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Using Systems Tools to Improve Literacy

Alan Ticotsky

Welcome Fifth Graders

Mairead Orpen teaches every 5th grader who attends Innovation Academy Charter School (IACS), a public charter school in Tyngsborough, MA. Mairead's class is named "Critical Thinking and Reading," or CTR for short. In the spring and fall of 2012, she developed a sequence of lessons and activities for her students that includes three important elements central to the vision that guides the school:

Element One
Academic Goal—Improving Reading Skills

Her goal is to help each student improve in the important skills of applied reading. Examples of applied reading include understanding math word problems, reading content area material, and analyzing text such as literature and periodicals. State standards and the Common Core Standards both emphasize the need for students to read complex texts, and to determine and understand the point of view presented by the author.

Element Two
Non-Academic Goals—Four Social Outcomes

Because IACS includes grades 5 through 12, Mairead works with students new to the school, so she is an important part of their orientation to the way things work there. The school's philosophy and mission, as embedded in its charter, guides teachers and staff to engage students in hands-on, collaborative project-based work with frequent presentations. IACS students are expected to develop skills in citizenship as well as attaining academic competencies. They are encouraged to grow in four specific outcomes:

- self direction
- problem solving
- effective communication
- group membership.

Element Three
School-Wide Goal—Understanding and Using Systems Thinking and System Dynamics

The IACS charter states that systems thinking and system dynamics "will provide a conceptual framework and guiding force in the development of curriculum." Students are expected to gain competence with systems tools and be able to apply them to help understand complex issues and ideas.

Mairead has helped her fifth-grade students progress toward all three goals beginning in their first few weeks at IACS. Starting the unit early in the school year in her CTR classes helped set the tone for the year and teach skills that would become part of each student's repertoire in CTR as well as in their other core classes. **Behavior-over-time graphs (BOTGs)** provided a beginning point and a structure.

Unit Sequence

1. What's Changing? BOTGs

Students read *The Lorax,* by Dr. Seuss, a story Mairead worked with in the spring with last year's students and decided to use in the beginning of the school year with this group. Mairead helped to pilot lessons posted at the Creative Learning Exchange website:

www.clexchange.org/ftp/documents/x-curricular/CC2012_TheLorax.pdf

and

www.clexchange.org/ftp/documents/x-curricular/CC2012_TheLoraxGraphslessons.pdf

The Lorax is a fable about an overly ambitious entrepreneur, the Once-ler, who destroys the environment in his greed for profit and growth. The character named the Lorax speaks for the animals and plants whose habitat has been destroyed, but the Once-ler insists business is business. Mairead asks students to draw behavior-over-time graphs (BOTGs) of the elements in the story that are changing. Teams of students compare their graphs and discuss their ideas, frequently citing the text. Mairead guides students to graph multiple variables on the same

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THIS ISSUE AT A GLANCE

EDITORIAL

This issue highlights two different initiatives: work at Innovation Academy (IACS) in Tyngsboro, Massachusetts, and a second series of lessons for financial literacy, *Dollars and Sense: Our Interest in Interest.*

Bringing systems thinking and system dynamics into K-12 classrooms requires work on numerous fronts. A founding principle of IACS is classroom use of system dynamics, and recently there has been an increased concentration on that aspect of the charter school. Alan Ticotsky, a systems mentor at IACS, shares here what is happening in one of their classrooms. We have had the benefit of his work in our previous newsletters, as well.

We also present the first of eight lessons in the new Dollars and Sense module, *Dollars and Sense: Our Interest in Interest*. This is the second exciting financial literacy module created by Jeff Potash of CIESD and the CLE funded by the Julis Foundation. It introduces the idea of compounding interest and creates a simulation for students to combine the factors of a personal financial plan that works.

As spring approaches, teachers need new interesting materials to help keep students engaged. We encourage you to look at the emerging *Dollars and Sense* lessons and the *Characteristics of Complex Systems* lessons, and we hope you will be inspired by Mairead's integration of systems thinking into her classroom.

Take care,
Lees Stuntz
(stuntzln@clexchange.org)

Why System Dynamics?

From an online blog by Richard Turnock at
http://turnock.blogspot.com/2012/04/why-system-dynamics.html

All systems everywhere have levels and flows. These are the only two concepts needed to understand *why* systems work the way they do (Forrester, 1996).

We were taught in school to accumulate knowledge and skills in order to get a job. We define learning as the accumulation of knowledge. We test every child at every grade level to measure their accumulated knowledge. We teach people how to do things so they have a skill in order to get a job.

Public education teaches people *what* is important to know. Students learn skills so that they know *how* to do things. Students are tested on *what* they know and the skills for *how* to use what they know. System Dynamics (SD) enables us to understand *why* systems work they way they do.

