Dollars and Sense

Stay in the Black: Saving and Spending

LESSON 6

Jeff Potash and John Heinbokel

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All 7 lessons, including simulations, of *Dollars and Sense* as well as the book with simulations on a CD are available from the Creative Learning Exchange.
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DEDICATION

From Mitch Julis of the Julis Foundation

My enthusiastic support for this project is in loving memory of my father Maurice Ralph Julis and in honor of my mother Thelma Rabinowitz Julis.

My parents were inspirational teachers throughout their careers in New York with a strong interest in finance and economics. I am sure they would have embraced this book with great enthusiasm.

Dollars and Sense

Additional copies of the book are available from:
The Creative Learning Exchange
www.clexchange.org
milleras@clexchange.org
978-635-9797 in Acton, Massachusetts

Dollars and Sense

Stay in the Black: Saving and Spending

Nothing is constant except change
Heraclitus of Ephesus (c. 535–475 BCE)

The materials provided here use systems thinking and mathematical tools and exploratory computer simulations to challenge students and teachers to develop a realistic and personal understanding of the dynamics of the economic system in which we live. With their resulting knowledge and understanding, they should be better able to control their financial futures, minimize the chance for future pain, and maximize the chance for fostering a prosperous future.

Personal finance, at its core, involves relatively few working parts. However, managing our finances is hard, because change is ever present and none of those parts ever stay the same for long. With money flowing in and out, our funds grow or shrink at different rates, at different times, and for different reasons. Without observing, analyzing, and understanding the patterns of change in money accumulations over time and without recognizing the connections that exist between all the parts of the system, adults frequently pay a real and heavy price.

As teachers, we can help our students prepare to deal with that critical but ever-changing system of personal finance. The innovative tools of *systems thinking* and *dynamic simulations* presented in these materials offer young students (5th–7th grade) a unique opportunity to develop a better understanding of the mathematics of change; to learn constructively and collaboratively; and, over a lifetime, to successfully manage their personal finance. The activities in the seven lessons of this Module 1 utilize a series of computer simulations and their accompanying worksheets, which are designed to help young students explore how (and why) their personal finances change over time. As students explore the diverse set of financial situations, they will learn in four different ways.

- *Learn by doing (constructivism)*: asking open-ended "what if's" and using meaningful real-world examples.
- *Learn by building a conceptual foundation* that connects critically important mathematical tools (tables, graphs) and skills with a systems thinking conceptual framework that visually represents the dynamically changing financial systems (e.g., a personal savings account).
- *Learn by challenging preconceptions*, and using computer simulations to discover that there is more than one right answer or way to successfully manage one's finances.
- *Learn by sharing, comparing, collaborating, and applying lessons learned* to meaningful personal financial problems.

The core message for success: Spend less than you earn!

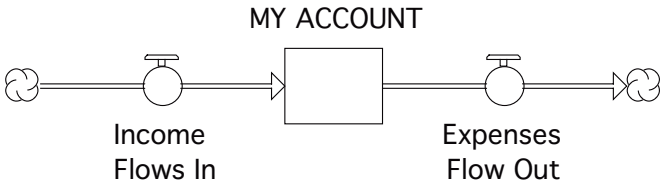
Sounds simple, but when money flows in and out in different amounts and at different times… it is not nearly so simple! Yet our experience shows that 5th to 7th graders, working with mathematical tables, graphs, and computer simulations, can (and do!) "get it"!!

How Is This Module Organized?

Module 1 (Personal Finance) focuses on "saving" and "spending." (Subsequent modules will deal with investment and credit.) As in each module, Module 1 is open-ended. It allows for and encourages students to create and share mathematical approaches, tables, and graphs in order to explain and discuss personal finance goals, plans, and choices with peers, teachers, or parents. These activities are supported by the worksheets provided here and by the simulations that are available on-line.

Module 1 includes seven lessons, each of which contains a computer simulation with at least one challenge. The lessons are organized into three sections, each section progressively building on the foundations of the earlier section(s).

The core systems thinking building blocks that guide student understanding of the structure of change also drive the computer models underlying the simulations.



- Money accumulates in MY ACCOUNT (we call that a "STOCK").
- An "inflow" into MY ACCOUNT—which can be wages, other deposits, or interest earned on the account—adds to that stock.
- An "outflow" from that stock—expenses—reduces or drains MY ACCOUNT.

Section 1: Introduction to Personal Saving and Spending

Section 1 provides an introduction to linear (constant) saving, linear spending, and simultaneous saving and spending. We STRONGLY RECOMMEND it as a prerequisite for subsequent lessons.

- **Lesson 1: Can I Manage My Money and My Music?**

Section 2: Extended Saving and Spending Illustrations

Section 2 moves the understanding of simultaneous inflows and outflows forward by guiding students in choosing their own personal financial goals, running a business, operating a public service, or helping a friend plan to purchase a car. We provide simulations of each of these four illustrative scenarios.

- **Lesson 2: Can I Reach a Personal Saving and Spending Goal?**
- **Lesson 3: Can I Make Money with a Lemonade Stand?**
- **Lesson 4: Can I Successfully Run the Local Food Bank?**
- **Lesson 5: Can I Help a Responsible Teen Buy a Car?**

Section 3: Growing Savings through Interest and Compounding

In Section 3, the lessons move into compounding growth (rather than linear growth) to explore the role of interest on savings. We provide an introduction to compound interest and then a more ambitious illustration of long-term planning that brings together earning, spending, and saving with compounded interest.

