the Creative Learning EXCHANGE

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The Infection Game

From *The Shape of Change* and *The Shape of Change Stocks and Flows*

by Rob Quaden, Alan Ticotsky and Debra Lyneis, illustrated by Nathan Walker

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Introduction

Students play a game that simulates the spread of an epidemic. The behavior we see in the game could represent bacteria spreading through an animal population, a virus spreading through a computer network, a rumor spreading through a school, the adoption of a fad in a country, or any other type of contagious agent.[1]

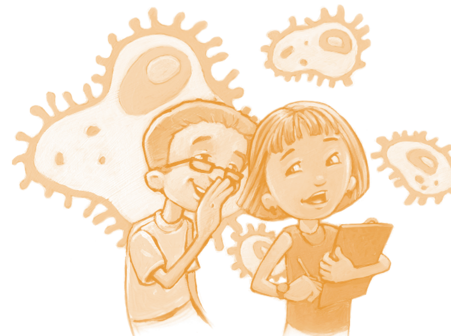
Social studies concepts could include the spread of diseases, ideas, social movements, or revolutions. The spread of disease can also be discussed from the science point of view. The disease in question might be a cold virus, the flu, smallpox, or AIDS. Math skills include drawing and interpreting graphs, fitting a curve through data, and looking at patterns of behavior over time.

Combine two classes to play this game. It takes at least 35 players to generate clear patterns of behavior.

How It Works

In this game the interaction that drives the spread of an epidemic is represented by the multiplication of numbers. One student will be assigned the number zero, while the rest will be assigned the number one. As they multiply their numbers together in pairs, the repeated multiplication process will cause more and more products to result in zero. In other words, the number zero simulates the infective agent spreading through the population.

A similar pattern in different situations is called a generic structure. This game simulates the generic structure of the spread of contagious activity, or infection. Once students understand the spread of an epidemic they also understand the spread of a rumor, a fad, a social movement, or a computer virus. The basic structure is the same.



Do not divulge this background information to students. Their motivation and learning is much more effective when they discover the structure for themselves.

MATERIALS

- Copies of four student worksheets:
1. *Individual Record Sheet A*, for one student
2. *Individual Record Sheet B*, for all remaining students
3. *Spread It Around*, for each student
4. *Spread It Around Again*, for each student
- One copy of the Teacher's Class Record Sheet

Infection continued on page 3

THIS ISSUE AT A GLANCE

EDITORIAL

Finally the sun of early spring shines in our windows—and reflects off the latest 12-inch snowfall. Snow has been deep on the ground all winter in the Northeast, so this year we especially eagerly anticipate the early crocuses and the daffodils! We also look forward to three very different and interesting conferences this summer.

- The Waters Foundation (www.watersfoundation.org) will host a conference featuring training both for beginners and more experienced practitioners in St. Louis, June 28-July 1.
- The International System Dynamics Conference (www.systemdynamics.org) has an expanded emphasis on K-12 this year, with a special poster session, workshops and roundtable to discuss cooperation between system dynamicists and K-12 educators. The ISDC is being held in Albuquerque, July 27-31. There are K-12 scholarships available. Please contact me if you are interested.(stuntzln@clexchange.org)
- The Society for Organizational Learning (SoL) Education Partnership (www.solonline.org), a partnership which encourages the integration of sustainability education, systems thinking and system dynamics, learning organization theory, and youth leadership, will hold a conference in Garrison, New York, just north of NYC, July 13-17, featuring both an adult gathering and a Youth Forum. E-mail Leah Mayor for more information (leah@sustainabilityed.org).

I look forward to seeing many of you at one (or more) of the three conferences.

Lees Stuntz
(stuntzln@clexchange.org)

Borton full of energy

From Tucson United School District ***Focus on TUSD***
October 2008, Vol. 7, Issue 2

Destiny Green rides the stationary bike while her teacher, Molly Reed, watches to see if she's generated enough power to turn on a small television set.

Students in Molly Reed's first- and second-grade classroom at Borton Primary Magnet School are peddling a project that has changed the way they view energy production and use. By riding a stationary bike in their classroom, they generate the energy needed to turn on light bulbs and small appliances. They've discovered they need to pedal longer and harder to turn on incandescent light bulbs compared to fluorescent bulbs. And they're exhausted when they ride long enough to turn on a tiny TV, let alone get a picture to appear.