Public education involves a way of thinking, learning and communicating that focuses on the past up to the present. Science, math, reading and writing are all focused on knowledge (*what*) and skills (*how*) that have been codified into a curriculum. In public education, students learn about the past up to the present.

Life is moving fast. We need a way to think, learn and communicate about the future. The current public school system does not meet that need.

Sustainability education and environmental literacy are focused on students learning more and more about how to do more things. By conforming to the way the current public education system focuses on *what* and *how*, we are asking students to accumulate more and more knowledge about the recent past. We are asking students to accumulate more and more skills about *how* things were done in the recent past.

System dynamics is a tool to think, learn and communicate about the future (Richmond, 2010). With SD, learning is about *why* systems work they way they do. *What* is needed to model a system is accumulated just in time to use in a model. The knowledge needed about *how* the parts of a system are related is accumulated just in time to use them in a model. The understanding needed about *why* feedback loops in systems tell a story is accumulated just in time to use them in a model.

SD enables us to understand *why* systems work the way they do. Politicians and decision makers need to know *why* systems work the way they do so that they can craft policies that are successful in the future. Policy makers need informed citizens who know *why* systems work the way they do.

Why do policymakers choose policies that fail? A policy response is rational for decision makers who fail to account for the feedback structure of a system. Only by considering the full feedback structure is the ineffectiveness of a policy revealed. By learning why feedback affects system behavior, small system dynamics models have a crucial role to play in policy making (Ghaffarzadegan, 2012).

Why System Dynamics *continued on page 12*

Using Systems Tools to Improve Literacy

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pad in order to discover causality and correlation among story elements.

2. How and Why are Things Changing? Connection Circles

Next, students create connection circles, a precursor to causal loop diagrams and a brainstorming tool to discover feedback in a story or system. They space the elements they graphed around a circle, and then draw arrows from causes to effects. Eventually, Mairead plans to teach the kids how to trace closed loops in their circles and to identify and differentiate between reinforcing and balancing feedback. But early in the year, she feels satisfied that they can describe causal connections and explain the competing elements in the story.

3. What Can be Done? Policy Decisions

How can the tragedy of *The Lorax* be avoided, both in the story and in real life? Students in her CTR classes are assigned to create a business plan that the Once-ler (or other business planners) could use. While Mairead was developing and teaching the unit, IACS was expanding its campus and cleared an area of forest to build an athletic track and field. So Mairead also assigned students the task of suggesting ways IACS could ensure that their expansion didn't spoil the acres of woods surrounding the school.

4. Expanding the Learning—Analyzing Nonfiction Text

Mairead helps the students transfer the knowledge and skill gained from *The Lorax* activity to other texts. Students read selected current events articles from classroom news magazines. They use the BOTGs and connection circles to analyze the articles and sort out the difficult issues facing our world today. For example, the problems facing the islands of Indonesia are very similar to *The Lorax* story; the expansion of lucrative palm oil plantations is reducing orangutan habitat, placing increasing pressure on a threatened species. Students can apply the same techniques they learned while reading Dr. Seuss and thinking about their expanding school to another complicated real world problem. For the rest of the school year and beyond, students have added a powerful set of analytic tools to their skill set as they move on in their learning.

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CAM Project Summer Workshops

Make Climate Science Come Alive with Student Media Production (made easy) workshops coming up this summer

The Climate Education in an Age of Media (CAM) project at the University of Massachusetts Lowell (http://cleanet.org/cced_media/index.html) invites you to attend two 3-day summer workshops for secondary and post-secondary science educators to combine student-created media production and climate science.

- **June 26-28** at the Cambridge Rindge and Latin School (CRLS) Media Arts Studio
- **July 9-11** at the Media Center, University of Massachusetts, Lowell campus

Gain the tools needed to quickly ramp up to the Next Generation Science Standards at a workshop that combines climate science, systems thinking, and science communications skills through media production. Tackle your media anxieties and tap into the excitement around media production, using easy-to-use lesson plans that bring student media production into any instructional environment.

Workshop leaders are Juliette Rooney-Varga, Associate Professor at University of Massachusetts Lowell, and Angelica Allende Brisk, Creative Design and Media Journalism Instructor, CRLS Media Arts Studio.

Teachers will receive a stipend for these workshops, and PDPs upon request. Space is limited and an application is required.

- **June** workshop details: http://cleanet.org/cced_media/workshops/june2013/index.html;
- **July** workshop details: http://cleanet.org/cced_media/workshops/july2013/index.html.