- **Lesson 6: How Does Interest Grow My Savings?**
- **Lesson 7: Can Compounding Interest Make Me a Millionaire?**

Each individual lesson offers the following:

1. An open-ended and meaningful question or problem for the students to explore or solve.
2. Support for that learning through a set of System Dynamics conceptual and simulation tools to help students structure, improve, and communicate their understanding of these issues and processes.
3. Encouragement to expand that understanding by identifying and exploring "better questions" and other contexts in which those dynamics also apply.
4. The challenge and the tools with which to address problems of students' own creation.
5. Opportunities to share and communicate what they have learned with peers, teachers, and parents.

Frequently Asked Questions

Will this be fun as well as educational?

Students love this approach. It is fun to play hands-on games and learn through experience. Students can work in teams, share ideas, talk with and listen to each other, not just respond to the teacher. Often something surprising happens and discovering the reason is eye-opening.

When students are active, cooperating, and solving their own problems, their level of engage-

ment is high and the learning sticks with them. In addition, students who have struggled with more typical academic tasks often have a new opportunity to "show what they know" using new learning tools.

Will this be complicated for me to teach?

Teachers are provided with concise supporting materials that include an overview and context for the student activities. Each lesson begins with a brief summary so that teachers can see what is covered. Background information is succinct and procedures are laid out step by step. Student worksheets are at the end of each lesson, ready to photocopy.

Can my students actually do these lessons?

Although the activities in this book have been written with a focus on 5th–7th grade capabilities, they may be used with a wide range of student ages. Lesson 1 was designed to serve as a foundation for later lessons (2–6); those later lessons can be pursued in whatever way best suits the needs and interests of the teacher. Lesson 7 assumes the knowledge and understanding developed in Lesson 6.

What benefits do the students get from these lessons?

- *Students acquire new learning tools and work independently and together to apply them. Each individual lesson fosters constructivist learning.*
- *Teamwork gives rise to better thinking through dialogue, motivation to tackle tougher problems together, mutual respect, and fun.*
- *All the lessons are structured to build cooperative learning.*
- *Finally, each lesson is designed to provide practical opportunities for students to experience by doing, by making different choices, and by comparing and evaluating relative outcomes.*

How do these activities interact with recognized 5th–7th grade content and standards? (See also "Meeting Standards" table below.)

The challenges presented in these activities take on big ideas that are central to the 5th–7th grade curriculum and that are transferable to other topics.

1. Module 1 lessons align with the National Council of Teachers of Mathematics (NCTM) Content AND Process Standards.

- *Content standards include skills for Number and Operations, Algebra, and Data Analysis and Probability.*
- *Process Standards apply to all areas (Problem Solving, Reasoning and Proof, Communication, Connections, and Representation).*

2. The lessons also address several of the Economics Standards advocated by the Council on Economic Education (CEE), including concepts involving opportunity costs; incentives; supply; demand; and price, interest, and earnings.

3. Finally, the lessons support the National Science Teachers Association (NSTA) standards related to the following:

- *Systems, order, and organization;*
- *Evidence, modes, and explanation; and*
- *Change, constancy, and measurement.*

Curriculum Connections

The tool-sets and mind-sets developed here have application far beyond *just* an understanding of personal finance. As students use graphs to understand how money accumulations (STOCKS) change over time, they also find that similar patterns of behavior arise in other places in the real world. And their practical application of the systems thinking tools taught here to represent change can be applied to a wide variety of "systems," ranging from populations (of people, animals, plants, etc.) to resources and even to emotions about people and events. All of these systems in the real world are subject to factors that increase and decrease the overall STOCK in variable ways.

Meeting Standards

The simulations and worksheets that are part of each lesson are designed to use personal finance challenges to address age-appropriate CONTENT and PROCESS standards in Mathematics, as well as emerging national standards in Economics, the NSTA standards identified above, and the transferable tool- and mind-sets of System Dynamics that support wide-ranging critical thinking and collaborative skills. The following table provides a more detailed breakdown of how Module 1 relates to these standards.

Dollars and Sense	
• Hands-on Activities	• Accommodation to different ability levels
• Teamwork	• Sophisticated content
• Reflection	• High-level critical thinking
• Dialogue among students	• Agreement with goals of national standards
• Constructivism and inquiry	• Simple preparation and easy directions

NOTES

1 The Waters Foundation uses these questions in its teacher training workshops—a good way to maintain focus on the central purpose of system dynamics in education. Students delve beyond surface events to question their causes and broader implications.

2 Gayle Richardson framed these questions as a way to help students understand and graph change. For more information, see "Getting Started with Behavior Over Time Graphs: Four Curriculum Examples," 1998, available from the Creative Learning Exchange at www.clexchange.org.

