Math: Grade 8, Lesson 4, Expressions and Equations

Lesson Objective: Students will extend the use of the properties of equality to solve linear equations having rational coefficients
Lesson Focus: Solving a linear equation
Practice Focus: Solve linear equations with rational number coefficients
TN Standards: 8.EE.C.7.b
Key Vocabulary:

- Distributive property
- Commutative property
- Equality

Teacher Materials:

- Whiteboard and markers

Student Materials:

- Paper and writing utensil or other notetaking device
- Student packet for math, grade 8 lesson 4, which can be found at www.tn.gov/education

Teacher Do	Student Do
<u>Opening</u> (1 minute) **Hello! Welcome to Tennessee's At Home Learning Series for math! Today's lesson is for all our 8th graders out there, though all children are welcome to tune in. This lesson is the first in our series.** **My name is ____ and I'm a ____ grade teacher in Tennessee schools! I'm so excited to be your teacher for this lesson! Welcome to my virtual classroom!** **If you didn't see our previous lessons, you can find them on www.tn.gov/education. You can still tune in to today's lesson if you haven't seen any of our others. But, it might be more fun if you first go back and watch our other lessons since we'll be talking about things we learned previously.** **Today we will be learning about linear equations in mathematics! Before we get started, to participate fully in our lesson today, you will need:** • **Paper and writing utensil or other notetaking device** • **Student packet for math, grade 8 lesson 4, which can be found at www.tn.gov/education** **Ok, let's begin!**	Students get materials ready for the lesson
<u>Intro</u> (10 minutes) **In this lesson, we are going to continue working on equations and expressions using the properties of equality to solve linear equations. Keep in mind, there are many ways to solve an equation, and it does not matter which options you choose, or in which order – what matters is that you use the properties of equality to make true statements that lead**	Students will take notes on the properties of equality and think about the ways to make true statements that

to a solution in the form of *x* equal to a constant. Let's start with some vocabulary and concept reminders.	lead to a solution in the form of *x* equal to a constant.
To solve an equation means to find all of the numbers x, if they exist, so that the given equation is true. In some cases, some simple guesswork can lead us to a solution. For example, consider the following equation: $$4x + 1 = 13$$ **What number x would make this equation true? That is, what value of x would make the left side equal to the right side**? [Give students a moment to guess a solution.]	
When $\mathrm{x} = 3$, we get a true statement. The left side of the equal sign is equal to 13, and so is the right side of the equal sign. In other cases, guessing the correct answer is not so easy. Consider the following equation: $$3(4x - 9) + 10 = 15x + 2 + 7x$$ **Can you guess a number for x that would make this equation true?** [Give students a minute to guess]	Students answer.
Guessing is not always an efficient strategy for solving equations. In the last example, there are several terms in each of the linear expressions comprising the equation. This makes it more difficult to easily guess a solution. For this reason, we want to use what we know about the properties of equality to transform equations into equations with fewer terms. **The ultimate goal of solving any equation is to get it into the form of x, or whatever symbol is being used in the equation, equal to a constant.** **Here's an example to remind you of the properties of equality.** [Write on the board] $$4 + 1 = 7 - 2$$ **Let's try to answer these questions about this equation:**	Students answer.
1. **Is this equation true?** [Pause for student reflection.] **2. Perform each of the following operations, and think about whether or not the equation is still true:** a. **Add three to both sides of the equal sign**. [Write on whiteboard.] **b. Add three to the left side of the equal sign, and add two to the right side of the equal sign.** [Write on whiteboard.] c. **Subtract six from both sides of the equal sign.** [Write on whiteboard.] d. **Subtract three from one side of the equal sign, and subtract three from the other side of the equal sign.** [Write on whiteboard.]	Students reflect.