Questions? Contact Marian Grogan at marian_grogan@terc.edu

Using Systems Tools to Improve Literacy

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Transferring the Skills: Sharing Authors' Purpose in Reading Journals

As many English and Language Arts teachers do, Mairead assigns students independent reading as a standing homework assignment. Monitoring student understanding and progress is a difficult task for teachers. Children are all reading separate books, many of them unfamiliar to the teacher. Requiring student journal entries, or reading response, can be boring to both teacher and young reader, producing a summary offering little insight and at times dampening student enthusiasm for the pleasure of reading.

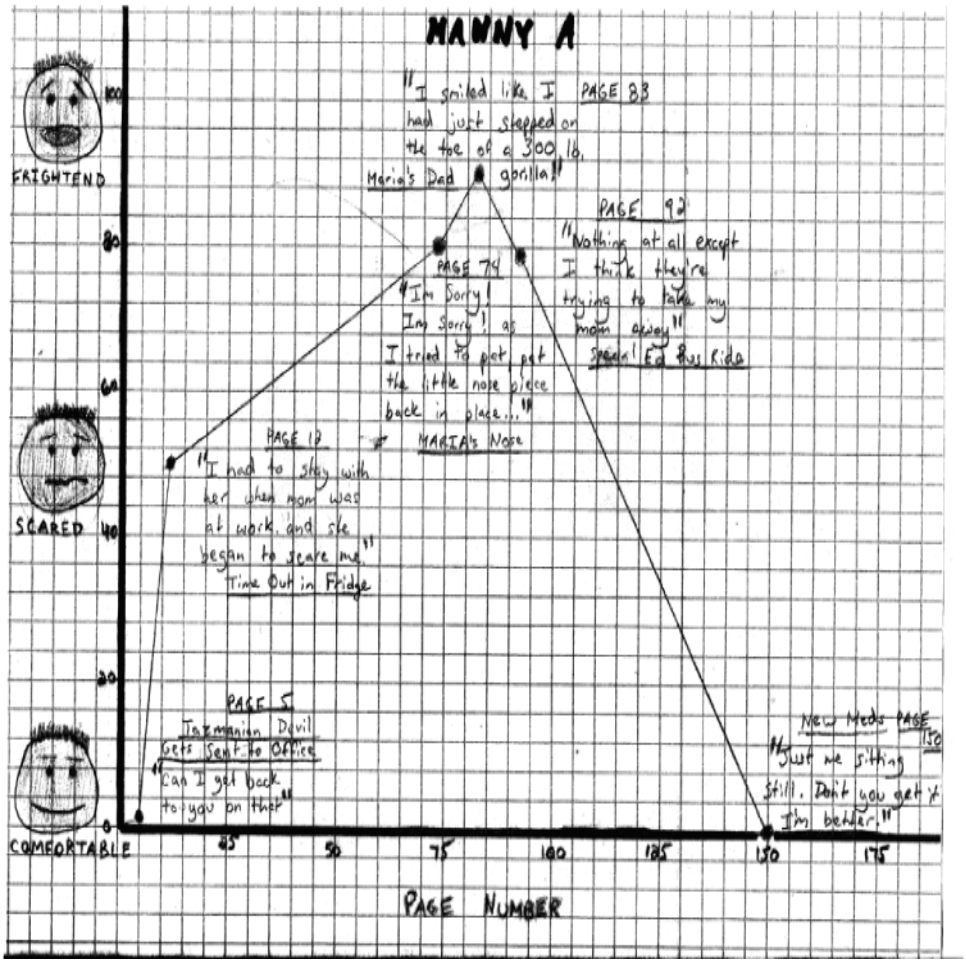
Mairead has found that encouraging students to use systems tools, such as BOTGs, connection circles, and feedback loops, raises the engagement level of student-teacher conversation about independent reading. Rather than a summary, Mairead receives an analysis from each student. What are the important changes the author writes about, and what is his or her perspective? These analytic skills applied to text are an important component of the Common Core Standards, so students are practicing them while Mairead gets a better (and more interesting) picture of how each child is progressing with independent reading.

More Applications for Systems Tools

Teachers who have learned to use systems tools are steadily finding ways to support student learning in new contexts. It's been said that once you learn about systems thinking, you read the newspaper differently: you identify the behaviors that are changing, feedback loops become more evident, and the sources of conflicts become clearer. We can hope that systems thinkers will help find solutions too.

Mairead Orpen finds systems thinking a natural fit for helping her accomplish the multiple goals she has for fifth graders:

- Dealing with the complex task of reading;
- Growing into responsible members of a learning community;
- Understanding how systems thinking and system dynamics can help make sense of complex situations.



