NUMB3RS Activity: Velocity of Circulation
Episode: "Money for Nothing"

Topic: Economics, simulation, interpreting graphs, using formulas **Grade Level:** 9 - 12
Objective: The students will simulate an economic situation and calculate the velocity of circulation.
Time: 20 minutes
Materials: TI-83 Plus/TI-84 Plus graphing calculator, 20 fake one-dollar bills, a large clock with a second hand that can be seen anywhere in the room (an overhead, digital timer would work as well) and a few bags of gum, suckers, etc. (whatever the students enjoy)

Introduction

In "Money for Nothing," an armored truck carrying cash and medicine for African Relief is hijacked and held for a $50-million ransom. The hijacked money is intended to be used for "microcredit." Charlie explains, "The efficiency of microcredit is something like the capillary action of a paper towel absorbing liquid. The economic structure of a community is like a paper cloth—people connected by commerce. The difference is, as money enters the fabric of economy, it actually creates more money. Say a woman has money to buy material and sell clothing at a market. The woman then brings back cash to her village, buys food and other essentials for her family. Money gets absorbed, spreads around, and soon more people have cash to spend and invest."

This activity demonstrates the Quantity Theory of Money and, specifically, the Equation of Exchange introduced by Irving Fisher in 1911:

$$M \cdot V = P \cdot Q$$

where M is Money Supply, V is Velocity of Circulation (the average number of times money changes hand), P is Average Price Level (a measure of inflation), and Q is Quantity of Goods and Services bought or sold in the economy in a year (also known as the Gross National Product [GNP]). Consequently, PQ is the dollar value of all transactions. To simplify maters in the activity, the equation $M \cdot V = D$ will be used where D is the dollar value of all transactions for the simulation ($D = PQ$).

The velocity of circulation is the most powerful component of this equation. This activity on the student sheet uses $20 in circulation; if each dollar bill changes hands an average of 6 times, transactions totaling $120 have taken place with the same $20. Stated differently, after $20 changes hands several times, the transactions taken place were valued at $120. Therefore, each dollar bill must have changed hands an average of 6 times. This can also imply if the total dollar value of GNP in a year is $600 billion, then the minimum amount of money needed to be in circulation (so that sufficient money is present in circulation) is only $30 billion.

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Discuss with Students

This will be a loud activity with a lot of movement. Imagine a crowded market place or a stock-market pit where this very idea of quickly buying and selling is epitomized. With that in mind, assign some students to start as buyers and other students to start as sellers. Make sure all desks and other hindrances to movement are out of the way. Situate the students so that the initial sellers are in the center of the room and the initial buyers surround them. Give each seller 10 objects from the goods to sell and each buyer $2. Set the price of each object at $1 for the entire simulation. When an object is sold, the seller must keep a record of the transaction (amount sold, price, and time of sale to nearest 15 seconds). Once the simulation is started, there will be times when someone is a buyer, then a buyer/seller, then a seller, etc. To simplify this concept for the students, remind them that if they have one of the bought goods, then they can sell it and need to keep a record of the transaction. On the other hand, if a student has money, he or she can buy one of the goods for sale but does not need to keep a record of that transaction.

Before beginning, remind the students that their goal is to make as many transactions as possible over 5 minutes and to not eat any of the goods until the simulation is complete.

Students may ask, "Why would I sell something I wanted to buy?" The futures market is a good example of this. When an investor buys a future value for December wheat, he has no intention of actually owning it. The investor is hoping that the value will go up before December, at which point he sells it and pockets a profit. This simulation is exactly the same thing. A person buys the goods with the hope that they can be sold at a profit. However, to simplify matters in the activity, the selling price of all goods will be a constant $1. This allows for the simulation to explore the velocity of currency without getting too complex.

To aid in the collection of the class' data, it would be helpful to project a copy of the data sheet on the board in which students can report their data.

Student Page Answers:

1. *Answers will vary, but should be around 7 dollars*. **2.** *From the multiple transactions each dollar went through. Question #3 will compute this factor.* **3a.** *Answers will vary.* **3b.** *No, it would start at 0 and then steadily climb to the calculated value.* **4.** *This will depend on the velocity of exchange for the simulation. To find the amount needed, divide 13.22 trillion by the velocity of circulation calculated in Question 3a.* **5.** *A typical pattern would be for the graph to start slowly, but then, as time progresses, the graph will shoot up sharply, and after a period of time it will increase at a constant rate*. **6.** *The slope was not constant. If the typical pattern in Question 5 occurs, then it would follow that the graph could be divided up into three time periods. The slope of the first part was very small; the slope of the middle part was increasing very quickly; the slope of the last part assumed a constant rate.*

Extension Page Answers:

1. *For the equation to stay true, V should decline proportionately, P or Q has to increase, or a combination of these changes has to take place.* **2.** *In the short term, only P will end up changing. This is because it takes a long time for the economy to adjust (variable Q) and people's habits do not change very fast (variable V). This means that an increase in P implies inflation.*

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Name: _____ Date: _____

NUMB3RS Activity: Velocity of Circulation

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The idea of microcredit is that a small amount of money can have great benefits for the economy when it has a high exchange rate among individuals. This exchange rate between people is called the velocity of circulation. It can be best measured through the Equation of Exchange introduced by Irving Fisher in 1911. A modified version of this equation is

$$M \cdot V = D$$

where M is Money Supply, V is Velocity of Circulation (the average number of times money changes hand), and D is Dollar Value of all Transactions.

To measure the velocity of circulation and observe how powerful it is, a simulation will be conducted. Your teacher will divide the class into two groups: those who initially have money and those who initially have goods to sell. For 5 minutes, the goal for the class is to conduct as many transactions as possible.

The rules:

- Have as many transactions as possible for 5 minutes.
- Everyone has a data sheet.
- All goods will be sold for $1 throughout the entire simulation.
- Each initial buyer starts with $2.
- Each initial seller starts with 10 goods to sell.
- Whenever a person is in possession of money, he or she can buy goods.
- Whenever a person is in possession of goods, he or she can sell them.
- Individuals fluctuate between sellers and buyers; sometimes individuals will be both.
- Whenever goods are sold, the person **selling** them records the time (to nearest 15 seconds) and amount of money for each transaction on the data sheet.

After 5 minutes, each current and past seller totals the dollar value of their transactions and records the totals on the board for each time interval.

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1. What was the total dollar value for the class transactions in the 5 minutes of the simulation?

2. Since the class only started with \$20, and this was a closed system, where did the extra money that was calculated come from?

3. **a.** Using the modified Equation of Exchange, $M \cdot V = D$, find the velocity of circulation for the entire simulation.

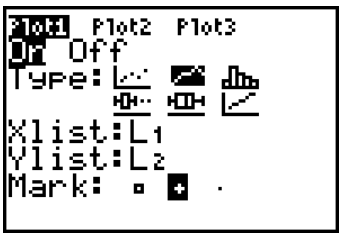
b. Would this value be constant for the entire simulation?

4. Suppose our simulation generated a *D* value of \$13.22 trillion (the official Gross Domestic Product for the United States in 2006). What would be the minimum amount of money needed for the simulation?

To better understand what is happening, create a line graph for time vs. dollar value of transactions for the class' data.

Entering the Data into the Graphing Calculator

Press [STAT], select **Edit…**, and enter the time interval values into L_1, then enter the class' dollar totals for each interval into L_2. To view the line graph of the data, press [2nd] [Y=], choose **Plot1**, and use the settings shown to the right.



For an appropriate window to view the graph, press [ZOOM] and choose **9:ZoomStat**.

5. What was the general trend of the graph?

6. Describe the slope of this graph.

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Dollar Transactions by Time

Time Interval	Time	Dollar Transactions
0	0:00	0
1	0:15	
2	0:30	
3	0:45	
4	1:00	
5	1:15	
6	1:30	
7	1:45	
8	2:00	
9	2:15	
10	2:30	
11	2:45	
12	3:00	
13	3:15	
14	3:30	
15	3:45	
16	4:00	
17	4:15	
18	4:30	
19	4:45	
20	5:00	
Total Dollar Value:		

The goal of this activity is to give your students a short and simple snapshot into a very extensive mathematical topic. TI and NCTM encourage you and your students to learn more about this topic using the extensions provided below and through your own independent research.

Extension: Inflation

Introduction

- The actual Equation of Exchange is

$$M \cdot V = P \cdot Q$$

where *M* is Money Supply, *V* is Velocity of Circulation (the average number of times money changes hand), *P* is Average Price Level (a measure of inflation), and *Q* is Quantity of Goods and Services bought OR sold in the economy in a year (a measure of Real GDP).

1. Suppose the Federal Reserve were to put additional money into circulation. According to the equation, what would happen?

2. What happens in the short term?

- You may also want to take the class data and calculate the velocity of circulation for each minute of the simulation. Does it increase at a constant rate?

Additional Resources

Read Irving Fisher's book, *The Purchasing Power of Money*, where the equation of exchange (Chapter 11) is introduced. The entire book is online at **http://www.econlib.org/library/YPDBooks/Fisher/fshPPMContents.html**.

Read about Irving Fisher's life at the Web site:
http://www.unc.edu/depts/econ/byrns_web/EC434/HET/Notables/fisher.htm

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