Here's how bike riding generates power: as a rider pedals the stationary bike, the back tire's friction moves an old skateboard wheel attached to a generator. As the generator spins, the magnet and copper wire inside attract electrons. That energy is sent through the wires to the device on a nearby energy board.

Four incandescent light bulbs are attached above four fluorescent bulbs on the board, showing the comparison between the energy needed to turn each kind of bulb on when a switch is flipped. The board also has outlets where small appliances such as a miniature television can be plugged in.

Eli Protas wants bikes to power his school. Even after seeing the effort needed to produce a small amount of energy, Eli wasn't daunted. "It would be awesome to power the entire school," he said enthusiastically. That's not possible, but students did take their newfound knowledge home and lobbied for energy changes there. Emma Radersdorf said her family spent an entire day changing all the light bulbs at her house from incandescent bulbs to fluorescent ones. Her classmates said they had swapped light bulbs, too, turned off the water faucet when water wasn't being used and turned off lights when they left rooms. Others said they'd gone on walks, ridden their bicycles and played outside more instead of watching television. Some said they'd been catching bugs, playing with Lego blocks and romping with their pets.

Those are the kinds of behavioral changes Reed hoped her class would make. Now students have moved on to teaching the rest of the school at 700 E. 22nd St. these lessons. Other classes will sign up for instruction time and come to Reed's classroom, also known as the Bicycle Room, for demonstrations. Children have also demonstrated their pedal project at a school open house. They'll volunteer at school fundraisers, more open houses, and any other public school event. Students have also distributed fliers around the school and posted handmade posters showing energy saving activities.

In the coming weeks, Reed's students will try pedal power to turn on other devices, such as a computer, blender, microwave and a bigger TV. "They can see that even the little things they do have an impact on their world," Reed said. "They'll take this knowledge with them forever."

The Infection Game

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Rules for Students

- You will each receive a sheet to track the results of the game.
- You will each be given a secret number which will be already filled in on your record sheet.
- Secrecy and accuracy are very important.
- You will play the game for several rounds. In the first round, find any other student, and quietly tell each other your numbers. Then, on your own, secretly multiply your two numbers together and record the product on the next line of your sheet. This will be your new number for the next round.
- **Example**: If you have a 2 and the other student has a 3, you will both get 2 X 3 = 6 for your new number on the next line.
- **Second round**: Find any other student, tell each other your number, secretly multiply them together, and record the new product for the next round.
- Continue to do this until the teacher ends the game.

Procedure

1. Explain the rules without telling the name of the game.

By using the numbers 2 and 3, instead of 0 and 1, in the example in the rules, you deliberately mislead the students a little. This adds to the surprise element.

2. Give one *unknowing* student *Individual Record Sheet–Form A* (page 60 in the book) and give the rest of the students *Individual Record Sheet–Form B* (page 61). Give *Form A* with the starting number 0 to a student who is reliable about following directions and who is likely to exchange numbers with a variety of boys and girls. Re-emphasize the importance of secrecy, and let students play the game for about 4 minutes. You do not need to interrupt play to announce rounds. It works best if you just let students mingle freely for about 4 minutes.

3. When time is up, ask students to notice the last product on their sheets. Most, if not all of the students should have the number zero. Ask who started with the number zero. Tell students that they will be asked to think about this later.

4. Gather data from the students now for later debriefing.

- Ask students who had their FIRST entry of zero in the beginning to raise their hands. (This should be only *one* student.) Record this information on the first column of the *Teacher's Class Record Sheet* (page 64).

- Ask for hands to count how many students had their FIRST entry of zero in the second round. Repeat this for all subsequent rounds and record the information until there are no new "infections" with zero. Do not discuss the results with students yet.

- It is essential to record *only* the number of *new* students infected each round in the first column.

- You will also need the *total* number of infected students as the game progressed. Record this in the second column of the *Teacher's Class Record Sheet*, by keeping a running tally and adding the number of new students each round, as below. (Do not be overly concerned about accuracy in counting. Small errors will not affect the overall outcome.)

Round	Number of NEW Zeros	TOTAL Number of Zeros
Start	1	1
1	1	2
2	2	4
3	4	8
4		

5. Provide some individual reflection time for students to think about the *total* number of students with a product of zero as the game progressed. *Without revealing the actual data*, ask students to draw *behavior-over-time graphs* representing what they think happened to the *total* number of students with a product of zero during the game using the *Spread It Around worksheet* (page 62).