Example of student graph of independent reading book

Each one of these jobs is a lot to ask of anyone. In Mairead's vibrant classroom, the work of a skillful teacher and engaged students creates steady progress. Their hard work and creative thinking is evident in group collaborations, individual presentations and projects, classroom conversation, and insightful text and diagrams. The natural fit between systems thinking and a class named "Critical Thinking and Reading" has been made operational at IACS. It's exciting to look forward to more applications by the students, as they move along with their new set of tools.

Dollars and Sense II: Our Interest in Interest, Managing Savings, and Debt

Lesson 1: Can Compound Interest Work for Me?

Overview of Contents

This lesson contains three "hands-on" and progressively challenging simulations designed to let students EXPLORE and EXPERIENCE the system of compounding interest, what Albert Einstein is alleged to have called "the most powerful force in the universe."

- Simulation 1 offers students a "simple" 7-Day Challenge: predict the final value of an allowance fund that, starting with $1 on Day 1, is matched daily (between $1 and $5 for each $1 in the fund) over the next 6 days;
- Simulation 2 lets students explore more "realistic" scenarios involving an interest rate (between 1 and 5%) on a Savings Account opened with a one-time deposit for a number of years (from 1 to 20); and finally
- Simulation 3 encourages students to compare options for building a $25,000 college fund using different starting ages (when the student is between 1 and 17), interest rates (1-10%), and rates of annual deposits.

In each case, students will see the results of different compounding interest scenarios plotted out over time in GRAPHS and TABLES.

Materials

- Computer Simulation (available online at http://www.clexchange.org/curriculum/dollarsandsense/Dollars and Sense II/ds2_lesson1.asp.
- Three handouts (use as needed) to record plans and results.

Core Objectives For Lesson 1

1. Compound Interest

The rate at which compound interest adds to savings is influenced by a combination of 3 key factors.

The core financial take-home message is this: the "power" of compound interest earned on one's savings rests with the amount of money deposited in a savings account, the interest rate paid on those savings, and the amount of time the account accrues interest.

2. Using Models to Test Options

The simulations offer no single right answer, just opportunities for students to explore different "What ifs" in discovering what works best for them personally.

The open-ended and hands-on focus of each of the three simulations in this lesson are designed to encourage students to explore and evaluate different options and opportunities in identifying and subsequently explaining to others a personal preference. At the core of this process is a recognition that there is no single right answer for everyone. Rather, there are options, trade-offs, and ultimately multiple pathways through which students can define and subsequently achieve personal financial goals.

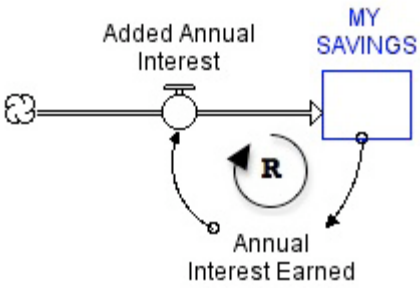
3. How Compound Interest Works

Students benefit by observing how the system of compound interest is structured and seeing it operate over time.

In addition to supporting a mathematical understanding (using equations, in addition to graphs and tables) of the compounding process, students are presented with systems thinking conceptual tools to bolster their understanding of interest as a "System" whose core structure explains its behavior (exponential growth).

Deepening Understanding For How The "System" Works

The conceptual tools of systems thinking help visualize the dynamic process that unfolds over time. The core process of compound interest is represented as a conceptual system (shown below): the amount of **annual interest earned** is governed by the amount of money in **MY SAVINGS** account and a rate of interest (e.g., 4% = .04) paid annually (not shown here) on that SAVINGS.



Compounding Interest involves a reinforcing feedback process. Interest flows into MY SAVINGS, causing that stock to grow, which translates into larger interest earnings the next year, more SAVINGS, and an ever-growing amount of interest over time.

Dollars and Sense *continued on page 6*

Dollars and Sense II, Lesson 1

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What follows are brief introductions to each of the three simulations, "annotated" versions of suggested student handouts to accompany each of the simulations, and possible follow-up questions and activities for extended learning opportunities.

SIMULATION 1: A 7-Day Mathematical Challenge

http://www.clexchange.org/curriculum/dollarsandsense/Dollars and Sense II/ds2_lesson1.asp

This exercise is designed for students who are unfamiliar or uncomfortable with solving a compound interest problem using an algebraic compounding equation. Presenting a simple compounding challenge—*Starting with a $1 allowance on day 1, how many $ will you have on day 7 given a daily match of $2 for every $1 you have?*—students are encouraged to solve the problem initially with pencil and paper.

