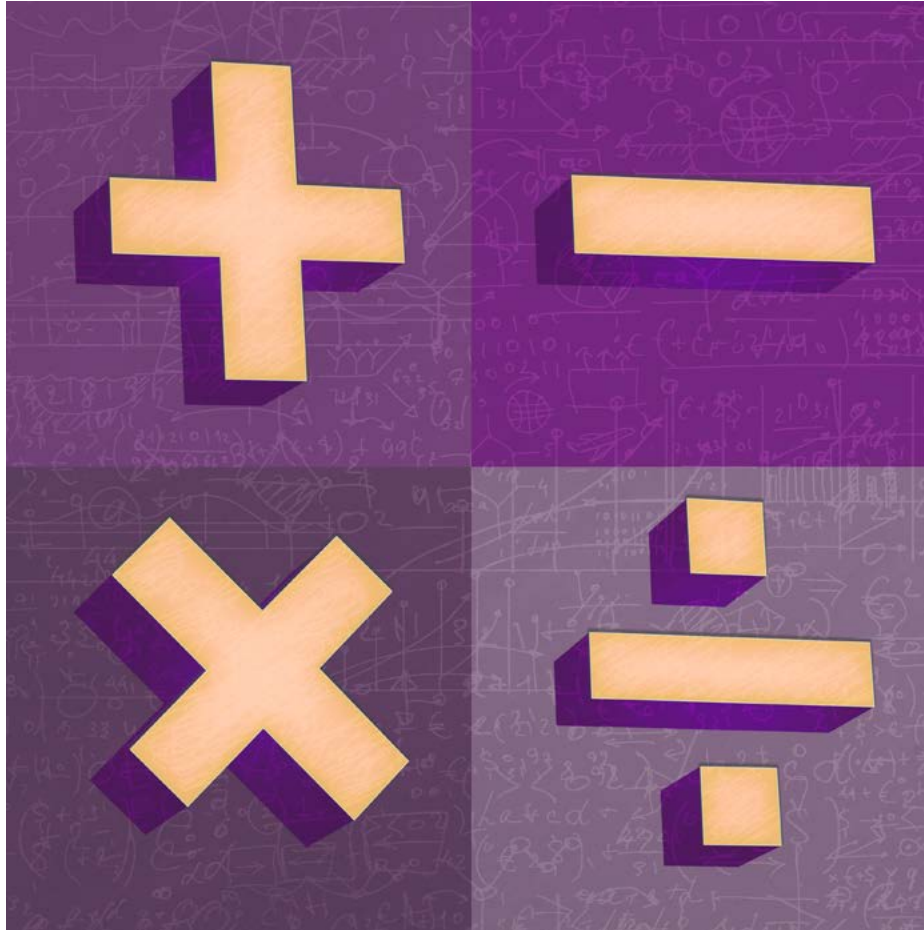


USING ORDER OF OPERATIONS TO EVALUATE NUMERICAL EXPRESSIONS

Volume 32

Developed with Kristin Hotter

Grade 5



TIME

45-60 minutes

CONTENT

As a class, you will practice solving problems that involve students using the correct order of operations. Together, you will then investigate how adding parentheses to different areas of given problems can change the final answer. Finally, students will play a game that practices order of operations using parentheses. The goal of each round of the game is to have a greater answer than your opponent.

OBJECTIVES

Students will be able to:

- Solve expressions using the order of operations
- Compare numerical expressions when parentheses have been added
- Hypothesize how parentheses can have the greatest effect on a given numerical expression

COMMON CORE STATE STANDARDS

CCSS.Math.Content.5.OA.A.1 — Use parentheses, brackets, or braces in numerical expressions, and evaluate expressions with these symbols.

INTRODUCTION

(Distribute Activity Sheet)

PRIOR TO THE ACTIVITY

Students should have a firm grasp of order of operations. They should be able to solve problems like the ones at the top of the Activity Sheet independently. Take a look at the Activity Sheet now. You'll notice that each bank of questions is exactly the same. We did not make a mistake. Each of those problems will be altered during your lesson to show students how the addition of parentheses can change an answer.

