Simplify Numerical Expressions – Order of Operations

STRAND: Computation and Estimation

STRAND CONCEPT: Rational Number Estimation and Operations

SOL 6.6c

Remediation Plan Summary

Students will explore order of operations, using the area of rectangles. Application of order of operations through simplifying numerical expressions is included. Some of this lesson extends beyond the parameters of grade 6, but allows for development of concepts needed to have a deeper understanding of the underlying skills needed to evaluate expressions in grades 7 and 8.

Common Misconceptions

Students incorrectly simplify the expression by working from left to right instead of using the order of operations.

Materials

Simplifying Expressions practice

Introductory Activity

Review with students the process of finding the area of a rectangle. Display three rectangles with the dimensions (9" x 4", 9" x 5", and 9" x 9"). Ask students to find the area of the two smaller rectangles. *Explain how you found the total area of the two rectangles.* Students may benefit from using tiles or graph paper to help them have a concrete model. Students should recognize that the most direct way is by finding the area of each of the smaller rectangles is by multiplying the length times the width. Have the students find the area of the larger rectangle. What do you notice about the area of the two smaller rectangles and the area of the larger rectangle? Guide students to discover that adding the areas of the two smaller rectangles will result in the area of the larger rectangle, e.g., 9 • 4 = 36; 9 • 5 = 45; 36 + 45 = 81.

Plan for Instruction

1. Put the following problem on the board: 4 + 3 • 2. Have students simplify the expression and then share their answer with a partner. Ask the students to share their answers whole group and explain how they found that answer. Keep a list of the responses. If students simplified to get 14, they may have added 4 and 3 to get 7, then multiplied by 2 get 14. Students who arrived at an answer of 10 by first multiplying 3 and 2 to get 6 and then finding the sum of 4 and 6 to get 10 would have some prior understanding of order of operations. Discuss with the students why using these two different procedures would give such different answers and the need for having an agreement in mathematics (an order) to which operations are performed in which order.
2. Have students write an expression to model the process they used in the warm-up to find the total area of the two small rectangles. Students should write one of the following expressions: $9 \cdot 4 + 9 \cdot 5$ or $4 \cdot 9 + 5 \cdot 9$. Select one of these

expressions, and use it to model the two procedures used in the warm-up: (1) doing operations left to right and (2) doing multiplication first and then doing addition.

3. Have students work in pairs to construct an explanation of why they used the method they did when finding the area of two rectangles. Allow plenty of time for discussion.
4. Allow pairs time to present their explanations. At the end, summarize the discussion by asking students which method they think is algebraically correct. Explain that mathematicians have agreed upon a set of rules when simplifying expressions so that everyone gets the same answer instead of multiple answers. Have the students write a rule, based on the discussion, for simplifying expressions that involve multiplication and addition. The rule should include something like, "A*ll multiplication must be done before any addition."* Close the discussion by agreeing that doing multiplication first and then doing addition was the correct method to use in the introductory activity.
5. Have the students write an expression to find the total area of all three rectangles from the warm-up (e.g., $9 \cdot 4 + 9 \cdot 5 + 9 \cdot 9$), and have students use their rule to simplify the expression.
6. Next, have students work in pairs to see if there is another way to solve their original warm-up problem of finding the area of two triangles. Since the rectangles have one dimension the same, they could be put next to each other to create one big rectangle. For example, the 9 x 4 and 9 x 5 rectangles together create a 9 x 9 rectangle with an area of 81. Have students write an expression that models the above approach. One algebraic expression could be $9 \cdot (4 + 5)$. *How would you simplify this expression?* Ask students to explain their process and hopefully they will say something similar to: "To simplify this expression, explain that 4 and 5 need to be added first and then the sum multiplied by 9 to get 81." Have students write a rule for simplifying expressions that involve parentheses and multiplication. The rule should include something like, "A*ll expressions inside of parentheses must be simplified before any multiplication."*
7. Display the expression, $3^2 + 5$. Have a student read the expression and then ask students to simplify it. *How did you solve this expression?* Ask students to explain their process and hopefully they will say something similar to: "A*ll exponents must be simplified before any addition."*
8. Have the class write an expression that combines exponents, parentheses, multiplication and addition as a group. Ask a few of the students to share their solutions with the class. Have students explain their process to solve the expression. Have students write a rule for simplifying expressions that involve exponents, parentheses, multiplication, and addition. The rule should say something similar to: "W*hen simplifying, expressions inside parentheses must be simplified first, then all exponents must be simplified, then all multiplication is done, and, finally, all addition is done."* Explain that these steps also include division with multiplication and subtraction with addition. Have students add to their steps something similar to: *Multiplication and division must be done from left to right first, and then addition and subtraction is done from left to right.* Explain to students that they have developed a set of steps called the ***order of operations***.

9. Ask the class create to help you develop a complete "order of operations" rule similar to the following:

> *When simplifying, do all expressions inside parentheses first, then all exponents, then all multiplication and division operations from left to right, and finally all addition and subtraction operations from left to right.*

It might be helpful for students to see how to organize the order of operations in a numbered list of steps, as shown below:

> 1. *Do any work within parentheses ( ) or other grouping symbols [ ] first.*
> 2. *Do any work with exponents (powers) or roots.*
> 3. *Do any multiplication and division in order from left to right.*
> 4. *Do any addition and subtraction in order from left to right.*

Post the class order of operations rule in the classroom for student reference.

10. Have students create two expressions, each containing parentheses, exponents, and all operations. On a separate sheet of paper, have them simplify their expressions, showing each step in the order of operations and the final answer. Have them exchange their problems with a partner, simplify each other's expressions, and discuss the problems until agreement is reached on the correct order of operations and final answer.
11. Distribute the "Simplifying Expressions" practice worksheet and have students work through the problems identifying their steps. Once the class is done, go over the answers and discuss any misconceptions.

Pulling It All Together (Reflection)

Exit Ticket: Explain to an absent student the steps you would use to simplify an expression and why the order of the steps is important.

Note: The following pages are intended for classroom use for students as a visual aid to learning.

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Name:

Simplifying Expressions

Simplify each expression, showing each step in the order of operations. To the right of each step, identify the step as parentheses, exponents, multiplication, division, addition, or subtraction.

Example

$(4 + 5) \bullet 4 - 3^2 + 9(2)$

$9 \bullet 4 - 3^2 + 9(2)$	parentheses—addition
$9 \bullet 4 - 9 + 9(2)$	exponents
$36 - 9 + 18$	multiplication, left to right
$27 + 18$	subtraction, left to right
45	addition

1. $9 - 2^3$

2. $72 - (7 + 8) \bullet 4$

3. $64 - 4 \bullet 2^3 + 7$

4. $3 + 7(2^3 - 6)^2$