PBS Lesson Series

Math: Grade 8, Lesson 3, Expressions and Equations

Lesson objective:

- Students will know that a linear equation is a statement of equality between two expressions.
- Students will know that a linear equation in *x* is actually a question: Can you find all numbers *x*, if they exist, that satisfy a given equation? Students know that those numbers *x* that satisfy a given equation are called solutions.

Lesson Focus: Linear equations in *x*

Practice Focus: Solve linear equations with rational number coefficients

Key Vocabulary:

- Solution
- Transformed
- Linear equations

TN Standards: 8.EE.C.7.b

Teacher Materials:

- Whiteboard and markers*

Student Materials:

- Paper and writing utensil or other notetaking device
- Student packet for math, grade 8 lesson 3, which can be found at www.tn.gov/education

**To save time and jump straight into lesson, it will be helpful to have initial set of equations pre-written on whiteboard.*

Teacher Do	Student Do
Opening (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 3, which can be found at www.tn.gov/education** **Ok, let's begin!**	Students get materials ready for the lesson

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Intro (3 minutes)
We want to define "linear equation in x." Here are some examples of linear equations in x. [Show students the examples below.]

$x + 11 = 15$	$5 + 3 = 8$	$-\frac{1}{2}x = 22$
$15 - 4x = x + \frac{4}{5}$	$3 - (x + 2) = -12x$	$\frac{3}{4}x + 6(x - 1) = 9(2 - x)$

Using what you know about the words *linear*, from Lesson 2, and *equation*, from Lesson 1, we're going to develop a mathematical definition of "linear equation in x."

When two linear expressions are equal, they can be written as a linear equation in x. Consider the following equations. [Show on whiteboard.]

Which are true, and how do you know? [Pause]

$$4 + 1 = 5$$
$$6 + 5 = 16$$
$$21 - 6 = 15$$
$$6 - 2 = 1$$

The first and third equations are true because the value on the left side is equal to the number on the right side.

Is 4 + 15*x* = 49 true? How do you know? [Pause]

Try making a list of values for *x* that make it false, along with one value that makes it true. A linear equation in *x* is a statement about equality, but it is also an invitation to find all of the numbers *x*, if they exist, that make the equation true. Sometimes the question is asked in this way: What number(s) *x* satisfies the equation? The question is often stated more as a directive: Solve. When phrased as a directive, it is still considered a question. Is there a number(s) *x* that makes the statement true? If so, what is the number(s) *x*? [Pause.]

Equations that contain a variable do not have a definitive truth value; in other words, there are values of the variable that make the equation a true statement and values of the variable that make it a false statement. When we say that we have "solved an equation," what we are really saying is that we have found a number (or numbers) *x* that make the equation true. That number *x* is called the solution to the equation.

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Students look for how expressions are related and think about how representations are related to help them as they write their own ideas for defining "linear equation in x" on their own paper or notetaking device.

Students answer.

Students answer.

Students answer.

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Teacher Model (12 minutes)
Let's look at four 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

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Students follow along writing their ideas on their own paper or notetaking device during

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problems, then hit play again and we'll go through them together. [Use the Scaffolding options, and minimize to examples 1, 2 and 3 if necessary.]	the examples. Students will pause as needed for individual work.
[Example 1] **Here is a linear equation in x: $4 + 15x = 49$. Is there a number x that makes the linear expression $4 + 15x$ equal to the linear expression 49?** Pause.	Students answer.
Suppose you are told this number x has a value of 2, that is, $x = 2$. We replace any instance of x in the linear equation with the value of 2, as shown: $$4 + 15 \cdot 2 = 49$$	
Next, we evaluate each side of the equation. The left side is: $$4 + 15 \cdot 2 =$$ $$4 + 30 =$$ $$34$$	
The right side of the equation is 49. Clearly, $34 \neq 49$. Therefore, the number 2 is not a solution to this equation. Is the number 3 a solution to the equation? That is, is this equation a true statement when $x = 3$? [Pause]	Students answer.
Yes, because the left side of the equation equals the right side of the equation when $x = 3$. The left side is $$4 + 15 \cdot 3 =$$ $$4 + 45 =$$ $$49$$	
The right side is 49. Since $49 = 49$, then we can say that $x = 3$ is a solution to the equation $4 + 15x = 49$. 3 is a solution to the equation because it is a value of x that makes the equation a true statement.	
Remember, when a number and a symbol are next to one another, such as 15*x*, it is not necessary to use a symbol to represent the multiplication – it is a convention. For clarity, when two numbers are being multiplied, it is necessary to use a multiplication symbol. For example, it is necessary to tell the difference between the number, 152, and the product, $15 \cdot 2$.	
[Example 2] **Here is a linear equation in x: $8x - 19 = -4 - 7x$. Is 5 a solution to the equation? That is, is the equation a true statement when $x = 5$?** [Pause]	Students answer.