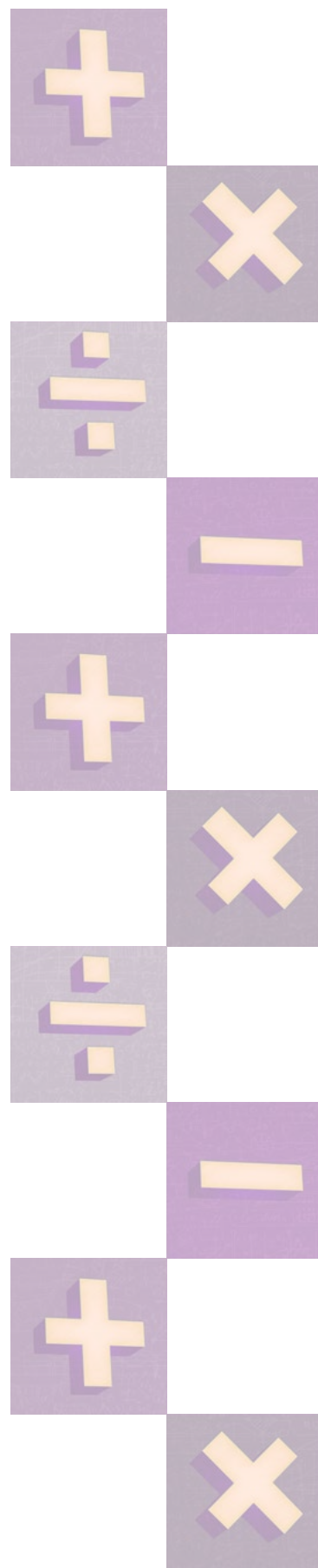
ACTIVITY I

Problem 1: $(30 + 8 \times 4 - 2 = \underline{\quad})$

1. Ask students to turn and talk with a partner about how to go about solving problem 1 $(30 + 8 \times 4 - 2 = \underline{\quad})$ on the Activity Sheet. (Give 2-3 minutes to discuss. Circulate as students discuss and take note of the conversations and conclusions students come to as they investigate the problem. Reconvene the whole group.)
2. What is the answer to this problem? (Ask students if other groups got other answers. Write all answers that groups come up with on the board. You will likely get multiple answers to the problem.)
3. I notice that we have a little disagreement about how to solve this problem. Let's see if we can work it out together.
 - I notice that this problem asks me to perform three different operations: addition, multiplication, and subtraction.
 - I remember when problems have multiple operations there is a special order I need to follow.
4. What do you remember about order of operations? (Students should be able to tell you that multiplication and division are performed first. Addition and subtraction are done after all multiplication and division are completed.)
5. I notice this problem has both multiplication and division. Which operation do I perform first? (The multiplication because it is the first to come up when reading the expression left to right.)
 - What is 8×4 ? (32)
 - (Rewrite the problem to read: $30 + 32 - 2$)
6. Now I'm left with addition and subtraction. Which operation do I perform next? (Addition because when left with just addition and subtraction you solve from left to right.)
 - What is $30 + 32$ (62)
 - (Rewrite the problem to read: $62 - 2$)
7. What is the answer to this problem? (60)

Problem 2: $(6 \times 5 + 3 \times 12 - 12 = \underline{\quad})$

1. Let's look at problem 2 as a whole group. $6 \times 5 + 3 \times 12 - 11 = \underline{\quad}$
2. What do you notice about this problem? (I notice there is multiplication, addition, more multiplication, and subtraction.)
3. Which part of the problem should be solved first? (6×5 which equals 30)
 - (Rewrite the problem to read: $30 + 3 \times 12 - 11$)
4. Which part of the problem should be solved next? (3×12 which equals 36)
 - (Rewrite the problem to read: $30 + 36 - 11$)
5. Which part of the problem should be solved next? ($30 + 36$ which equals 66)
 - (Rewrite the problem to read $66 - 11$)
6. What is the answer to this problem? (55)