Lesson	Math Standards (NCTM)	Economics Standards (CEE)	System Dynamics Objectives (CLE)
Lesson 1: **Can I Manage My Money and My Music?** Saving for a GOAL (an mp3 player and tunes), and spending "wisely" to make that savings last. ***Lesson 2:*** **Can I Reach a Personal Saving and Spending Goal?** Pursuing saving and spending PLANS to reach a personal goal. ***Lesson 3:*** **Can I Make Money with a Lemonade Stand?** Running a business, with income, expenditures, and profit. ***Lesson 4:*** **Can I Successfully Run the Local Food Bank?** A non-profit maximizing the "good" it does (rather than profits!) while needing to be sustainable. ***Lesson 5:*** **Can I Help a Responsible Teen Buy a Car?** Role of "trade-offs" (short-term vs. long-term gratification, sacrificing free time for work) to pursue a "big" financial goal. ***Lesson 6:*** **How Does Interest Grow My Savings?** Introducing the "miracle" of compound interest and its power for generating long-term savings. ***Lesson 7:*** **Can Compounding Interest Make Me a Millionaire?** Putting all of the pieces together—saving, spending, and earning interest—to see if an "average" person can become a millionaire!	**CONTENT STANDARDS** **Number and Operations** • Understand meanings of operations and how they relate to one another. **Algebra** (includes some Grade 6–8 standards) • Understand patterns, relations, and functions. • Use mathematical models to represent and understand quantitative relationships. • Analyze change in various contexts. **Data Analysis and Probability** • Formulate questions that can be addressed with data; collect, organize, and display relevant data to answer questions. • Develop and evaluate inferences and predictions that are based on data. **PROCESS STANDARDS** **Problem Solving**: Build new mathematical knowledge; apply/adapt a variety of strategies to solve problems; reflect on process. **Reasoning and Proof**: Make/ investigate mathematical conjectures; develop/evaluate mathematical arguments; use various types of reasoning and methods of proof. **Communication**: Organize and consolidate thinking; communicate coherently and clearly to peers, teachers, and others; analyze and evaluate thinking/strategies of others. **Connections**: Recognize and use connections among mathematical ideas; recognize and apply mathematics in contexts outside of mathematics. **Representation**: Create/use representations to organize, record, and communicate mathematical ideas and to model and interpret physical, social, and mathematical phenomena.	**Standard 1**: Students will identify what they gain and what they give up when they make choices. **Standard 2**: Students will make effective decisions as consumers, producers, savers, investors, and citizens. **Standard 3**: Students will evaluate methods of allocating goods and services, by comparing the benefits and costs of each method. **Standard 4**: Students will identify incentives that affect people's behavior and explain how incentives affect their own behavior. **Standard 8**: Students will predict how prices change when the number of buyers or sellers in a market changes. **Standard 12**: Students will explain situations in which they pay or receive interest. **Standard 13**: Students will predict future earnings.	1. Systems are dynamic, meaning that they are characterized by change over time (familiarity with Behavior-over-Time Graphs). 2. Dynamics in systems are a result of the interaction of stocks and flows (ability to create a simple one-stock stock/flow diagram). 3. Altering inflows and outflows can create many patterns of change in stocks (understanding different graph patterns and the underlying data and dynamics to which they are linked). 4. Inflows and/or outflows are controlled in many ways to achieve a desired size of stock (ability to manipulate a simple one-stock model to achieve desired outcomes). 5. Reinforcing feedback loops (e.g., compound interest) are powerful and often non-intuitive in their effects (familiarity with the concept of reinforcing feedback and how it influences stocks and flows).

Lesson 6

How Does Interest Grow My Savings?

NOTE — The material developed in Lesson 1 is strongly recommended to familiarize students with the basic concepts that are used and further ex-panded in this lesson.

Instructions for Teachers

Student Challenge:

Lesson 6 recognizes that the mathematics of compound interest is likely to be a challenge for some students. To help them understand the concept, students are given two exercises.

- In Exercise 1, students work with pencil and paper to explore how the compounding process works in the "real world", using 5-day illustrations of the spread of rumors, of disease, and of an offer to double the money in an account each day.
- In Exercise 2, students use a computer simulation to explore the impact of different rates of compounding interest over different periods of time in a savings account.

MATERIALS

- Computer Simulation (available on-line at http://clexchange.org/curriculum/dollarsandsense/lesson6.asp).
- Two worksheets (use as needed) to record PLANS and results.

In both exercises, the GOALS are (1) to introduce students to the powerful (and often explosive) nature of compound growth, as it plays out over time, and (2) to offer a real-world understanding of the potential power of compound interest (which Albert Einstein reputedly called "the most powerful force in the universe!") in shaping their personal finances.

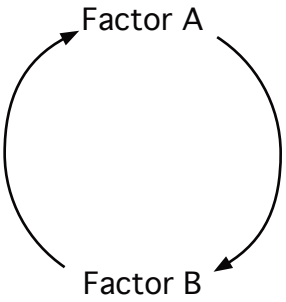
At the Lesson's End:

- Students will have completed a structured exploration of how the process of compounding growth, which involves what systems thinkers call a reinforcing feedback system, affects not only their personal finances, but also a number of other social and biological systems.
- Students will have used tables, graphs, and systems thinking concepts to explore the impact of different interest rates and periods of time on their personal finances, and they will be able to share their results with classmates (and parents!) in comparing different strategies.

(See the following Instructions and the Worksheets for more details.)

