Samantha purchased subway tokens from a machine. The instructions said that, for any amount of money you insert, you would receive the maximum number of tokens your money can purchase, along with your change.

Samantha put a $20 bill into the machine. She received 12 tokens and $2.60 in change. After thinking for a minute, Samantha decided the machine didn’t do what it advertised. How did she know?

Explain your thinking with words and numbers.

**Extra:** Can you think of a logical explanation for why the machine did this? Use math to support your idea.

**MATH STANDARDS ALIGNMENT:**
*Interpret a multiplication equation as a comparison, e.g., interpret 35 = 5 × 7 as a statement that 35 is 5 times as many as 7 and 7 times as many as 5. Represent verbal statements of multiplicative comparisons as multiplication equations.*

**Mathematical Practices**
1. Make sense of problems and persevere in solving them.
2. Construct viable arguments and critique the reasoning of others.

**Personal Finance Big Ideas:**
*What is Money*

**METHOD 1: LOGICAL REASONING, BASED ON THE CHANGE**
Samantha received $2.60 in change. If the machine had given her the maximum number of tokens for her $20, that would mean that a token would cost more than $2.60. Ten tokens at that price would cost $26, more than the $20 Samantha put in the machine, so she shouldn’t have received 12 tokens.

**METHOD 2: DIRECT CALCULATION OF COST PER TOKEN**
I’m assuming that the machine gave her an exact $20-worth between the tokens and the change. Samantha received $2.60 in change. I subtracted that from $20 to find out the cost of the 12 tokens.

$20.00 – $2.60 = $17.40

I divided to find the cost of each of the 12 tokens.

$17.40/12 = $1.45

If each token cost $1.45, Samantha could have received one more token and change.

$2.60 – 1.45 = $1.15 change
METHOD 3: GUESS AND TEST TO FIND COST PER TOKEN

I assume the machine gave Samantha the correct change for 12 tokens. I subtracted to find the cost of the 12 tokens. $20.00 – $2.60 = $17.40

I used guess and test to find the cost of one token. I could tell it had to be between $1, which would cost $12 and $2, which would cost $24.

<table>
<thead>
<tr>
<th>cost per token</th>
<th>cost of 12</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1.50</td>
<td>$18.00</td>
<td>too much by .60</td>
</tr>
<tr>
<td>$1.40</td>
<td>$16.80</td>
<td>too little by .60</td>
</tr>
<tr>
<td>$1.45</td>
<td>$17.40</td>
<td>yes!</td>
</tr>
</tbody>
</table>

The tokens cost $1.45. The machine could have given Samantha one more token and change.

METHOD 4: BASED ON MAXIMUM POSSIBLE COST OF TOKEN

If Samantha had received the maximum number of tokens, the maximum price per token would have been less than $2.00.

$20.00/12 = 1.666...

The change that she received, $2.60 was more than that, so she should have received another token, or a different amount of change.

**Extra:** [Below is a sampling of possible responses based on the machine giving Samantha $20 of value.]

The machine only had 12 tokens left in it. They cost $1.45 each for a total of $17.40. It gave them to Samantha with the correct change.

The tokens cost $1.60 each. Samantha received 12, for a total of $19.20. The machine should have given her $0.80 change.