Problems 3–6:

1. Take a few minutes to solve problems 3-6 on your own.
 - (Circulate to ensure students are going through each problem in the correct step by step order.)
2. Use the same line of questioning as above as you go through problems 3-6. The answers to the problems are:
 3. 34
 4. 54
 5. 72
 6. 38

ACTIVITY II: WHAT IF? AND MORE WHAT IF'S

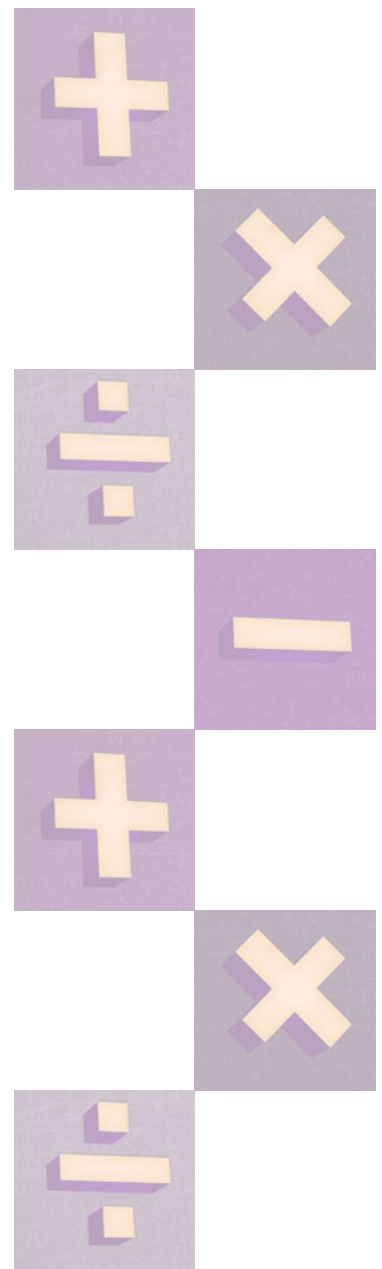
Now that we have a firm grasp on order of operations let's twist things up a little bit. You and your partner solved **Problem 1** together a few minutes ago. Look at the second set of problems under the heading "What If."

What If Problem 1:

1. Look at What If Problem 1. What do you notice about it? (It's exactly the same as problem 1 at the top.)
 - We're going to change the problem a little bit right now. (Put parentheses around $4 \div 2$. The new problem reads $30 + 8 \times (4 - 2) =$)
 - You'll notice I put a pair of parentheses around a particular section of the problem. Think back to the acronym PEMDAS. What do the parentheses mean? (When you put parentheses around a section of a problem, that section needs to be solved first.)
 - The original answer to the problem was 60. Let's see if the answer changes at all with the parentheses.
2. What is $4 - 2$? (2)
 - (Rewrite the problem to read $30 + 8 \times 2$.)
3. The problem contains addition and multiplication, which operation should be performed next?
 - (Multiplication; 8×2 equals 16)
 - (Rewrite the problem to read $30 + 16$)
4. What's the answer to the problem? (46)
5. Did the parentheses change the problem? (Yes, because the original answer was 60. The answer now is 46.)

More What Ifs Problem 1:

1. Look down at the third section of your activity sheet where you see the heading "More What Ifs." You'll notice the same problem again.
 - Let's change the problem again. (Put parentheses around $30 + 8$. The new problem reads $(30 + 8) \times 4 - 2 =$)
2. What do we need to do first for this problem? (Add 30 and 8 which equals 38)
 - (Rewrite the problem to read $38 \times 4 - 2$)
3. The problem contains multiplication and subtraction, which operation should be performed next? (Multiplication)
4. How do you know? (If there are no parentheses, multiplication is always performed before subtraction.)
5. What is 38×4 ? (152)
 - (Rewrite the problem to read $152 - 2$)
6. What is the answer to the problem? (150)



ACTIVITIES I AND II SUMMARY

Parentheses play an important role in problems. We solved the same problem three different times. The first time we didn't have any parentheses. The second and third times we solved, we moved the parentheses to different parts of the problem. Each time we solved, we got a different answer to the problem.