In representing the changing daily match of $$ as a FLOW adding to one's total accumulation—or STOCK—of MY ALLOWANCE $, systems thinking tools help students see how compounding interest—or, in systems terms, reinforcing feedback—works: the daily "match" adds to the total of MY ALLOWANCE $ which, on the next day, increases the amount of the match, adding more ALLOWANCE $, and an even larger match, and so on.

The simulation itself broadens students' ability to explore "what ifs," using a "Daily Match" between $1 and $5 for each of MY ALLOWANCE $. Seeing multiple results helps students understand the NON-LINEAR dynamics of compound interest, where interest grows faster later than earlier and where differences in the amounts of interest translate into far larger differences over time.

Systems thinking tools help students see how compounding interest—or, in systems terms, reinforcing feedback—works.

SIMULATION 1 HANDOUT with ANSWERS and GUIDES FOR TEACHERS

Can Compounding Interest Work for Me? A 7-Day Mathematical Challenge

1. Open the Simulation, read the Introduction, and summarize your task below:

It is important that students understand (and can explain) the learning objective for using the simulation. The task is to compare two allowance payment options, a lump sum ($100) or, starting with $1 on the first day, a $2 match daily for each $ already in the account for a week.

Which option should you choose?

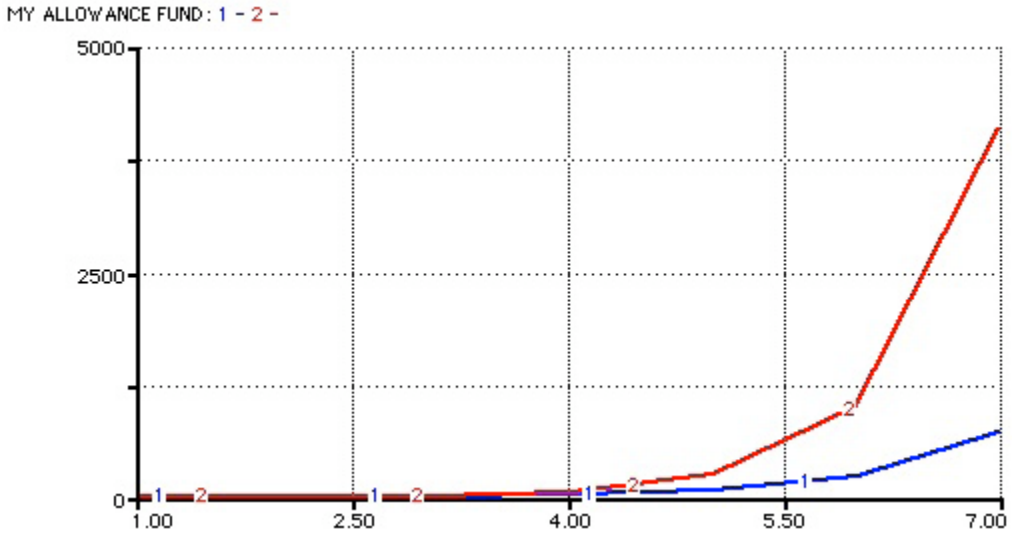
2. Can you solve this using the mathematical table below? (answers in red)

Time	MY ALLOWANCE FUND	New Allowance $ Added Next Day
1	1	2
2	3	6
3	9	18
4	27	54
5	81	162
6	243	486
Final	729	

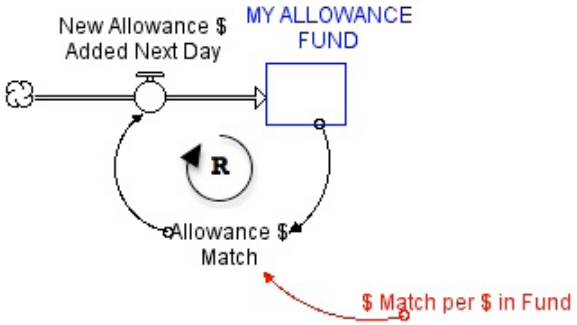
3. Now use the simulation to explore this and other scenarios. What if your father had offered a different amount of "compounding interest," for instance:

$1: $64 $3: $4,096 $5: $46,556

The key concept to communicate here is the NON-LINEAR nature of compound interest. A doubling (say, from $1 to $2) generates more than 7x the final total Allowance Fund $; a tripling (from $1 to $3) produces more than 60x the total. A graph offers another perspective (illustrated below, with $2 and $3 compounding). That's the power of the compounding process!



4. Can you describe mathematically how "allowance $ match" (at right) is calculated each day? Can you create a mathematical equation to solve this or similar problems? (See below.)



