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MATHEMATICS

Grade 6

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Lesson 3: Order of Operations with Exponents

Focus Standard(s): 6.EE.2

Additional Standard(s): 6.EE.1, 6.EE.3

Standards for Mathematical Practice: SMP.2, SMP.3, SMP.4, SMP.7

Estimated Time: 60 minutes

Materials and Resources:

- Chart paper
- White boards-1 per student
- Dry erase markers-1 per student
- Markers
- Copy paper for Exponent Vocabulary 6-Door Foldable or vocabulary notebook
- Index cards
- Handout 3.1: Watch Out for Parentheses Task
- Order of Operations Expressions Game: http://www.shodor.org/interactivate/activities/OrderOfOperationsFou/
- My Favorite No: https://www.teachingchannel.org/videos/class-warm-up-routine
- Watch Out for Parentheses Task: https://www.illustrativemathematics.org/content-standards/tasks/1136

Learning Target(s):

- Students will evaluate numerical expressions involving whole-number exponents.
- Students will use order of operations to solve numerical expressions involving whole numbers.
- Students will evaluate the placement of parentheses in numerical expressions as they affect the value of the expression.

Guiding Question(s):

- Why do we need a specific order to solve numerical expressions?
- What are the steps in the order of operations?
- Does the placement of parentheses in an expression affect the value of the expression?

Vocabulary

Academic Vocabulary:	Instructional Strategies for Academic Vocabulary:
• Evaluate • Exponent • Numeric expression • Order of operations	☐ Introduce words in a mathematical context. ☐ Model how to use the words in discussion. ☐ Read and discuss the meaning of word in a mathematical context

Symbol	Type of Text and Interpretation of Symbol
	Instructional support and/or extension suggestions for students who are EL, have disabilities, or perform well below the grade level and/or for students who perform well above grade level.
✓	Assessment (Pre-assessment, Formative, Self, or Summative)

Instructional Plan

Understanding Lesson Purpose and Student Outcomes: Students will be introduced to simplifying expressions with exponents using the order of operations.

Anticipatory Set/Introduction to the Lesson:
Display the following on the board before students arrive:
Sam and Julio both found the value of the expression $3 + 6^2$.

Sam:	$3 + 6^2$	Julio:	$3 + 6^2$
	9^2		$3 + 36$
	81		39

Ask students who is correct, Sam or Julio? Let students discuss their answers and conclude who is correct by comparing the work of Sam and Julio (SMP.3).

Activity 1: Order of Operations

Introduce new vocabulary words and have students create a vocabulary foldable (see lesson 2, activity 1 for instructions) or record new vocabulary words in their vocabulary notebook.

- Evaluate: to find the value of an algebraic expression by replacing variables with numbers.
- Order of Operations: the rules that tell which operation to perform first when more than one operation is used (see above).

T: If we want to solve $3+2^5-4\div 2$ using the order of operations, when do you think we need to evaluate the 2^5?"

Note: Students should make the connection that exponents must be evaluated before adding and subtracting because students multiply to find the value of the number with an exponent.

T: An exponent applies to its immediate base. How would you evaluate 2^5? (2 x 2 x 2 x 2 x 2 = 32)

Note: A misconception students have about exponents is that they multiply the base times the exponent (2x5). Remind students that the exponent indicates how many times the base is used as a factor in a repeated multiplication problem.

Display:

Example 1: $2+5^3$

Example 2: $(2+5)^3$

T: Do you think these two expressions have the same value? Why or why not? Turn and Talk to your partner to respond.

✓ Have students work with partners to discuss the differences in the two examples, evaluate the expressions, and decide on an answer (SMP.2).

Demonstrate how to solve each example and answer any questions. Present additional examples to clarify student understanding. Allow students to use response boards to display answers.

Note: Teachers often refer to the saying "Please Excuse My Dear Aunt Sally" when teaching order of operations. It is risky to use this phrase because students will look at it as a six-step process, when really it is only four steps.

Tell students the following order is preferred over the expression Please Excuse My Dear Aunt Sally:

1. Grouping symbols (parentheses), [brackets], {braces} – from the inside out
2. Exponents
3. Multiplication and division – from left to right in the order they appear
4. Addition and subtraction – from left to right in the order they appear

Create an anchor chart for the order of operations as it appears above and have students copy the order of operations in their math notebook. Write the following on the anchor chart:

$2+ (3-1) \times 3^2$

Demonstrate how to evaluate the expression following the order of operations:

Numerical Expression	$2+ (3-1) \times 3^2$
Step 1: $(3 - 1) = 2$	$2 + 2 \times 3^2$
Step 2: $3^2 = 9$	$2 + 2 \times 9$
Step 3: $2 \times 9 = 18$	$2 + 18$
Step 4: $2 + 18 = 20$	20

The value of the expression $2+ (3-1) \times 3^2$ is 20.

Note: A common mistake would be to add 2 + 2 before multiplying 2 x 9.

T: Would we get the same value if we do the addition before the multiplication?
What value would we get if we did the addition first? (36)
Why is it important to have an order of operations? (answers will vary)

Write the following on the board: $[8(4 - 1) + 2] + 3^3 \div 3$. Explain that since there are brackets with multiple computations, we must use the order of operations within the brackets first. Demonstrate how to evaluate the expression following the order of operations:

Numerical Expression	$[8(4 - 1) + 2] + 3^3 \div 3$
Step 1: $(4 - 1) = 3$	$[8(3) + 2] + 3^3 \div 3$
Step 2: $8(3) = 24$	$[24 + 2] + 3^3 \div 3$
Step 3: $[24+2] = 26$	$26 + 3^3 \div 3$
Step 4: $3^3 = 27$	$26 + 27 \div 3$
Step 5: $27 \div 3 = 9$	$26 + 9$
Step 6: $26 + 9 = 35$	35

The value of the numerical expression $[8(4 - 1) + 2] + 3^3 \div 3$ is 35.

