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# Exploration: Order of Operations (4) <br> $a * b+c \div d$ and $a(b+c) \div d$ 

## Part I.

1. What operation does the asterisk (*) represent in mathematics? List other symbols that have the same meaning.
2. Why do we use parenthesis in mathematics? What purpose do they serve? Explain your reasoning.
3. What operation does a number right next to the parenthesis mean?
4. Launch the Order of Operations (4) Applet.
a. Use the sliders to change the values of each variable.

Set the slider values so $\mathrm{a}=1, \mathrm{~b}=2, \mathrm{c}=4$, and $\mathrm{d}=2$.
b. All check boxes should be checked and both sides have lines hidden such as below:

c. Predict the solution for each of the two expressions provided in the table above.
d. Are these two expressions equivalent? Explain your thinking.
e. Uncover the left side by clicking on the checkbox below the left side. Check your prediction against the solution provided. How did your prediction compare?
f. Uncover the right side by clicking on the checkbox below the right side. Check your prediction against the solution provided. How did your prediction compare?

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5. Uncheck the last three boxes on each side. Set the sliders so $a=1, b=2, c=1$, and $d=1$.
a. Check the "Cover right side" checkbox.

Fill in the table below and predict the solutions for each side.

b. Check your predictions by selecting the boxes on the left of the table.

Compare your prediction for the left side with the solution provided.
What was the first operation that was done to the left hand expression?
What was the second operation? The third?
Change the information in the chart as needed.
c. Check your prediction for the right side by un-checking the box below the right side.

What was the first operation that was done to the right hand expression?
What was the second operation? The third?
Change the information in the chart as needed.
d. Look at the first operation performed in each expression. Why do you think that operation was done first for the left hand expression?

Why do you think that operation was done first for the right hand expression?
e. What do you notice about the value of each expression? Are they equivalent? Why or why not?

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## Part II. Complete the Table

Set the slider values to the values given in the table below.

- Cover both sides by clicking the check boxes below the table.
- Record the expression in the table below then predict the solution. (Show the steps in the table.)

- Uncover the steps and check the solution. (First example provided) *Make sure to cover both sides before going to the next example.

| $\begin{gathered} \hline \mathbf{E x} \\ \# \\ \hline \end{gathered}$ | Slider <br> Values | Left Expression | Right Expression | Are they Equivalent? Why or why not? |
| :---: | :---: | :---: | :---: | :---: |
| 1. | $\begin{aligned} & \hline a=1 \\ & b=2 \\ & c=4 \\ & d=2 \\ & \text { Solutions } \rightarrow \end{aligned}$ | $1 * 2+4 \div 2$ | $1(2+4) \div 2$ | These expressions are not equivalent. <br> On the left, according to the order of expressions, multiplication and division are done before adding so $1 * 2$ is 2 and $4 \div 2$ is 2 then $2+2$ is 4 . <br> On the right, ( ) are before multiplying and dividing, so $2+4$ is 6 then 6 times 1 is 6 then $6 \div 2$ is 3 . |
|  |  | $2+4 \div 2$ | $1(6) \div 2$ |  |
|  |  | $2+2$ | $6 \div 2$ |  |
|  |  | 4 | 3 |  |
| 2. | $\begin{aligned} & \hline \mathrm{a}=1 \\ & \mathrm{~b}=5 \\ & \mathrm{c}=4 \\ & \mathrm{~d}=2 \\ & \\ & \text { Solutions } \rightarrow \end{aligned}$ | $1 * 5+4 \div 2$ | $1(5+4) \div 2$ |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| 3. | $\begin{aligned} & \mathrm{a}=1 \\ & \mathrm{~b}=5 \\ & \mathrm{c}=6 \\ & \mathrm{~d}=1 \end{aligned}$ <br> Solutions $\rightarrow$ |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| 4. | $\begin{aligned} & \hline \mathrm{a}=1 \\ & \mathrm{~b}=1 \\ & \mathrm{c}=5 \\ & \mathrm{~d}=1 \\ & \\ & \text { Solutions } \rightarrow \end{aligned}$ |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| 5. | $\begin{aligned} & \begin{array}{l} a=1 \\ b=4 \\ c=6 \\ d=1 \\ \text { Solutions } \rightarrow \end{array} \end{aligned}$ |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

In examples 3, 4, and 5 the values for $\boldsymbol{a}$ and $\boldsymbol{d}$ are kept at 1 . Explain how the three sets of expressions are similar.

Use your understanding of order of operations to explain why the sets of expressions are equivalent.

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## Part III.

1. Predict what the expression $5 \cdot 6+8 \div 2$ will be equivalent to by showing or explaining each step.
a. Click on the "Cover left side" and "Cover right side" checkboxes in the applet
b. Set the sliders to the values $a=5, b=6, c=8$ and $d=2$ in the applet.

Uncover the left side to check your solution to the problem above.
If your solution was not correct, what part(s) of the solution did you get incorrect? Explain the difference between your reasoning and the solution itself.
2. Predict whether or not the expression $5(6+8) \div 2$ will be equivalent to the one above. Why or why not? Then solve it, showing or explaining each step.
a. Uncover the right hand expression by un-checking the "Cover right side" checkbox.

Use the applet to check your solution to the problem above. If your solution was not correct, what part(s) of the solution did you get incorrect? Explain the difference between your reasoning and the solution itself.

