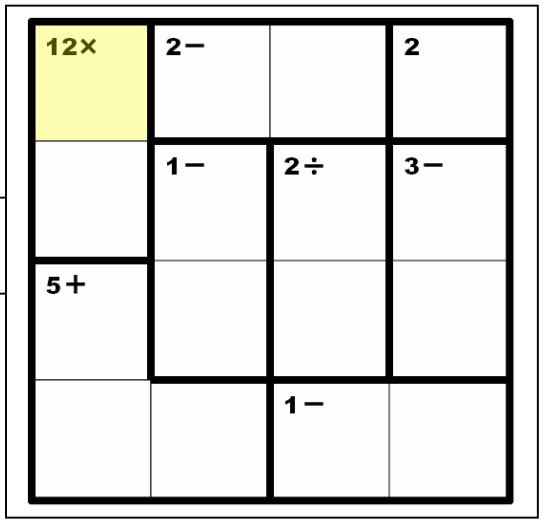

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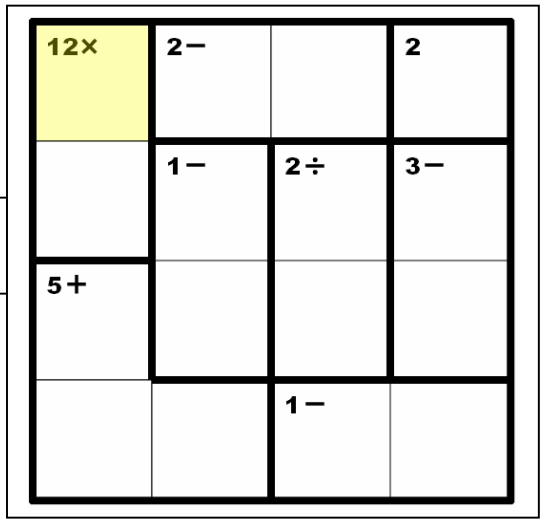


Some simple Bingo rules; a full treatment can be found in our book *Simply Great Math Games*

ACTIVITY B

Bingo

Materials:

- ☒ paper
- ☐ transparency of activity master
- ☐ scientific calculator

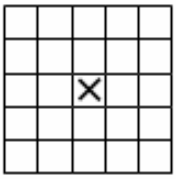
Overview: Here's a motivating way for students to practice the order of operations in a game context. You can create many variations of the game to give you opportunities to drill your students without boring them.

Vocabulary: order of operations, factorial, exponent, numerical expression, square root, greatest integer function

PROCEDURE

Skills:

- Order of operations
- Using exponents
- Using factorials
- Using square roots
- Problem solving



Note:
The ! (exclamation point) is used to denote factorials, and is used as follows:

$1! = 1$

$2! = 1 \cdot 2 = 2$

$3! = 1 \cdot 2 \cdot 3 = 6$

$4! = 1 \cdot 2 \cdot 3 \cdot 4 = 24$

$5! = 1 \cdot 2 \cdot 3 \cdot 4 \cdot 5 = 120$

Notice that factorials grow quite rapidly in size.

1 Have the students copy the game board as shown in the margin. Place the numbers from 1 through 24 randomly in the squares of the game board, and have the students duplicate your arrangement of numbers the first time you play the game. You may also use a transparency of the activity master.

2 The object of the game is to claim five squares in a row, either horizontally, vertically, or diagonally, as in a standard game of bingo. Students may work alone or in pairs.

3 Randomly select three numbers between 1 and 6. This can be done using a regular six-sided die, a spinner, a table of random digits, or a calculator that has a random number generator.

4 Students use the three numbers selected to make a numerical expression that equals one of the numbers on their game board. For example, if the numbers 2, 4,and 5 are selected, then some examples of the numerical expressions that may be formed are:

$1 = 2 + 4 - 5$	$2 = 2 \cdot (5 - 4)$
$3 = 5 - 4 + 2$	$4 = 5 - (\sqrt{4} \div 2)$
$5 = 5 + 2 - \sqrt{4}$	$6 = 5 + (\sqrt{4} \div 2)$
$7 = 5 + (4 \div 2)$	$8 = 2 \cdot 5 - \sqrt{4}$
$9 = 5 + \sqrt{4} + 2$	$10 = 4 \cdot 5 \div 2$
$11 = 2^4 - 5$	$12 = (5 - 2) \cdot 4$
$13 = 2 \cdot 4 + 5$	$14 = 4! - 2 \cdot 5$

5 Students may use the four operations of arithmetic, as well as parentheses, exponents, square roots, and the Greatest Integer Function (see Taking a Closer Look).