A behavior-over-time graph is a line graph sketch showing how the number of infections changed over time during the game. It reveals a pattern of behavior.

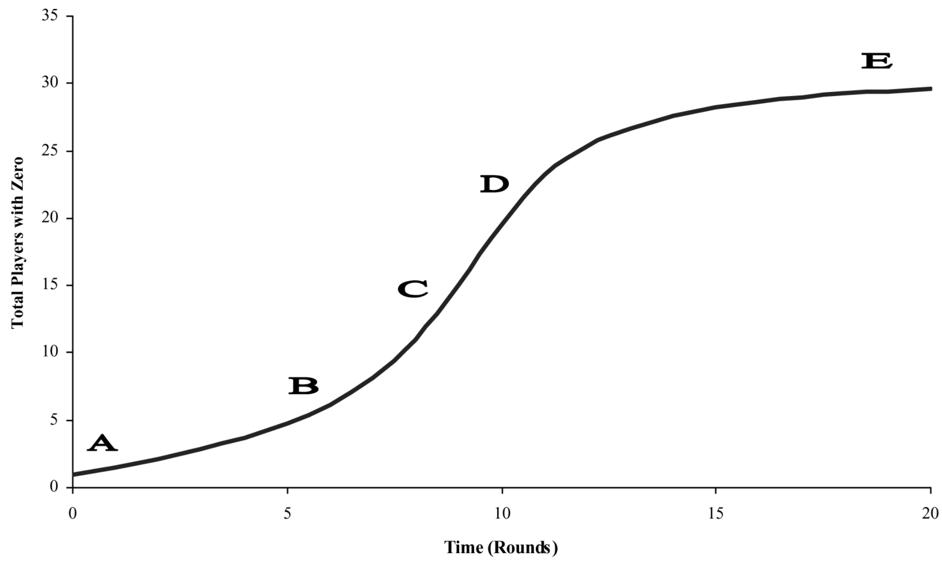
6. Students share their predictions with their teammates, reach a consensus and draw the team graphs on their worksheets. Ask each team to send a representative to the board to sketch the team's graph and explain the reasoning behind it. At this point, it is more important for students to explain their thinking than to produce the "correct" graph.

7. Compare the student predictions with a graph of the actual results of the game. Using data previously collected on the *Teacher's Class Record Sheet*, use the values in the Total Number of Zeros column to plot a graph on the board. (See graph on next page.)

Infection Game
continued on page 4

The Infection Game

continued from page 3



there were fewer healthy people to infect, so the disease spread more slowly. The number of infected people was still increasing, but at a slower rate.

- **What was happening at region E? Why is the line flat?**

There was no further growth. Everyone was infected.

Focus on the general pattern. Your graph will be different from our example, but the general shape will be similar.

Bringing the Lesson Home

Use the class graph (above) to help students understand the progress of the "infection" and its real-world implications. Devote ample time to this step. Let students use their experience to construct a deeper understanding of the world around them.

How does the class graph compare to the team prediction graphs? By evaluating their earlier predictions, students reflect on their own thinking.

What does the graph tell us? What happened to the number of students "infected" with zero during the game?

At first only one student was infected, but the infection eventually spread to everyone in the class in a general pattern called "S-shaped growth."

Why does the line have an S shape? How does this relate to what was happening during the game?

Engage students in a dialogue about the shape of the graph and relate the different sections of the graph to different phases in the game. If the students have difficulties, ask questions rather than giving them answers to get them to think about the different phases.

- **What was happening at region A? Why is the line flatter?**

This is the initial spread. Very few people had the infection, so it spread very slowly at first.

- **What was happening at region B? Why is the line steeper?**

Growth was increasing. As more and more people were infected and they interacted with others, the disease spread at an increasing rate.

- **What happened at C? Does the curve change its shape?**

At this point the curve changes its direction, like an "S."

- **What was happening at region D?**

Now growth was decreasing. When most people already had the illness,

Now, broaden the lesson with questions like these.

How is this like something else we are studying?

Explore links to the curriculum. For example, in a history class, ask students to predict the effect of Europeans carrying the smallpox virus to native people in the Americas. In economics, ask students to list some fads or products that spread rapidly through society.

Can students think of other examples of this infection behavior? Without intervention, the "infection" starts out slowly and spreads more rapidly until it approaches saturation.