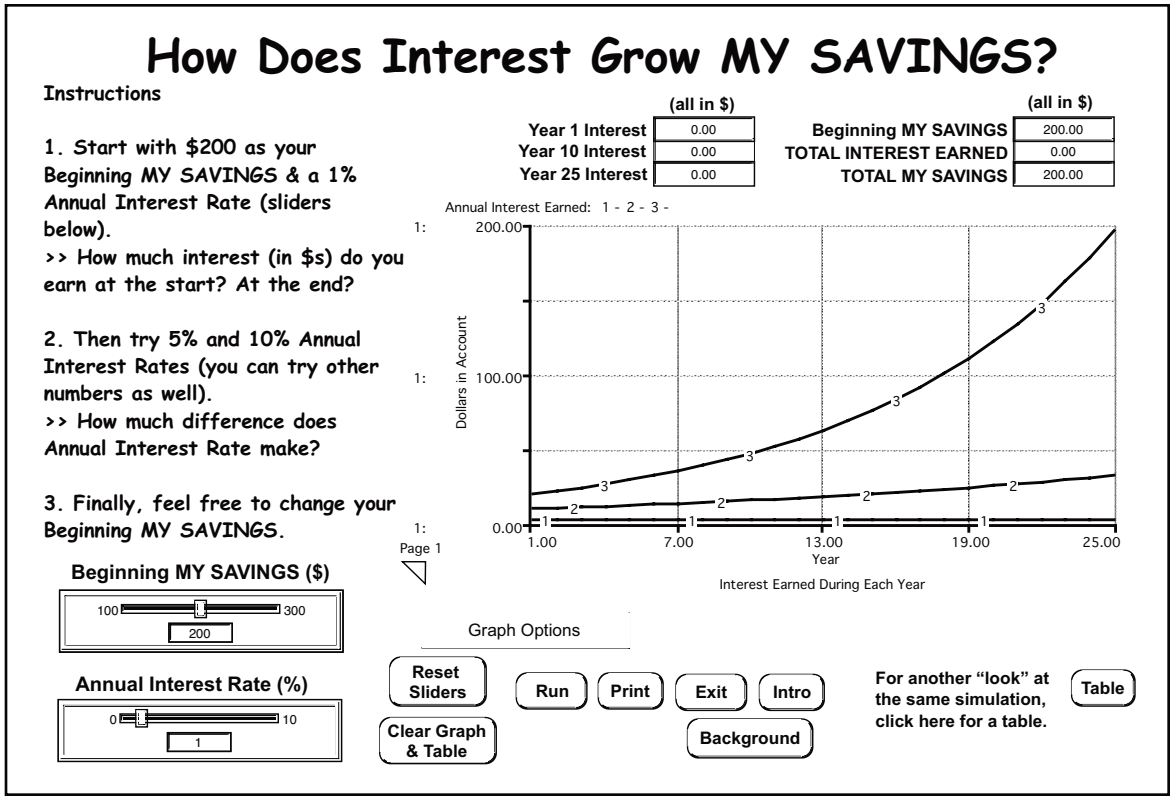
Overview

This lesson contains two separate exercises. First, students learn about the general process of compounding as it influences not only personal finance, but also other processes such as the spread of rumors and the spread of disease. Common to all of these is a systems concept called "reinforcing feedback."



Reinforcing feedback is a type of circular causality, where a change in one factor causes a change in another factor (or factors) in the same direction and then cycles back to cause the original factor to change again in the original direction (see loop). Often described as generating "virtuous" or "vicious" cycles, reinforcing feedback leads either to increasing growth or decline over time.

Second, is an exercise that utilizes a computer simulation and focuses explicitly on compound interest in a bank savings account. The simulation's Control Panel, reproduced below, illustrates the impact of different interest rates (1%, 5%, and 10% respectively for PLANS 1,



2, and 3) on an initial savings account of $200 over a 25-year period).

Students will observe that the amount of Interest Income they receive each year grows at an ever-increasing rate (NOT a constant interest being earned each year or even a linearly increasing interest!). That is because the amount of Interest Income the bank pays each year is governed by two factors:

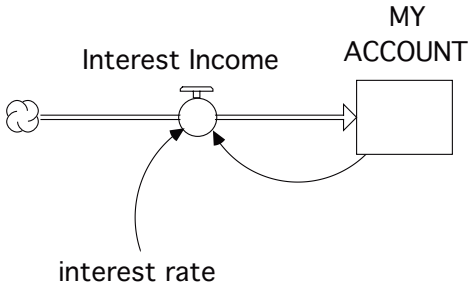
a. The amount of money in MY ACCOUNT; and

b. An interest rate paid by the bank.

Each year's Interest Income is added to MY ACCOUNT, so that the base for next year's interest payment will include interest paid in previous years.

Compound interest is an example of reinforcing feedback. Interest income added to MY ACCOUNT increases the amount of money in that STOCK of money. The next time interest is calculated, there is additional interest because now there is more money in MY ACCOUNT. This happens each time, resulting in still more money in MY ACCOUNT . . . and so on.

If left alone for a long period of time,
the reinforcing feedback produces explosive growth.



Lesson Structure

Two separate exercises are contained in this lesson: the first looks at the process of compounding from a broad conceptual perspective, and the second uses a simulation to explore the dynamics of compound interest.

Exercise 1. How Does Compounding Work?

Working on Paper to Develop a Conceptual Understanding of the System

1. Developing a Basic Understanding of the Compounding Process

The process of compounding growth is a common part of our lives. Students will select (or be assigned) one of three "everyday" illustrations and then do the following: (1) calculate (using a Table and Graph) how compounding leads to ever accelerating growth and (2) use a Stock and Flow Conceptual Map and Causal Loop Diagram to better represent how the compounding process works. The three illustrations are described below.

- **Rumors:** 1 person starts a rumor. Each day for 5 days, that person tells 1 other, each of whom, in turn, tells 1 other each day, each of whom tells 1 other each day, … and so on. How many people (rumor mongers) are spreading the rumor after 5 days?
- **Infection:** A person becomes sick and remains sick for 5 days. Each day, that person infects 2 others; they each infect 2 others each day, each of whom infects 2 each day, … and so on. How many sick people are there after 5 days?

A powerful hands-on lesson, "The Infection Game," contained in Creative Learning Exchange's *The Shape of Change* curricula, offers students the opportunity to physically simulate the spread of an infection in a classroom and graph the results.

For more information, see www.clexchange.org.