CHECK FOR UNDERSTANDING

Repeat the steps above for Problem 2, working through the original, the What If and the More What If versions.

Problem 2

Take a look at problem 2. When we solved it without any parentheses, the answer was 55.

Move down to the “What If” section. Find problem 2 and let’s put parentheses around 12 - 11.

New problem: $6 \times 5 + 3 \times (12 - 11)$

- What do we need to do first? ($12 - 11$ which equals 1)
- How do I rewrite the problem? ($6 \times 5 + 3 \times 1$)
- Which part of the problem gets solved next? (6×5 which equals 30)
- How do I rewrite the problem? ($30 + 3 \times 1$)
- Which part of the problem gets solved next? (3×1 which equals 3)
- How do I rewrite the problem? ($30 + 3$)
- What is the answer to the problem? (33)

When we solved with no parentheses we got 55. This time we got 33 as the answer.

Move down to “More What Ifs” and put parentheses around $5 + 3$ in problem 2.

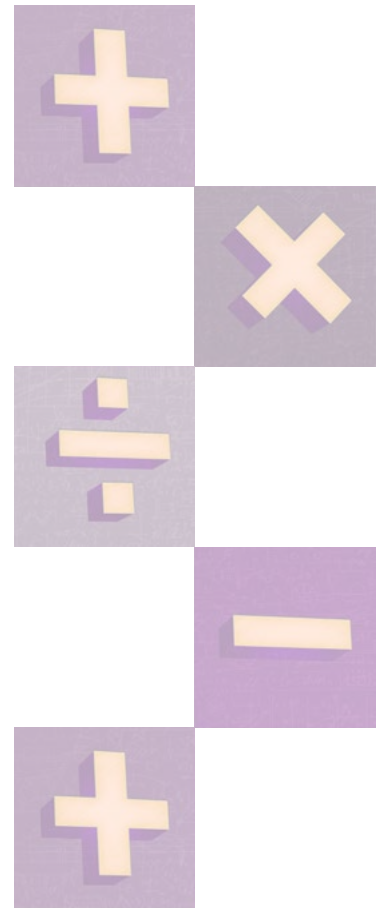
New Problem: $6 \times (5 + 3) \times 12 - 11$

- What do we need to do first? ($5 + 3$ which equals 8)
- How do I rewrite the problem? ($6 \times 8 \times 12 - 11$)
- Which part of the problem gets solved next? (6×8 which equals 48)
- How do I rewrite the problem? ($48 \times 12 - 11$)
- Which part of the problem gets solved next? (48×12 which equals 576)
- How do I rewrite the problem? ($576 - 11$)
- What is the answer to the problem? (565)

The parentheses really changed the problem on this one.

Our answers ranged from 33 to 55 to 565.

(Students will complete problems 3-6 as additional practice either at the end of the lesson or as homework. Students can choose where they want to place the parentheses in each of the problems. You can also decide to tell student where to place the parentheses in each of the provided problems.)