6 Students write their numerical expression on their game board to claim their square. You may want to have them write their expressions in ink so they don't change their answers.

6 Play continues until one or more students gets a bingo.

Good Tip!

These drills are a great way to practice order of operations throughout the year. You can create game boards easily. The **Bingo 3** transparency requires the use of 3 numbers, and the **Bingo 4** transparency requires using 4 numbers. You can also change the numbers used in the game board, as well as the choice of random numbers used to form the expressions.

Journal Prompts:

Using the numbers 2, 3, and 6, show a student who was absent how to make an expression that equals 1.
Describe how the Greatest Integer Function works.

Homework:

Using the numbers 2, 5, and 6, find expressions for as many of the numbers from 1 through 24 as you can.

Taking a Closer Look:

You may also wish to introduce the Greatest Integer Function in this game. The Greatest Integer Function provides a way for students to obtain integer answers to expressions that would otherwise be non-integer. The notation is usually written using square brackets [ ]. Here are some examples:

$5 \div 2 = 2.5$, but $[5 \div 2] = 2$	$\sqrt{2} \approx 1.41$, but $[\sqrt{2}] = 1$
$\sqrt{5} \approx 2.24$, but $= [\sqrt{5}] = 2$	$5^3=125$, so $\sqrt{5^3} = \sqrt{125} \approx 11.18$, but $[\sqrt{5^3}] = 11$

Assessment:

Students can give their game boards to another student to check their work. Typing an expression in a scientific calculator is an easy way to check answers.

Bingo

Rules:

1. Place the numbers 1 through 24 in the boxes below. Exchange papers with a neighbor.
2. Randomly select 3 numbers between 1 and 6.
3. Write an expression using these three numbers to form an answer to a number on your game board. Write your expression next to the number on the game board.
4. Repeat steps 2 and 3.
5. Continue until you have claimed 5 boxes in a row.

		X		

ACTIVITY 14

Neighbors

Materials:

- ☒ paper
- ☒ scraps of paper numbered 1-6 or 1-10 and container
- ☐ dice or spinners (appendix)
- ☐ transparency of activity master

Overview: Students will enjoy competing against the teacher in this activity. Once they learn the game, they will enjoy playing it in pairs. For homework, they can explore game strategies and game options to maximize their scores!

Vocabulary: operations

PROCEDURE

Skills:

- Problem solving
- Practicing order of operations

1 Draw the game board on the board as the students copy it on paper. Number six scraps of paper one through six (or ten scraps numbered one through ten) and place them in a bag or other container. You may also use a die or spinner.

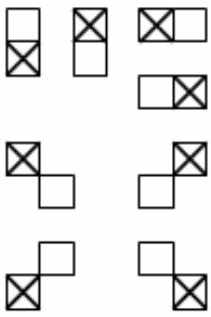
2 Draw three numbers and have the students use them to create a problem that has one of the game board numbers as its answer. They should mark it out with an "x". Their goal is to cover the largest possible answer. For example, if the numbers 1, 2, and 3 are chosen, some problems are:

Note:
3! means 3 x 2 x 1 = 6

$1 + 2 + 3 = 6$ $\qquad$ $(1 + 2) \times 3 = 9$

$3! + (2 + 1)! = 12$ $\qquad$ $(2 + 1)^3 = 27$

3 Repeat step two. This time, the students must cover a number that is adjacent to their previous answer. For example, if the numbers 3, 4, and 5 are chosen next, they could be used to create these problems:



$4! + 3! - 5 = 24 + 6 - 5 = 30 - 5 = \mathbf{25}$

$4! + 5 \times 3 = 24 + 15 = \mathbf{39}$

$^{4!}/_{3} \times 5 = {}^{24}/_{3} \times 5 = 8 \times 5 = \mathbf{40}$

The new answer may be a neighbor vertically, horizontally, or diagonally to their previous answer as shown on the left.