- *Other infectious diseases like the flu or medical problems like head lice*
- *Rumors spreading through a school*
- *Computer viruses*
- *A fad like a style of clothing, a new toy, a popular song or movie*
- *The adoption of a new technology like cell phones or DVD players*

- *A social movement or political idea like the American Revolution, abolition of slavery or women's suffrage*

The game is a simplified version of reality. This makes it easier to understand the "structure" of reality. However, be aware that the game includes a number of assumptions that make it different from real life.

In what way is this simulation NOT realistic? What are limitations of the simulation?

This simulation shows a disease from which there is no recovery. That is, once you are infected, it is not possible to revert back to "uninfected." In the real world this almost never happens. Usually there are some individuals who recover. Other individuals might be resistant and not get the disease at all. Depending on the ability of the students, you might ask them how the rules of the game would need to change to make the game more realistic.

The simulation also implies that contact with a carrier will always result in getting the disease. Again this is highly unlikely—the probability that a contact will result in actual infection is almost always less than 100%.

While it is possible to change the rules of the game to reflect these issues, doing so will not significantly alter the shape of the graph.

Take Another Look

It is also interesting to explore the *rate* of the spread of the infection. In student terms: how many *new* people were infected in each round of the game (rather than the *total* number of people infected)?

Students can now analyze the data of the number of *new infections* each round. Lead a discussion similar to the debriefing of "the total number of students with a zero", but this time focus on "*new* students with a product of zero."

The total number of infected students is a stock, or an accumulation over time. It is increased by the number of new infections that flow in each round.

- As before, ask students to draw *behavior-over-time graphs* of what they think happened to the number of *new* infections over the course of the game using the worksheet *Spread It Around Again* (page 63).

- After discussing their predictions, use the teacher's data for the "Number of New Zeros" to draw and analyze the actual graph of the game. Again, the class graph may differ somewhat from our example below, but the general shape should be similar.

- Focus on the general pattern of behavior, not the details.

- Carefully lead a dialogue to elicit student understanding.

What happened to the number of new infections?

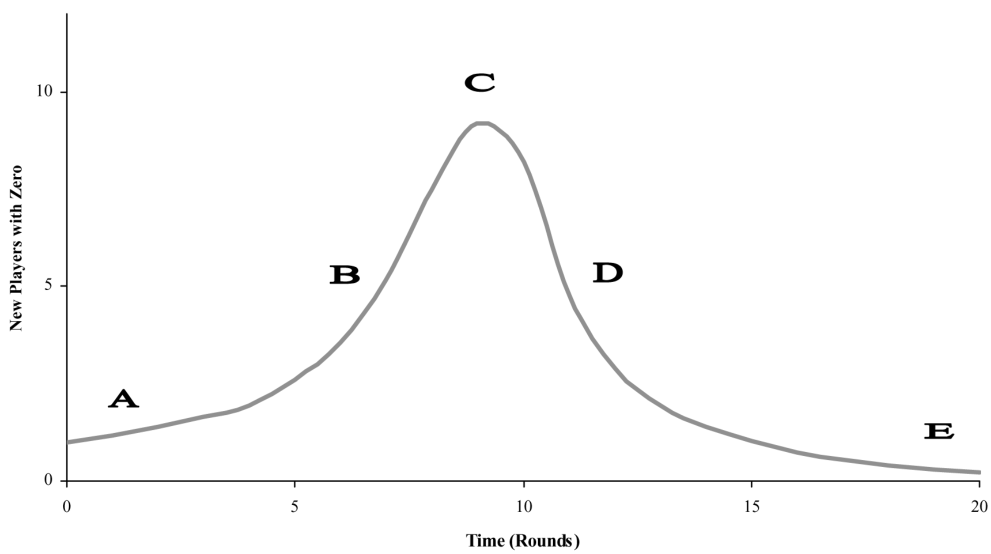
There were only a few new infections at first. Then there were many. By the end there were no new infections. This pattern is called a "bell-shaped" curve.

How is the class graph different from the team predictions? How is it similar? What does the shape of the curve say about what was happening in the game?

As before, ask questions to elicit understanding of the phases of the game.

• What was happening at region A?

The infection started off slowly, but then grew at an increasing rate as more and more people transmitted the infection.