e. **Multiply both sides of the equal sign by ten.** [Write on whiteboard.] **f. Multiply the left side of the equation by ten and the right side of the equation by four.** g. **Divide both sides of the equation by two.** [Write on whiteboard.] **h. Divide the left side of the equation by two and the right side of the equation by five.** [Write on whiteboard.] **3. What do you notice? Describe any patterns you see.** **There are four properties of equality that allow us to transform an equation into the form we want. If A, B, and C are any rational numbers, then:** – **If $A = B$, then $A + C = B + C$.** – **If $A = B$, then $A - C = B - C$.** – **If $A = B$, then $A \cdot C = B \cdot C$.** – **If $A = B$, then $\frac{A}{C} = \frac{B}{C}$, where C is not equal to zero.** **All four of the properties require us to start off with $A = B$. That is, we have to assume that a given equation has an expression on the left side that is equal to the expression on the right side. Working under that assumption, each time we use one of the properties of equality, we are transforming the equation into another equation that is also true; that is, the left side equals the right side.**	 Students describe patterns.
<u>Teacher Model</u> (7 minutes) **Let's look at two examples. While you are watching, follow along on your own paper or other notetaking device. Remember, if you need a little more time, you can always pause the video to work on the problems, then hit play again and we'll go through them together.** [Example 1] **Let's solve the linear equation $2x - 3 = 4x$ for the number x.** [Write equation on whiteboard] **Examine the properties of equality by choosing "something" to add, subtract, multiply, or divide on both sides of the equation. Keep in mind, there are different potential responses. Let's look at a "best" choice option for the first step in solving the equation, remembering that in this and any other equation, the goal is to get *x* equal to a constant; therefore, the "best" choice is one that gets you to that goal most efficiently.** **First, we must assume that there is a number x that makes the equation true. Working under that assumption, when we use the property, if $A =$**	 Students follow along writing their ideas on their own paper or notetaking device during the examples. Students will pause as needed for individual work.

B, then $A - C = B - C$, we get an equation that is also true. $$2x - 3 = 4x$$ $$2x - 2x - 3 = 4x - 2x$$ **Now, using the distributive property, we get another set of equations that is also true.** $$(2-2)x - 3 = (4-2)x$$ $$0x - 3 = 2x$$ $$-3 = 2x$$ **Using another property, if $A = B$, then $\frac{A}{C} = \frac{B}{C}$, we get another equation that is also true.** $$\frac{-3}{2} = \frac{2x}{2}$$ **After simplifying the fraction $\frac{2}{2}$, we have** $$\frac{-3}{2} = x,$$ **which is also true.** **The last step is to check to see if $x = -\frac{3}{2}$ satisfies the equation $2x - 3 = 4x$.** **The left side of the equation is equal to** $$2 \cdot \left(-\frac{3}{2}\right) - 3 = -3 - 3 = -6.$$ **The right side of the equation is equal to** $$4 \cdot \left(-\frac{3}{2}\right) = 2 \cdot (-3) = -6.$$ **Since the left side equals the right side, we know we have found the number x that solves the equation $2x - 3 = 4x$.** [Example 2] **Solve the linear equation $\frac{3}{5}x - 21 = 15$. Keep in mind that our goal is to transform the equation so that it is in the form of x equal to a constant. If we assume that the equation is true for some number x, which property should we use to help us reach our goal, and how should we use it?** [Pause.]	
We should use the property if $A = B$, then $A + C = B + C$, where the number C is 21.	Students answer.
What if you wanted to subtract 15 from both sides, where C is -15? Keep in mind you want the form of x equal to a constant. Subtracting 15 from both sides of the equal sign puts the x and all of the constants on the same side of the equal sign. There is nothing mathematically	

incorrect about subtracting 15, but it does not get you any closer to reaching the goal. **If we use $A + C = B + C$, then we have the true statement:** $$\frac{3}{5}x - 21 + 21 = 15 + 21$$ **and** $$\frac{3}{5}x = 36.$$ **Which property should we use to reach our goal, and how should we use it?** [Pause.]	
We should use the property if $\mathbf{A = B}$, then $\mathbf{A \cdot C = B \cdot C}$, where $\mathbf{C}$ is $\frac{5}{3}$. **If we use $A \cdot C = B \cdot C$, then we have the true statement:** $$\frac{3}{5}x \cdot \frac{5}{3} = 36 \cdot \frac{5}{3},$$ **and by the commutative property and the cancellation law, we have** $$x = 12 \cdot 5 = 60.$$ **Does $\mathbf{x = 60}$ satisfy the equation $\frac{3}{5}\mathbf{x - 21 = 15}$?** [Pause.]	Students answer.
Yes, because the left side of the equation is equal to $\frac{180}{5} - 21 = 36 - 21 = 15$. Since the right side is also 15, then we know that 60 is a solution to $\frac{3}{5}x - 21 = 15$. **The right side is** $$-4 - 7 \cdot 5 = -4 - 35$$ $$= -39.$$ **Since $21 \neq -39$, then $x \neq 5$. That is, 5 is not a solution to the equation.** **Is 1 a solution to the equation? That is, is this equation a true statement when $x = 1$?** [Pause.]	Students answer.
Yes, the left side and right side of the equation are equal to the same number when $x = 1$. **The left side is** $$8 \cdot 1 - 19 = 8 - 19$$ $$= -11.$$ **The right side is** $$-4 - 7 \cdot 1 = -4 - 7$$ $$= -11.$$ **Since $-11 = -11$, then $x = 1$. That is, 1 is a solution to the equation.**	Students answer.