announce the answer they got. The opposing team then decides to "accept" or "reject" the answer. If they believe the answer is legitimate, they say, "Accept", and play resumes with their turn. If they doubt that the team really found a problem with that answer, they say, "Reject". In this case, the first team must show their problem. If they did bluff, they score zero for that round, and play goes to the opposing team. If, however, they did find a way to get that answer, they receive a bonus of a double score. If they said they got a 32, and they did, by surviving the bluff they would get 64 points. Bluffing serves a very useful purpose. It engages the non-playing team. They can't relax and wait for their turn; they must consider all the options possible with the other team's numbers. However, the double-point bonus discourages them from challenging relentlessly.

8. You have three options for ending the game.
   a. Play continues for a specified number of rounds or for a specified time limit.
   b. Play continues until one team reaches a specified score such as 1,000.
   c. Play continues until one team has recorded six neighbors. The other team then gets a 50 point bonus and the highest score wins. This option helps keep a low-scoring team in the game. Their opponent will not want to get their sixth neighbor if it means the other team will win. In this case, they are allowed to create a problem that has an answer that is not a neighbor and add it to their score. They will not want to end the game until they can establish at least a 51-point lead.

9. Be creative in adapting the rules to fit your class. You can increase or decrease the complexity of the game using options described below in "Taking a Closer Look." You can also adjust penalties or bonus points as needed or enforce time limits for moves.

Good Tip!

To increase the difficulty of the game for older students, you may require that the numbers selected must be used in the order in which they were selected.
Another option is to allow numbers to be grouped into multi-digit numbers. If 1, 2, and 3 are selected, students could then create these problems:
12 x 3 = 36
31 x 2 = 62
3! + 21 = 27

Journal Prompts:

If the numbers 3, 5, and 6 are selected, what is the largest score possible? What is the smallest score? Show how you get these scores.
What numbers on the game board are difficult to hit? Why is that true?
What operations tend to give you bigger answers? Is this always true?

Neighbors

1	2	3	4	5	6	7	8
36	39	40	42	44	45	48	9
35	84	85	88	90	92	50	10
33	80	128	132	135	96	52	11
32	75	120	144	140	100	54	12
30	72	115	110	108	105	55	14
28	70	66	65	64	63	60	15
27	25	24	22	21	20	18	16

Hoppy

Put two markers of type ***X*** on their places, and two markers of type ***Y*** on their places. Your goal is to exchange their places with the fewest number of moves. These moves are permitted:

- Sliding a marker onto an open space next to it.
- Jumping a marker over a single marker next to it, as long as you land on an empty space.

X	X		Y	Y

You can also play the game with more squares: Can you predict how many moves it will take?

X	X	X		Y	Y	Y

X	X	X	X		Y	Y	Y	Y

Backwards Math

Name_____

Here are the answers to one hundred math problems. Use four 4's to create problems that will give these answers. Remember to use the correct order of operations to solve your problems: Parentheses, Exponents, Multiply or Divide, Add or Subtract.

1 = _____
2 = _____
3 = _____
4 = _____
5 = _____
6 = _____
7 = _____
8 = _____
9 = _____
10 = _____
11 = _____
12 = _____
13 = _____
14 = _____
15 = _____
16 = _____
17 = _____
18 = _____
19 = _____
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22 = _____
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32 = _____
33 = _____
34 = _____
35 = _____
36 = _____
37 = _____
38 = _____
39 = _____
40 = _____
41 = _____
42 = _____
43 = _____
44 = _____
45 = _____
46 = _____
47 = _____
48 = _____
49 = _____
50 = _____

Name _____ Per ____

Number Yoga Quiz

Using each of the digits 2, 3, 4, 5 exactly once, create expressions equaling:

1 =

2 =

3 =

4 =

5 =

6 =

7 =

8 =

9 =

10 =

Name _____ Per ____

Number Yoga Quiz

Using each of the digits 2, 3, 4, 6 exactly once, create expressions equaling:

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6 =

7 =

8 =

9 =

10 =

Name _____ Per ____

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Using each of the digits _____ exactly once, create expressions equaling:

1 =

2 =

3 =

4 =

5 =

6 =

7 =

8 =

9 =

10 =

Name _____ Per ____

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8 =

9 =

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