***Infection Game** continued on page 6*

The Infection Game

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• What was happening at region B? Why is the shape of the curve changing?

When fewer contacts resulted in new infections, the number of new infections slowed down, but the total was still increasing.

• What happened at C?

The number of new infections reached its peak. This corresponds to point C on the previous graph where the line changed direction like an "S." (All of the letters on the graphs correspond. This point is particularly noteworthy because it is a turning point.)

• What was happening at region D?

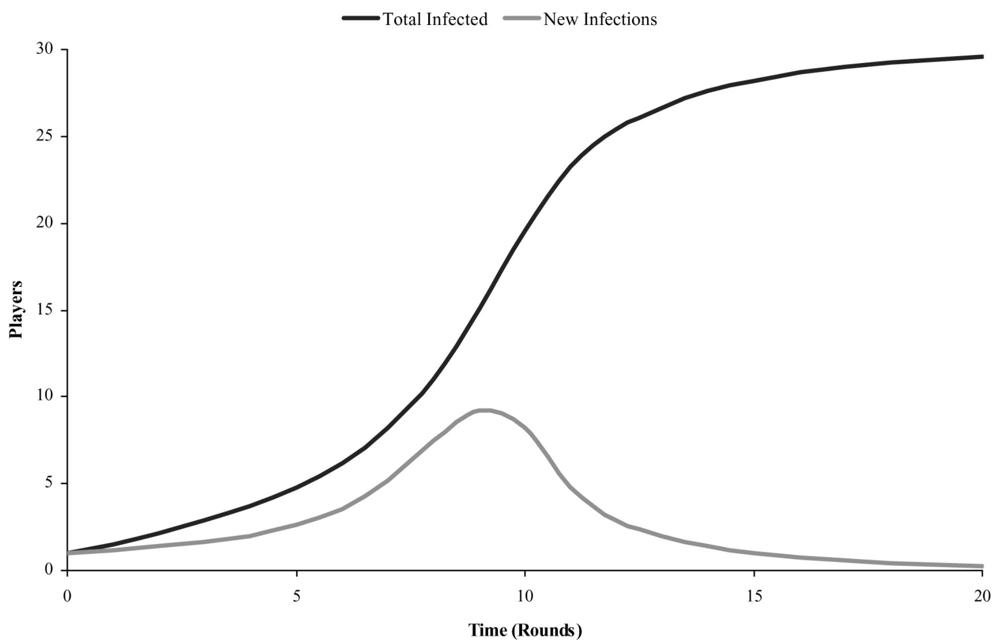
The number of new infections was declining. The total number of infections was still increasing, just at a slower rate.

• What was happening at region E?

There were no new infections because everyone was already infected. The epidemic had run its course.

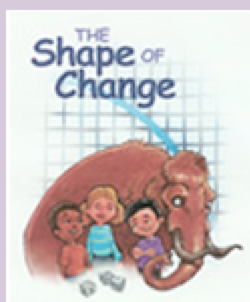
How does the graph of the new infections relate to the graph of total infections? If these graphs are drawn on the same time scale, what will they look like?

The rate of new infections starts off slowly, but increases at an increasing rate. When the rate reaches its maximum (top of bell curve), the total number of infections continues to increase, but at a slower rate. So, while the number of NEW infections is DECREASING, the TOTAL number of infections is still IN-CREASING. When the number of new infections is zero, the total number of infections has reached its maximum—everyone is infected.



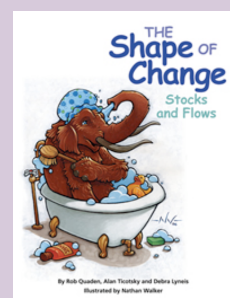
How does this pattern relate to the other curriculum and real world examples of "infections" discussed earlier?

As before, discuss the spread of other diseases, rumors, computer viruses, fads, social movements and other contagions.



The Shape of Change Books

by Rob Quaden, Alan Ticotsky and Debra Lyneis



The Shape of Change (new edition, 2008) gives students the opportunity to experience change over time through games, experiments and other classroom activities. Students draw line graphs to examine the changes more closely. In *The Shape of Change: Stocks and Flows*, students next seek to understand why these changes occurred. Based on their earlier classroom experience and graphs, and building in small incremental steps, students draw stock/flow maps to capture the feedback processes that caused the changes. Stock/flow maps give students a way to express, examine and understand the causes of change all around them.