- **An Offer You Can't Refuse:** Your father offers you a choice; he will (1) give you $100 today, or (2) give you $1, and then each day for the next 5, he promises to add 2 dollars for every 1 you already have. How much will you have after 5 days with that second offer?

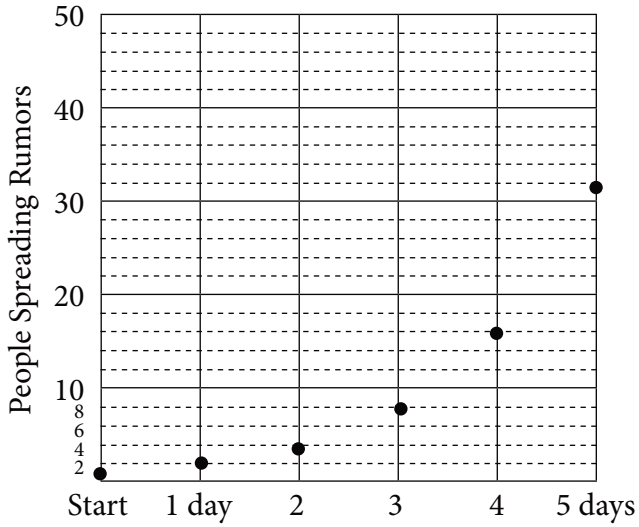
2. Using Graphs and Tables

As in the previous lessons, students use Graphs and Tables to describe and communicate the patterns of change that they observe over time in the three illustrations. Each has distinct strengths that the students should recognize and be prepared to discuss.

- The Graph provides a powerful visual representation of the compounding process (non-linear growth).
- The Table records the size of the STOCK daily **and** the rate of change (the inflow).

Illustration 1:

Graph

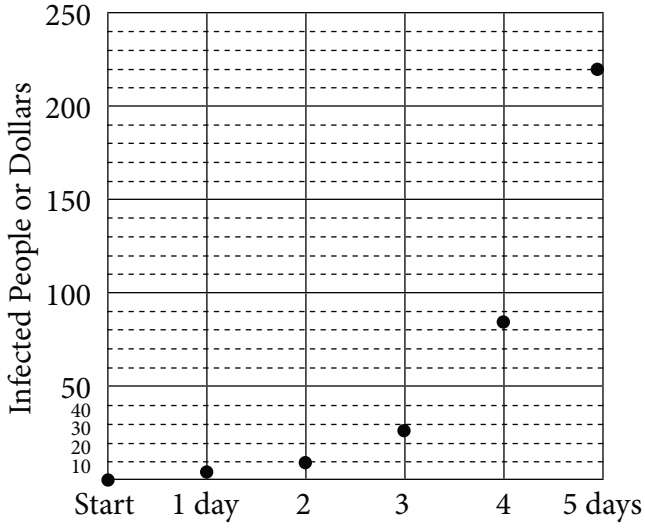


Table

Days	STOCK	Daily Change
0	1	1
1	2	2
2	4	4
3	8	8
4	16	16
Final	32	----

Illustration 2 or 3:

Graph



Table

Days	STOCK	Daily Change
0	1	2
1	3	6
2	9	18
3	27	54
4	81	162
Final	243	----

3. Telling a Story using Conceptual Systems Thinking Tools

Students use two systems thinking tools—Stock and Flow Maps and Casual Loop Diagrams—to diagram and describe the common dynamics of compounding. These tools contain important causal arrows that explain what is happening in the system and why.

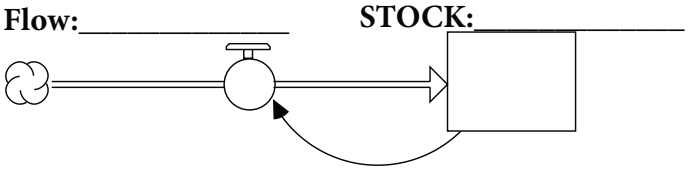
Using both a Stock and Flow Map and Casual Loop Diagram, each of the three stories is illustrated below (with answers given for each of the three numbered challenges).

- In the Stock and Flow Map, the arrow shows that the accumulation in the STOCK affects the size (rate) of the Flow. Thus, in each case, the Flow will add to the STOCK; that larger STOCK then causes a larger Flow the next time.

Stock and Flow Map

FLOWS:
1. New Rumormongers
2. People Become Ill
3. New Dollars added to my Account

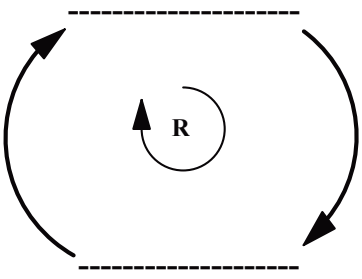
STOCKS:
1. PEOPLE SPREADING RUMORS
2. SICK PEOPLE
3. MY DOLLARS



Causal Loop Diagram

- In the Causal Loop Diagram, the first arrow shows that one element causes a change in a second; the second arrow shows that this change in turn causes a change in the original element in the same (or reinforcing) direction. An "R" inside the loop indicates a Reinforcing Feedback Loop.

1. New Rumormongers
2. People Become Ill
3. New Dollars added to My Account



1. PEOPLE SPREADING RUMORS
2. SICK PEOPLE
3. MY DOLLARS

Some people prefer telling stories with Stock and Flow Maps; others use Causal Loop Diagrams.

4. Putting the Pieces Together (Exercise 1)

Students now ANALYZE and DESCRIBE the common story in all three illustrations.