MATERIALS

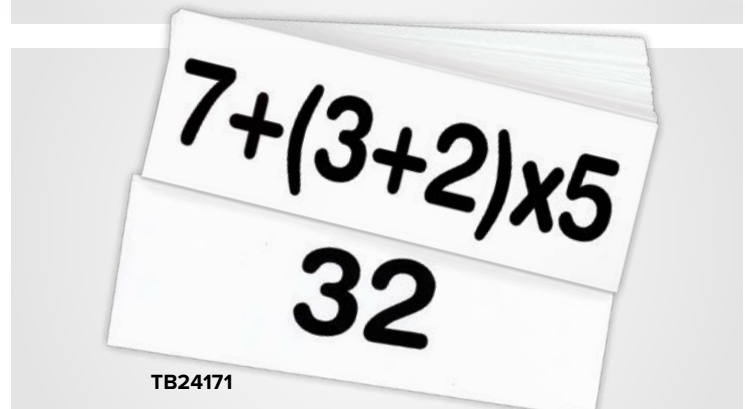
Included Activity Sheet and Game Cards

ADDITIONAL OPTIONAL MATERIALS

TB27200 Algebraic Expressions and Equations Dominoes

TB26596 Order of Operations Flash Cards

TB24171 Order of Operations Flash Cards - Pre-Algebra



ACTIVITY III: GAME

To gain additional practice, students can partner up to play the following game.

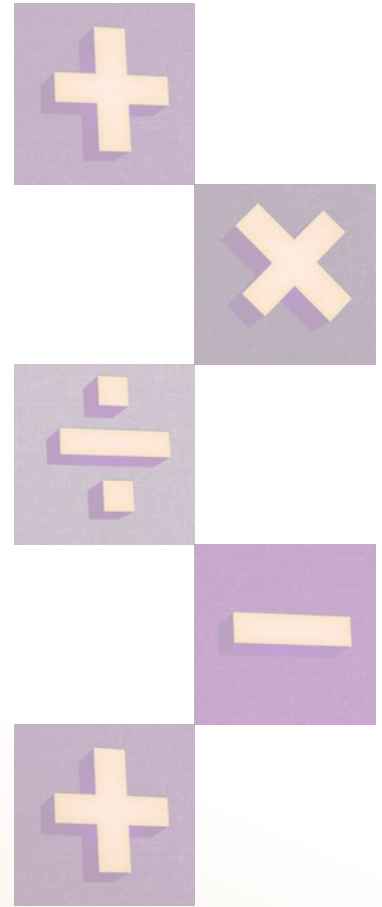
1. Students will work in pairs. Give each student a set of game cards. Have students cut out their set of game cards.
2. Call out a game card number. Give students 30-45 seconds to add a set of parentheses somewhere in the expression.
3. When time is called, students will work with their partners to solve both new expressions.
4. The partner who created an expression with the greater answer gets both game cards. If both partners have the same answer, each player gets his own card. The partner with more game cards at the end of play wins.

Example Using Card 1:

Player 1 put the parentheses around (3 + 10): New Problem: $(3 + 10) \times 2 + 7$.
The answer to this problem is 33.

Player 2 put the parentheses around (2 + 7): New Problem: $3 + 10 \times (2 + 7)$.
The answer to this problem is 93.

Player 2 wins the round and gets a point.



INTERVENTION

- Limit problems to only two operations, either multiplication or division and either addition or subtraction.
- Check out these videos that help students remember the order of operations rules.

<https://www.youtube.com/watch?v=BdgcItiemoY>

<https://www.youtube.com/watch?v=ZzeDWFhYv3E>



The Order of Operations Song (PEMDAS)
Silly School Songs



Order of Operations Song
PEMDAS Rap for 5th Grade and Up

Nasco
education

1.800.558.9595

NascoEducation.com

Lesson Plans are developed with teachers with no claim of original authorship.

Card 1: $3 + 10 \times 2 + 7$	Card 2: $15 - 4 + 3 \times 6 \div 2$	Card 3: $25 \div 5 + 20 \times 10 + 3$	Card 4: $8 \times 6 + 2 \times 7$
Card 5: $9 + 6 \times 4 + 12 \div 4$	Card 6: $24 \div 3 + 5 \times 4 + 6$	Card 7: $17 - 4 + 6 \times 5 - 3$	Card 8: $19 - 20 \div 5 - 2 \times 11$
Card 9: $64 - 4 \times 2 + 18 \div 3$	Card 10: $100 \div 20 \div 5 \times 6 + 11$	Card 11: $120 - 11 \times 6 + 15 \div 5$	Card 12: $32 - 8 \times 4 \div 2 \times 2$

Use your knowledge of orders of operations to solve the following problems.