Activity 2: Parentheses in Expressions – "My Favorite No"

Note: To prepare for this activity, watch a video that demonstrates My Favorite No being used.

Distribute index cards or half sheets of paper. Display this expression: $46 – (26 - 2 + 8) \div 2^3 \times 3$. Give students 5 minutes to evaluate the expression. Instruct students to show each step of their calculations.

- ✓ At the end of the time collect the students' work being careful not to reveal the students' names. Go through the cards identifying those that have the work done correctly as "Yes" and those that have errors as "No". Look for misconceptions (these will be called "My favorite no") such as the following:
  - Adding 2 + 8 before you subtract 2 from 26
  - Exponent: Multiplying 2 x 3 instead of 2x2x2
  - Subtracting 24 from 46 before adding 8
  - Subtracting 32 from 46 before doing exponents then division and multiplication
  - Multiplying before dividing
  - Not understanding that the last operation they will do is subtracting from 46.

Select one card solved using a misconception to be your "Favorite No." Copy the incorrect work for the problem on the board without changing it. Facilitate an open discussion about why the work is not correct. If a student says the work or answer you displayed is incorrect, have them offer a reason why it is incorrect and have them tell how they would correct it (SMP.3).

For students who are EL, have disabilities, or perform well below the grade-level:

- Supply students with multiplication charts to assist with applying the operations.

Note: If time allows, show more than one misconception.

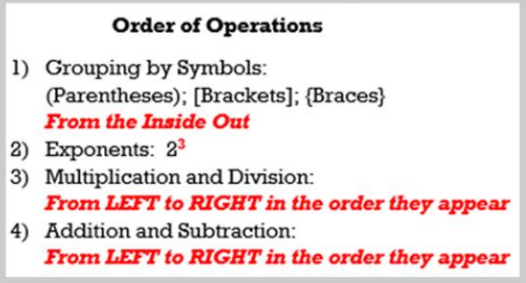
Activity 3: Watch Out for Parentheses

Distribute **Handout 3.1: Watch Out for Parentheses Task.** Instruct students to work independently to evaluate each expression and explain if any parentheses can be removed from the expressions without changing the values. Tell students to discuss their answers with their elbow buddy and critique their responses (SMP.3). Put students in groups to create a poster displaying their work for finding the value of each numerical expression and their answer and justification for the question (SMP.4). Tell students they will use the posters for a Gallery Walk in tomorrow's lesson.

Note: Students should be able to recognize the structure of the expressions and understand the purpose of the parentheses (SMP.7).

For students who are EL, have disabilities, or perform well below the grade-level:

- Students will use an order of operations card during the activity.



Extensions for students with high interest or working above grade level:

- Allow students to play an Order of Operations Expressions Game if they finish their work early. This game can be used as an enrichment tool in this lesson for the students who have a strong foundation in the skill and can move forward. The game can also be used to differentiate presentation of the lesson. Before students begin the activity, set it up to your specifications.

Reflection and Closing:

✓ Review Activity 3 with the class using prompting questions.
Prompting Questions:

- Does moving the parentheses in a numerical expression change the value of the expression?
- Why is it important to have a standard order for evaluating numerical expressions?
- What is the Order of Operations?

✓ Distribute 2 index cards to each student. Instruct students to create 2 numerical expressions with multiple operations using parentheses and exponents. Instruct students to write each expression on a separate index card and write their name on the card. Tell students to exchange one card with a Crosstown Companion and then exchange the other card with a different Crosstown Companion.

Homework
✓ On the index cards students received from their two crosstown companions, have students find the value of the 2 numerical expressions showing all the steps they used to solve the expression on the card. Have students write their name on the card.

Handout 3.1: Watch Out for Parentheses Task

Name: _____ Date: _____

Evaluate the following expressions.

A. $2[5 + (3)(2) + 4]$

B. $2[(5 + 3)(2+4)]$

C. $2[5 + 3(2 + 4)]$

Can the parentheses in any of these expressions be removed without changing the value the expression? Justify your answer with words and/or calculations.

_____

_____

_____

_____

Retrieved from: https://www.illustrativemathematics.org/content-standards/tasks/1136

Handout 3.1: Watch Out for Parentheses Task - Key

Solution

a. 2(5+(3)(2)+4). We may evaluate this expression in two ways:

Distributing the lead constant first:

$2 \cdot 5 + 2 \cdot 3 \cdot 2 + 2 \cdot 4 = 10 + 12 + 8 = 30$

or distributing the lead constant last:

$2(5 + 6 + 4) = 2 \cdot 15 = 30.$

Either way, we should first multiply (3)(2) = 6 before adding any of the terms. The parentheses in the middle are not necessary. Instead of writing (3)(2) we can say $3 \cdot 2$.

b. Notice that in the expression 2((5+3)(2+4)), the outer set of parentheses are not necessary:

$2((5 + 3)(2 + 4)) = 2(5 + 3)(2 + 4).$

The other parentheses are necessary since they indicate that we should first perform the additions inside these parentheses:

$2(5 + 3)(2 + 4) = 2(8)(6) = 96.$

c. In this expression, we complete the operations from the inside out. The inner most addition must occur first, then the inner multiplication, then the secondary addition and finally the outer multiplication:

For training or questions regarding this unit,
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