A. Each of the three illustrations involves a compounding or Reinforcing Feedback Loop, where the STOCK affects the size of the Flow (and *vice versa*). As the STOCK grows, the Flow increases, which then increases the STOCK, which increases the Flow still more … and so on, leading to compound or exponential growth. Hence, the stories about the three illustrations are similar.

1. One rumormonger tells a second on day 1, making a total of 2 rumormongers at the end of day 1; on day 2 those 2 tell 2 more (making 4); on the next day the 4 tell 4 more … and so it goes.
2. A single infected person infects 2 more people on day 1, making a total of 3 infected people at the end of day 1; each of the resulting 3 infects 2 more people on day 2 (adding 6 more for a total of 9) … and so on.
3. A single dollar generates 2 more on day 1 making a total of $3 at the end of day 1; each of those $3 generates 2 more on day 2 (adding $6 more for a total of $9) … etc.

B. Students see a Reinforcing Feedback Loop operating in a variety of other familiar contexts, such as the following examples:

1. Spreading rumors or infections could easily be converted to word-of-mouth advice: "I bought one of these, so should you." We can see that phenomenon in "fads"—the right clothing to buy, the best new electronic device to buy, the newest hairstyle, etc.
2. The world of finance is built on growth: "Good" companies are those that report that their sales are growing (over last quarter or year); if a company is able to double its sales each year—wow!
3. Noise in the lunch room can also show reinforcing growth. As people talk, the NOISE LEVEL (a STOCK) increases. That means people have to talk louder to be heard ('making more noise' is the Flow), causing the NOISE LEVEL to increase further, … and so on, to bedlam.
4. On a less obvious front, emotions or behaviors often are subject to reinforcing growth; for instance, anger builds on itself (we talk about it festering). On a more positive side, a little confidence can also lead to more confidence, and so on.

Exercise 2: Earning Interest on a Savings Account

An Introduction to Compounding Interest - Simulation

In this simulation, students start with $200 in their bank accounts and then explore what happens, over 25 years, if the account earns a constant interest at rates of 1% each year, 5% each year, or 10% each year. The simulation's Control Panel was illustrated earlier in this lesson.

1. Using the Computer Simulation to Explore How Interest Works

For each situation, students record information in a Table; expected results are shown below.

If the interest rate is:	Interest Earned: Year 1?	Year 10?	Year 25?	Total Interest Earned: Full 25 Years
1% each year?	$2.00	$2.19	$2.54	$56.49
5% each Year?	$10.00	$15.51	$32.25	$477.27
10% each Year?				

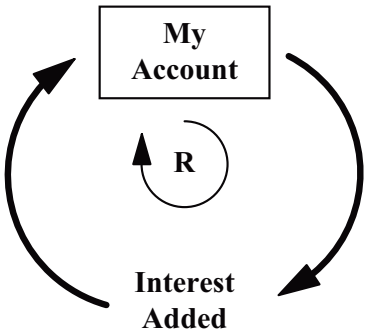
2. Putting the Pieces Together

A. Students are asked to write at least 2 observations about the interest income they earned over the 25 years with hints to look for patterns as they move across the columns (hint 1, below) and up and down the rows (hint 2, below) of the Table.

1. In all cases, more interest is earned each year as the 25 years progress. This is the result of the Reinforcing Feedback Loop: adding interest to the account makes the account bigger, which earns more interest the next year, which makes the account still bigger, so that your savings grow ever-faster with time.
2. As the interest rate increases, so too does the Interest Earned and that increase is not proportional to the increased interest rate. Note above that doubling the interest rate from 5% to 10% results in about **5 times** as much interest income over the 24 years.

B. Students are also challenged to use a Stock and Flow Map (with an added Connector from the Stock to the Flow) and a new tool, a Causal Loop Diagram, to explain what is happening with the compounding interest. Both tools provide means to describe a Reinforcing Feedback Loop and each tells essentially the same story.

For the Causal Loop Diagram, note that the arrow on the right side (moving from MY ACCOUNT to Interest Added) serves the same purpose as the skinny arrow in the Stock and Flow Map; the arrow on the left side (from Interest Added to MY ACCOUNT) serves the same purpose as the Flow in the Stock and Flow Map.



Where and When Will Students Need Guidance?

1. Fully understanding the mathematics behind the process of compounding is likely to be beyond the grasp of many, although we tried to keep it as simple as possible by working with illustrations that used whole numbers in Exercise 1. As such, the simulation (as in the earlier conceptual exercise) is designed to help students learn by observing an unfamiliar pattern of behavior and asking better questions. Compounding, in general, is not beyond their means to understand. Students need to be comfortable with the basics in understanding why compounding growth is not linear: because the amount of growth is influenced by the size of the STOCK. Thus, as the STOCK grows, it leads to greater growth, a still larger STOCK and still greater growth….
2. Interpreting Graphs: Students should be able both to interpret and (in the first exercise) to create Graphs illustrating Behavior-over-Time.
3. Computer games can focus all too often on "Winning." The purpose in using this simulation is to be able to compare PLANS and their implications. It recognizes a range of options (e.g., looking for higher interest rates and keeping one's money in a savings account for a long time) to reap the greater benefits of larger interest payments.

Bringing the Lesson Home

What is the important student-learning from these exercises and this simulation?

- *Interpreting Graphs: Students work with Behavior-over-Time Graphs and should recognize their value for illustrating compounding or exponential growth.*
- *Understanding how compounding works, not only within a financial context (compound interest) but also in a number of broader settings.*
- *Applying these insights beyond the particular illustrations:Although the simulation does have a "best" answer (there is a particular strategy which yields the greatest amount of interest here), it is equally important that the student recognize the limits of this simulation in framing better questions: e.g., What are the trade-offs in long-term saving versus spending? What is a realistic long-term interest rate? Learning can be most powerful when students think outside the box.*

Name_____

How Does Compounding Work?