$30 + 8 \times 4 - 2 = \underline{\quad}$	$6 \times 5 + 3 \times 12 - 11 = \underline{\quad}$	$51 - 2 \times 10 + 3 = \underline{\quad}$
$16 + 64 \div 2 + 6 = \underline{\quad}$	$9 \times 3 + 9 \times 5 = \underline{\quad}$	$40 + 32 \div 8 - 6 = \underline{\quad}$

What If?

$30 + 8 \times 4 - 2 = \underline{\quad}$	$6 \times 5 + 3 \times 12 - 11 = \underline{\quad}$	$51 - 2 \times 10 + 3 = \underline{\quad}$
$16 + 64 \div 2 + 6 = \underline{\quad}$	$9 \times 3 + 9 \times 5 + 3 = \underline{\quad}$	$40 + 32 \div 8 - 6 = \underline{\quad}$

More What Ifs?

$30 + 8 \times 4 - 2 = \underline{\quad}$	$6 \times 5 + 3 \times 12 - 11 = \underline{\quad}$	$51 - 2 \times 10 + 3 = \underline{\quad}$
$16 + 64 \div 2 + 6 = \underline{\quad}$	$9 \times 3 + 9 \times 5 + 3 = \underline{\quad}$	$40 + 32 \div 8 - 6 = \underline{\quad}$

Use your knowledge of orders of operations to solve the following problems.

$30 + 8 \times 4 - 2 = \underline{\quad}$ $30 + 32 - 2$ $62 - 2$ 60	$6 \times 5 + 3 \times 12 - 11 = \underline{\quad}$ $30 + 3 \times 12 - 11$ $30 + 36 - 11$ $66 - 11$ 55	$51 - 2 \times 10 + 3 = \underline{\quad}$ $51 - 20 + 3$ $31 + 3$ 34
$16 + 64 \div 2 + 6 = \underline{\quad}$ $16 + 32 + 6$ $48 + 6$ 54	$9 \times 3 + 9 \times 5 = \underline{\quad}$ $27 + 9 \times 5$ $27 + 45$ 72	$40 + 32 \div 8 - 6 = \underline{\quad}$ $40 + 4 - 6$ $44 - 6$ 38

What If? Sample Answers

$30 + 8 \times (4 - 2) = \underline{\quad}$ $30 + 8 \times 2$ $30 + 16$ 46	$6 \times 5 + 3 \times (12 - 11) = \underline{\quad}$ $6 \times 5 + 3 \times 1$ $30 + 3$ 33	$51 - 2 \times (10 + 3) = \underline{\quad}$ $51 - 2 \times 13$ $51 - 26$ 25
$16 + 64 \div (2 + 6) = \underline{\quad}$ $16 + 64 \div 8$ $16 + 8$ 24	$9 \times (3 + 9) \times 5 + 3 = \underline{\quad}$ $9 \times 12 \times 5 + 3$ $108 \times 5 + 3$ $540 + 3$ 543	$40 + 32 \div (8 - 6) = \underline{\quad}$ $40 + 32 \div 2$ $40 + 16$ 56

More What Ifs? Sample Answers

$(30 + 8) \times 4 - 2 = \underline{\quad}$ $38 \times 4 - 2$ $152 - 2$ 150	$6 \times (5 + 3) \times 12 - 11 = \underline{\quad}$ $6 \times 8 \times 12 - 11$ $48 \times 12 - 11$ $576 - 11$ 565	$(51 - 2) \times 10 + 3 = \underline{\quad}$ $49 \times 10 + 3$ $490 + 3$ 493
$(16 + 64) \div 2 + 6 = \underline{\quad}$ $80 \div 2 + 6$ $40 + 6$ 46	$9 \times 3 + 9 \times (5 + 3) = \underline{\quad}$ $9 \times 3 + 9 \times 8$ $27 + 72$ 99	$(40 + 32) \div 8 - 6 = \underline{\quad}$ $72 \div 8 - 6$ $9 - 6$ 3