<u>**Guided Practice**</u> (9 minutes) **Get your pencil and paper ready. Here's question number one.** [Write the equation on the whiteboard.] **Now, pause the video and work on this question, and when you're done, hit play again and we'll talk through it. We can do that with each of the problems.** [Exercise 1] **Solve the linear equation $x+x+2+x+4+x+6=-28$. State the property that justifies your first step and why you chose it.** [Pause.] ***The left side of the equation can be transformed from $x+x+2+x+4+x+6$ to $4x+12$ using the commutative and distributive properties. Using these properties decreases the number of terms of the equation. Now we have the equation:*** $4x+12=-28$ $4x+12-12=-28-12$ $4x=-40$ $\frac{1}{4}\cdot 4x=-40\cdot\frac{1}{4}$ $x=-10.$ **The left side of the equation is equal to $(-10)+(-10)+2+(-10)+4+(-10)+6$, which is -28. Since the left side is equal to the right side, then $x=-10$ is the solution to the equation.** [Exercise 2] **Solve the linear equation $2(3x+2)=2x-1+x$. State the property that justifies your first step and why you chose it.** [Pause.] **Both sides of equation can be rewritten using the distributive property. I have to use it on the left side to expand the expression. I have to use it on the right side to collect like terms.** **The left side is** $2(3x+2)=6x+4.$ **The right side is** $2x-1+x=2x+x-1$ $=3x-1.$ **The equation is**	Students pause video to work selected problems on their student page. Students solve the equation. Students compare their solutions to the teacher's work. Students solve the equation.

$6x+4=3x-1$ $6x+4-4=3x-1-4$ $6x=3x-5$ $6x-3x=3x-3x-5$ $(6-3)x=(3-3)x-5$ $3x=-5$ $\frac{1}{3}\cdot 3x=\frac{1}{3}\cdot(-5)$ $x=-\frac{5}{3}.$ **The left side of the equation is $\mathbf{2(3x+2)}$. Replacing $\mathbf{x}$ with $-\frac{5}{3}$ gives $\mathbf{2\left(3\left(-\frac{5}{3}\right)+2\right)=2(-5+2)=2(-3)=-6}$. The right side of the equation is $\mathbf{2x-1+x}$. Replacing $\mathbf{x}$ with $-\frac{5}{3}$ gives $\mathbf{2\left(-\frac{5}{3}\right)-1+\left(-\frac{5}{3}\right)=-\frac{10}{3}-1-\frac{5}{3}=-6}$. Since both sides are equal to -6, then $\mathbf{x}=-\frac{5}{3}$ is a solution to** $\mathbf{2(3x+2)=2x-1+x.}$	Students compare their solutions to the teacher's work.
<u>Independent Practice</u> (4 minutes) **Let's look at what we have explored today. We know that properties of equality, when used to transform equations, make equations with fewer terms that are simpler to solve. When solving an equation, we want the answer to be in the form of the symbol *x* equal to a constant.** **We've worked a lot of problems today, and here are two more to try on your own.** [Write problems on whiteboard] 1. Guess a number for x that would make the equation true. Check your solution. $5x-2=8$ 2. Use the properties of equality to solve the equation $7x-4+x=12$. State which property justifies your first step and why you chose it. Check your solution. **Here are the answers!** [Teacher writes or shows both.] **For question one, when *x*=2, the left side of the equation is 8, which is the same as the right side. Therefore, *x*=2 is the solution to the equation.**	Students complete Exit Ticket. Students solve the equation. Students solve the equation. Students compare their solutions to the teacher's work.

For question two, use the commutative and distributive properties on the left side of the equal sign to simplify the expression to fewer terms. $$\begin{aligned} 7x - 4 + x &= 12 \\ 7x + x - 4 &= 12 \\ (7+1)x - 4 &= 12 \\ 8x - 4 &= 12 \\ 8x - 4 + 4 &= 12 + 4 \\ 8x &= 16 \\ \frac{8}{8}x &= \frac{16}{8} \\ x &= 2 \end{aligned}$$ **The left side of the equation is $7(2) - 4 + 2 = 14 - 4 + 2 = 12$. The right side is also 12. Since the left side equals the right side, $x = 2$ is the solution to the equation.** **You can now complete the student practice worksheet for grade 8, lesson 3 if you want some additional practice.**	
<u>**Closing**</u> (1 minute) • **I enjoyed doing some mathematics with you today! Thank you for inviting me into your home. I look forward to seeing you in our next lesson in Tennessee's At Home Learning Series!** • **Bye!**	