Here, the diagram seeks to focus student attention on the two factors that affect the growing STOCK (or accumulation) of MY ALLOWANCE FUND: (1) the "interest rate" (developed in the previous question) as well as (2) the current number of dollars in MY ALLOWANCE FUND on which interest is calculated. Each day, the STOCK of MY ALLOWANCE FUND grows, which translates into an ever-increasing flow of New Allowance $ added.

For those interested, this may also be a good time to introduce the mathematics of exponential growth. The generic mathematical equation for simple compound interest is defined as:

$$P = C(1+r)^t$$

Where P = future value
C = initial deposit
r = interest rate
t = number of years invested

In this exercise, that equation translates into the following:

Total Allowance $ = Initial Deposit ($1) x (1 + "Daily Match") to the power of number of days "invested" (or 7 here)

In the case of a daily match of $2, that means: Total Allowance $ = 1 * $(1+2)^7$ = 37 = 729

Dollars and Sense *continued on page 8*

Dollars and Sense II, Lesson 1

continued from page 7

5. Consider a different problem with compounding "interest:" Someone starts a rumor about you on Day 1 and tells two people; each day, for a total of 7 days, each of these rumormongers tells two people. How many people will have heard the interesting rumor after 7 days?

TOTAL RUMORMONGERS: ___

Using either a table or the equation developed above:

Total Rumormongers = Initial (1) * (1 + 2 new people)7 = 729

6. Can you invent a 7-day compounding problem of your own?

Ultimately, the best learning occurs when students apply what they've learned to other "problems" or situations. Ideally, engaging students in this conversation will facilitate that level of learning.

SIMULATION 2: Interest on a Single Deposit

http://www.clexchange.org/curriculum/dollarsandsense/Dollars and Sense II/ds2_lesson1.asp

This exercise offers a simple introduction to the real world system of compounding interest on savings. Starting with a word problem ("If I put $100 in a bank account or bought a Certificate of Deposit (CD) earning 4% annual interest, how much will I have in 8 years? Or 12 or 15? What if I start with $225? $382? $1,250?"), the lesson offers both a mathematical equation and a hands-on simulation, the latter providing opportunities for exploring additional scenarios of interest. GRAPHICAL output of MY SAVINGS is supplemented with TABULAR output showing how annual interest adds to SAVINGS, thus leading to more interest, still higher SAVINGS and so on. This simple exercise shows how the "power" of compound interest reflects the amount of principle (or SAVINGS), the annual interest rate, and—above all else—the importance of TIME.

SIMULATION 2 HANDOUT with ANSWERS and GUIDES FOR TEACHERS

Can Compounding Interest Work for Me? Calculating Interest Based on a Single Deposit

1. Open the Simulation, read the Introduction, and summarize your task below:

It is important that students understand (and can explain) the learning objective for using the simulation: The task is to compare interest earned on a single deposit in a Savings account.

2. Can you solve these problems using the mathematical equation below?

Simple Compound Interest Equation
(where interest is compounded only once per year)

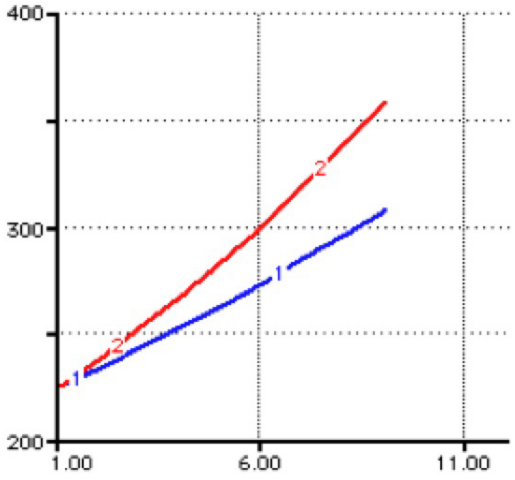
$$P = C\,(1+r)^t$$

Where P = future value
C = initial deposit
r = interest rate (expressed as decimal: e.g., 0.06)
t = number of years invested

$100 at 4% interest/8yrs:	$136.86
$100 at 4% interest/12yrs:	$160.10
$100 at 4% interest/15yrs:	$180.09
$225 at 4% interest/8yrs:	$307.93
$225 at 6% interest/8yrs:	$358.62

3. Use the simulation to check your results.

Note that the graph provides an opportunity to compare different strategies, as shown below (with a $225 deposit earning 4% versus 6% for 8 years), while the table more clearly shows how annual interest adds to Savings. Ideally, both help inform the role of interest rates, together with TIME (and Deposit amount!) in creating the "power" of the compounding process.