The process of compounding growth is a part of our everyday lives. **Select one of the three illustrations below and, using the tools provided below (Table, Graph, Stock and Flow Map, and Causal Loop Diagram), describe what is happening in the story.**

1. Rumors: 1 person decides to start a rumor. Each day for 5 days, that person tells 1 other, each of whom, in turn, tells 1 other each day, each of whom tells 1 other each day, … and so on. How many people are spreading the rumor after 5 days?

2. Infection: A person becomes sick and remains sick for 5 days. Each day, that person infects 2 others; they each infect 2 others each day, each of whom infects 2 each day … and so on. How many sick people are there after 5 days?

3. An Offer You Can't Refuse: Your father offers you a choice; he will (1) give you $100 today, or (2) give you $1, and then each day for the next 5, he promises to add 2 dollars for every 1 you already have. Which is the better deal for you?

A. Calculate your answer. Use the Table and then present your answer on the appropriate Graph below.

Illustration 1:

Table

Days	STOCK	Daily Change
0	1	
1		
2		
3		
4		
Final		

Graph

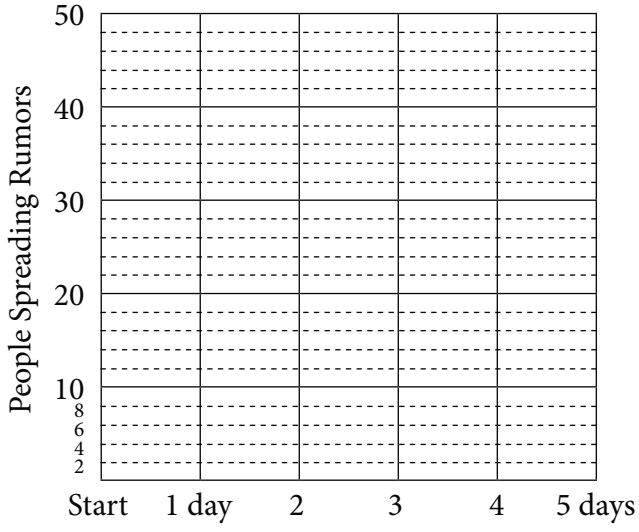
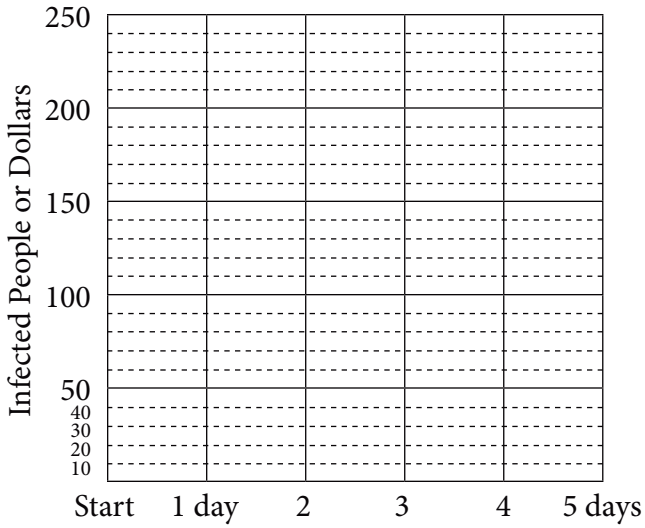


Illustration 2 or 3:

Table

Days	STOCK	Daily Change
0	1	
1		
2		
3		
4		
Final		

Graph



B. Tell the story using systems thinking.

Use the two diagrams below to help describe the system behind what is happening. In each case, select and insert the 2 key elements from your illustration (using the list to the right) in the appropriate space.

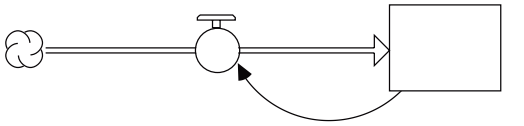
Key Elements Available

1. New Rumor Spreaders
2. People Become Ill
3. New Dollars for my Account
4. People Spreading Rumors
5. Sick People
6. My Dollars

Stock (S) and Flow (F) Map:

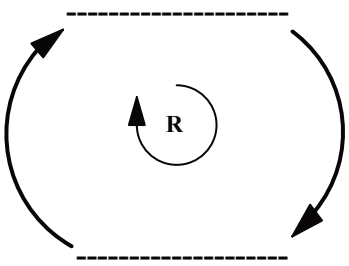
S:_____

F:_____



HINT: The skinny arrow indicates that the STOCK (whatever it contains) AFFECTS the Flow…

Causal Loop Diagram:



HINT: The two arrows indicate that one element CAUSES a change in the other element; that change, in turn, CAUSES the first element to change again. The "R" indicates this is a Reinforcing Feedback Loop; that means the original change (whether it is increasing or decreasing) is amplified each time you go around the loop.

Now <u>tell</u> the STORY (What is happening and WHY) in words.

_____

_____

C. What is the story that is common to all three illustrations?

_____

_____

Name_____

Earning Interest On a Savings Account

Albert Einstein reputedly called compound interest "*the most powerful force in the universe.*" What did he mean by this? Let's explore…

You now have a real bank savings account, opened with $200 (perhaps a gift!). Each year the bank pays you interest on the amount of money in your account. That interest is then added to your account. What this means is the interest the bank will pay you on your account next year will build on the interest the bank has already paid you. Each year you get more interest than the year before. Pretty neat!