No, because the left side of the equation does not equal the right side of the equation when $\mathbf{x = 5}$. The left side is $$8 \cdot 5 - 19 =$$ $$40 - 19 =$$ $$21$$ **The right side is** $$-4 - 7 \cdot 5 =$$ $$-4 - 35 =$$ $$-39$$ **Since $21 \neq -39$, then $\mathbf{x \neq 5}$. 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 $\mathbf{x = 1}$. **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 $\mathbf{x = 1}$. That is, 1 is a solution to the equation.**	
[Example 3] **Here is a linear equation in x: $3(x + 9) = 4x - 7 + 7x$. We can make our work simpler if we use some properties to transform the expression on the right side of the equation into an expression with fewer terms. Try this at home, then we'll dive into the next example.** [Pause long enough to provide a bit of time for students to transform the equation into fewer terms, then proceed.]	Students simplify the equation.
Notice that on the right side, there are two terms that contain x. First, we will use the commutative property to rearrange the terms to better see what we are doing. $$4x + 7x - 7$$ **Next, we will use the distributive property to collect the terms that contain x.**	

$$4x + 7x - 7 = (4 + 7)x - 7$$ $$= 11x - 7$$ **Finally, the transformed (but still the same) equation can be written as $3(x + 9) = 11x - 7$.**	
Is $\frac{5}{4}$ a solution to the equation? That is, is this equation a true statement when $x = \frac{5}{4}$? [Pause.]	Students answer.
No, because the left side of the equation does not equal the right side of the equation when $x = \frac{5}{4}$.	
The left side is $$3\left(\frac{5}{4} + 9\right) = 3\left(\frac{41}{4}\right)$$ $$= \frac{123}{4}.$$	Students solve the equation.
The right side is $$11 \cdot \frac{5}{4} - 7 = \frac{55}{4} - 7$$ $$= \frac{27}{4}.$$	
Since $\frac{123}{4} \neq \frac{27}{4}$, then $x \neq \frac{5}{4}$. That is, $\frac{5}{4}$ is not a solution to the equation.	
[Example 4 , if time permits]	
Here is a linear equation in x: $-2x + 11 - 5x = 5 - 6x$.	
We want to check to see if 6 is a solution to the equation; that is, is this equation a true statement when $x = 6$? Before we do that, what would make our work easier? We could use the commutative and distributive properties to transform the left side of the equation into an expression with fewer terms.	Students solve the equation.
$$-2x + 11 - 5x$$ $$= -2x - 5x + 11$$ $$= (-2 - 5)x + 11$$ $$= -7x + 11$$	
The transformed equation can be written as $-7x + 11 = 5 - 6x$. Is 6 a solution to the equation; that is, is this equation a true statement when $x = 6$? [Pause.]	
Yes, because the left side of the equation is equal to the right side of the equation when $x = 6$.	Students answer.
The left side is	

$= -42 + 11$ $= -31.$ **The right side is** $5 - 6x = 5 - 6 \cdot 6$ $= 5 - 36$ $= -31.$ **Since $-31 = -31$, then $\mathbf{x = 6}$. That is, 6 is a solution to the equation.**	
<u>Guided Practice</u> (9 minutes) **Get your pencil and paper ready. Here's question number one.** [Write 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] **Is the equation a true statement when $x = -3$? In other words, is -3 a solution to the equation $6x + 5 = 5x + 8 + 2x$?** ***If we replace x with the number -3, then the left side of the equation is*** $\mathbf{6 \cdot (-3) + 5 = -18 + 5}$ $\mathbf{= -13}$ **and the right side of the equation is** $\mathbf{5 \cdot (-3) + 8 + 2 \cdot (-3) = -15 + 8 - 6}$ $\mathbf{= -7 - 6}$ $\mathbf{= -13}$ **Since $-13 = -13$, then $x = -3$ is a solution to the equation $6x + 5 = 5x + 8 + 2x$.** **Let's do this again with question two. Here's the problem** [write on board]**. Hit pause, and then come back when you are done.** [Exercise 2] **Does $\mathbf{x = 12}$ satisfy the equation $16 - \frac{1}{2}\mathbf{x} = \frac{3}{4}\mathbf{x} + 1$? Explain.** **If we replace x with the number 12, then the left side of the equation is**	Students pause video to work selected problems on their student page (should also be written on the board in case students don't have the practice page available). Students solve the equation. Students solve the equation.

$$16 - \frac{1}{2}x = 16 - \frac{1}{2} \cdot (12)$$ $$= 16 - 6$$ $$= 10,$$ **and the right side of the equation is** $$\frac{3}{4}x + 1 = \frac{3}{4} \cdot (12) + 1$$ $$= 9 + 1$$ $$= 10.$$ **Since $10 = 10$, then $x = 12$ is a solution to the equation $16 - \frac{1}{2}x = \frac{3}{4}x + 1$.**	
<u>Independent Practice</u> (4 minutes) **Let's look at what we have explored today. We know that equations are statements about equality. That is, the expression on the left side of the equal sign is equal to the expression on the right side of the equal sign. We know that a solution to a linear equation in *x* will be a number and that when all instances of *x* are replaced with the number, the left side will be equal to the right side.** **We've worked a lot of problems today, and here are two more to try on your own.** [Write problems on whiteboard] 1. Is 8 a solution to $\frac{1}{2}x + 9 = 13$? Explain. 2. Write three different equations that have $x = 5$ as a solution. **Here are the answers!** [Teacher writes or shows both.] **For question one, if we replace x with the number 8, then the left side is $\frac{1}{2}(8) + 9 = 4 + 9 = 13$, and the right side is 13. Since $13 = 13$, then $x = 8$ is a solution.** **For question 2, your answers will vary, but you should only accept equations where x = 5 makes a true number sentence.** **You can now complete the student practice worksheet for grade 8, lesson 3 if you want some additional practice.**	Students complete Exit Ticket.
<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!**	

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