Time	MY SAVINGS P	Added Annual Interest
1	$225.00	13.50
2	$238.50	14.31
3	$252.81	15.17
4	$267.98	16.08
5	$284.06	17.04
6	$301.10	18.07
7	$319.17	19.15
8	$338.32	20.30
Final	$358.62	

4. Now use the simulation to explore a personal scenario of interest ("What if?"). Identify a GOAL and a PLAN for generating Savings using a single deposit.

Amount of Single Deposit: $_____ GOAL: $_____

Explore plan options for achieving the GOAL. Select the most appealing option and describe how and why it will work.

This is an open-ended exercise, following up on what students have learned about the three core factors that underlie the "power" of compound interest. Students should have a clear GOAL in mind, and should be encouraged to explore (and share) different strategies for achieving it. Describing their "choice" provides a vehicle for them to explain both what they've learned and to highlight different options and trade-offs.

Interest Rate: _____ % Time: _____

Why it is my choice:

SIMULATION 3: Options for Building College Savings

http://www.clexchange.org/curriculum/dollarsandsense/Dollars and Sense II/ds2_lesson1.asp

The engaging question here is simple: Is it possible to avoid borrowing for college? Using a target of $25,000 —the average debt for current graduates—this exercise invites students to "educate" parents on the importance of saving early and regularly, and again recognizes the "power" of compounding interest over years. The simulation offers students many strategies for achieving their financial goal. Rather than offering a "right answer," it strives to engage students (and parents) in evaluating options and choosing one that best works for them. The simulation can also be used to explore how similar decisions influence retirement funds—more interesting to parents and teachers, perhaps, than students!

Dollars and Sense *continued on page 10*

Dollars and Sense II, Lesson 1

continued from page 9

SIMULATION 3 HANDOUT with ANSWERS and GUIDES FOR TEACHERS

Can Compounding Interest Work for Me? Building College Savings

1. Open the Simulation, read the Introduction, and summarize your task below:

It is important that students understand (and can explain) the learning objective for using the simulation. The task is to see how a parent(s) can avoid borrowing for college by saving $25,000 before their child enters college.

2. Compare two plans, one of which involves saving at birth (or year 1), another at age 10. Prepare plans that include the following:

	Plan A	Plan B
a. When (what age) to start saving?	1	10
b. How much to put in SAVINGS to start?	___	___
c. How many years to save?	___	___
d. How much to deposit each year?	___	___
e. At what age does the child start college?	___	___
f. What is the likely annual interest rate?	___	___
g. How often each year is interest compounded?	___	___

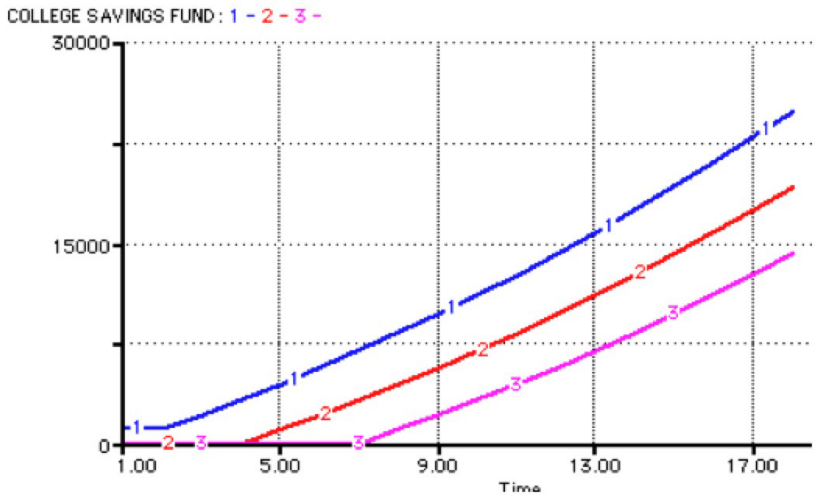
The focus here is primarily on TIME. That is, the earlier one starts saving for college, the less of one's own money it will take to reach the $25,000 goal.

3. Next, use the simulation to explore these and other options.

For illustrative purposes, using a 4% interest rate, annual deposits of $1,050 starting at birth will reach that goal; with a similar interest rate of 4%, and savings starting at age 10, deposits are closer to $2,750 per year.

Perhaps a more interesting exploration—one of many—involves starting the $1,050 payments at ages 1, 4, and 7 and comparing the results on the graph (see below). Note that total interest differs by more than $4,600. That's significant!

There are any number of "right answers" for achieving the $25,000 savings goal, and students should be encouraged to explore and compare multiple strategies.



4. Print the option that you propose to share with a parent and be prepared to justify your choice.

Ultimately, the challenge here is advocating for one strategy over any number of others. The quality of that advocacy is based both on the comprehensiveness of their exploration (Have they considered all of the options that "fit" with their savings expectations?) and their recognition of compound interest as a desirable part of their plan.