1. Use the computer simulation to explore how interest works.
Start with $200 in your account. See what happens over 25 years, if your account earns interest rates of 1% each year, 5% each year, or 10% each year.

For each situation, record information in the Table below.

If the interest rate is:	Interest Earned: Year 1?	Year 10?	Year 25?	Total Interest Earned: Full 25 Years
1% each year?				
5% each Year?				
10% each Year?				

2. Briefly answer the following questions using the information from the Table.
Write at least 2 observations about the interest you earned over the 25 years. (HINT: Look for patterns as you move across, as well as up and down, in the table above.)

A. _____

B. _____

3. What do you notice about the amount of money you received in interest when the interest rate doubled from 5% to 10%? (Hint: Did the amount of interest you receive double?)

_____

_____

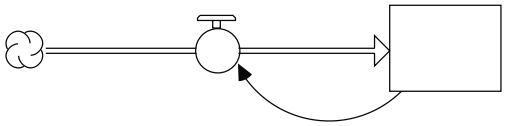
Name_____

4. Explaining how interest works. Can you explain to someone else what happened with interest in your bank account?

A. We would like you to tell the story by first labeling the Stock and Flow Map below.
   1. What is the STOCK that is accumulating?
   2. What is flowing in to add to that accumulation?

S:_____

F:_____

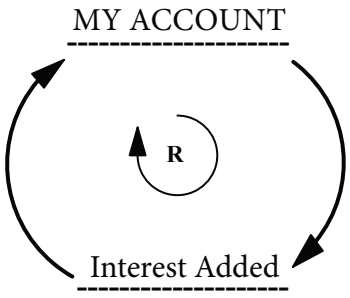


B. Next, add the "compounding" part of the interest story. The red arrow says something in the STOCK caused something to happen to the Flow. What caused what to happen?

_____

_____

C. Another way to describe what is happening uses a Causal Loop Diagram. Note that the diagram contains two arrows to create a closed loop. Can you use this to describe what is causing what to happen to MY ACCOUNT and Interest Added? When does it stop?



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About Us

The Creative Learning Exchange

The Creative Learning Exchange (CLE) is a non-profit organization in Acton, Massachusetts dedicated to promoting learner-centered learning and system dynamics in K-12 education. The CLE disseminates classroom curricular materials developed by teachers, publishes a quarterly newsletter, hosts a biennial conference for educators and interested citizens, maintains a listserve, and provides system dynamics training materials and programs for educators. Information is available at *www.clexchange.org.*

System Dynamics

System dynamics is a field of study and a perspective for understanding change. Using computer simulation and other tools, system dynamics looks at how the feedback structure of systems causes the change we observe all around us. System dynamics was developed fifty years ago by Professor Jay W. Forrester at MIT and is used to address problems in areas ranging from ecology, to business management, economics, and psychology. Under Forrester's guidance, system dynamics is helping teachers make K-12 education more learner-centered, engaging, challenging and relevant to our rapidly changing world.

CLE Curriculum Series

This series of books, *Dollars and Sense, The Shape of Change* and *The Shape of Change: Stocks and Flows,* introduces students and their teachers to some of the basic ideas of system dynamics and systems thinking as a way to observe and understand change.

These books:
Dollars and Sense
The Shape of Change *and*
The Shape of Change: Stocks and Flows

can be purchased from the Creative Learning Exchange at:

www.clexchange.org

978-635-9797

milleras@clexchange.org

These and other lessons can be downloaded in PDF format free of charge from the CLE website.

Lesson Title(s):
Dollars and Sense, Lesson 6: How Does Interest Grow My Savings?
Dollars and Sense, Lesson 7: Can Compounding Interest Make Me a Millionaire?

Overview:
The simulations in *Dollars and Sense* introduce 5th – 7th grade students to the terminology and basic structures of saving and spending using stocks and flows as well as graphs. Students become aware of the tradeoffs whereby present decisions to save or spend money can affect future financial goals.

Related Characteristic(s) of Complex Systems:
Conflicts arise between short-term and long-term goals.

Ideas and Examples for Connecting to the Characteristic:
Lesson 6 of the *Dollars and Sense* series introduces students to the concept of exponential growth through examples and exercises using compounding interest, the spread of rumors and the spread of infection. Using the simulation, students explore how money in a savings account grows over time under various interest rates.

In Lesson 7, they test various scenarios for saving and spending that will enable them to reach the long-term goal of saving one million dollars. Living below one's means in the short term is often viewed as a difficult sacrifice. This lesson illustrates the benefits of starting to save early in life to realize the full benefits of compounding interest over a long timeframe.

To prompt discussion with students:

1. Ask students about their own savings habits. Do they receive an allowance from their parents or money as gifts? What do they do with their money – save a portion or spend everything?
2. If the concept of saving a large sum such as one million dollars is difficult, use smaller amounts (such as weekly allowance sums) and shorter timeframes to illustrate how long it will take them to achieve more modest savings goals. Be sure to specify how much additional savings comes from earning interest.
3. Help students brainstorm a list of "big purchases" they may make in their lifetimes or their parents have made for the family (college education, car, house, etc.). Ask what they think the impact of such big purchases may be on one's ability to save one million dollars. Iterate that the key to saving large sums of money is to spend less than you earn and allow interest to accumulate over a long period of time!

Resource(s)
Dollars and Sense by Jeff Potash

A fun quiz about saving and spending habits of millionaires:
http://themint.org/kids/the-truth-about-millionaires.html