5. Finally, identify that factor or factors (a – g listed on page 10) that are most important for achieving your PLAN. Explain their importance below.

Here, students should be able to compare the relative impact of deposits, interest rate, and TIME in shaping their PLAN. Where deposits start early, interest should be a more substantial contributor, with that reinforced by higher interest rates. Again, this provides an opportunity for students to evaluate their plan.

6. What if you were saving for retirement? Can you apply what you've learned with the College Fund in identifying the best strategy for building a healthy Retirement Fund, say at age 65?

The core structure of a Retirement Fund is that of a Savings Fund. As such, this College Savings model can easily be converted into a Retirement Fund by altering the presumed starting date (as early as 18? or later?) and the "Age Starting Retirement" (65? 70?). Ask students: Given what you've learned from College Savings, what would be a wise strategy (again, to advise your parents, perhaps?) for maximizing a Retirement Fund? Then have them explore…

Summary Challenge (after completing the lesson)

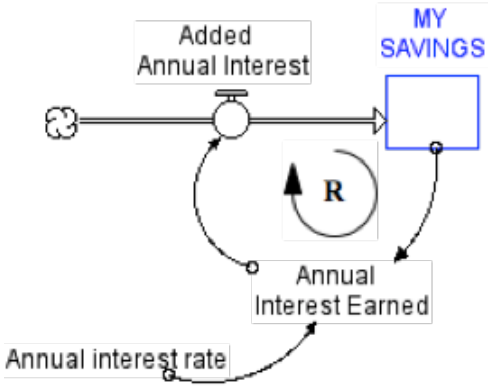
Students are encouraged, after completing each of the simulations, to apply what they've learned to address a meaningful, real world savings problem of personal interest. (Suggested written options are included with the handouts.) This challenge obliges them to ground their understanding of how the system works with realistic decisions regarding deposits, interest rates, time, and costs. Sharing their plan engages others in constructive discussion of options and choices.

SUMMARY CHALLENGE HANDOUT with GUIDES FOR TEACHERS

Pick #1 or #2 and write your answer in the space below (add graph or table, if desired):

1. Identify something that you intend to save for to buy in either 5, 10, or 20 years. Can you use what you've learned in this lesson to describe how you'll do so, and why your plan will be successful? (Make sure it's realistic!) Explain.

2. Substitute a friend or family member in Question #1. Identify something they hope to buy in 5-20 years and use what you've learned to help them create a realistic plan with which they will be successful. Explain.



In this final exercise, students are challenged to apply what they've learned to address a meaningful, real world savings problem of personal interest. In asking them to think long-term, they need to think about how, when, and what they'll make for deposits, together with researching realistic interest rates that strive to maximize interest payments. They'll also need to consider the likely cost of something at the time they're ready to buy it (e.g., college costs are always rising!). The goal here is not to generate THE right answer but to challenge the student to explain A right answer that best addresses their needs and capabilities. Challenging them to explain their plan to others provides opportunities to engage others in similarly applying what they've learned.

Why System Dynamics?

continued from page 2

Policy makers fall prey to the "Pull my finger" joke. They develop a policy that responds to correlations, trends and events, believing they understand the cause, as when the finger pull and the sound are close together in space and time. The irony of public policy making is that, without understanding system feedback, what happened in the past will be made worse by a policy response.

Without SD, public education is teaching students to look to the past to make decisions about the future. The public school system is walking backwards into the future.

The public school system is the primary obstacle to students using SD. The entrenched paradigms are the foundation for education institutions that teach *what* and *how* from K12 through university doctorate programs. Educators and students are evaluated based on *what* they know and *how* to use what they know. SD enables us to understand *why* systems work they way they do.

System dynamics is a tool to think, learn and communicate in a new way so that educators engage students mental models. When mental models rely on "Pull my finger" thinking, a person is not going to understand feedback. To use SD requires a new way of thinking: think about levels and flows connected in feedback loops within a closed boundary.

To use SD requires a new definition of learning: Learning is improving the quality of our mental models (Richmond, 2010). The current public school system does not attempt to improve the quality of students' mental models.

To use SD requires a new way of communicating: Communicate about *why* your model works using feedback loops. This is where qualitative tools like causal loop diagrams and behavior-over-time graphs are used and useful.

Jay Forrester is the founder of System Dynamics. He has said for many years that with the right guidance "students must create their own models and learn from trial and error." In this way, dynamic modeling is learning by doing. "I believe that immersion in such active learning can change mental models" (Forrester, 2009).

Why System Dynamics? System Dynamics enables us to understand why systems work they way they do in order to prepare for the future.

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