Both books can be ordered from the CLE website clexchange.org Questions concerning your purchase should be directed to: Andi Miller, milleras@clexchange.org

STOCKS AND FLOWS

When we add Stocks and Flows to this lesson, we take the next step, to help students understand *why* these things changed. Students learn that all change over time can be viewed as a process of accumulation: the number of infected people is an accumulation that grows in every round.

The level of water in a bathtub is an accumulation that increases by the flow of water in through the faucet and decreases by the flow of water out the drain over time. This analogy is used throughout the book.

We call these accumulations "Stocks." The amounts entering and leaving the stocks over time are called "Flows." Envisioning change over time in this framework helps students understand the similar structures that underlie all change.

Frequently Asked Questions

Why would students need to learn about stocks and flows?

Learning about stocks and flows gives students a way to visually represent and examine the causes of change over time in a common language that applies across disciplines.

Does this approach engage kids?

Yes. Using the language of stocks and flows to explore the causes of change raises the level of dialog, reflection, and critical thinking in the classroom because students must make their assumptions very explicit. Students use the diagrams to share and refine their thinking together.

So what? Does an understanding of stocks and flows apply beyond the classroom?

As students proceed through the lessons, they begin to recognize similar stock/flow structure in the systems that surround them. Students learn that stocks are changed only by their flows, so any policy to change a stock—in the game or in real life—must focus on altering its flows. Students can build practical problem-solving skills based on this basic understanding of how the system works.

The Infection Game stock/flow map combines behavior over time graphs, stocks and flows, and reinforcing and balancing feedback loops to understand how and why the infection spread among them. There are two stocks and two feedback loops in this simulation.

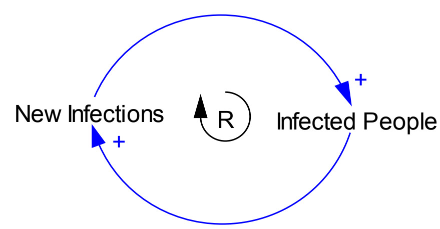
Seeing the structure

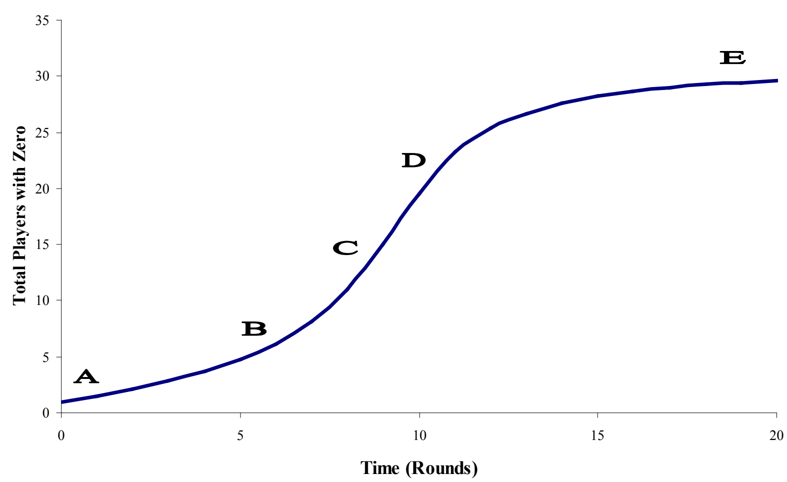
1. Review the Infection Game graph (below) of the total number of players with zero. Briefly discuss again what happened in the game to produce this behavior.

At first (point A), few people were infected with zero, but as more people became infected and they infected others, the rate of infection increased (point B). Eventually, the rate of infection slowed (point D) because many people were already infected. Eventually everyone was infected (point E).

2. Notice that the first section of the graph (at points A and B) is an upward curving exponential growth graph. These were examples of positive feedback loops.

Think about what happened in the Infection Game. At first only one person was infected, but as more people had zero, the infection spread more and more quickly. More infections led to even more infections. A **reinforcing feedback loop** must be at work here, causing the **exponential growth** we see in the graph from the beginning of the game. Maybe a loop like this one was causing the growth:





Look closely at the graph for hints about what structure could be causing the behavior you observed.

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The Infection Game

continued from page 7

Causal loop drawings are only very rough sketches. A stock/flow map will show more precisely how the system works.

3. Now take a look at the next segment of the graph (starting at point C). Notice that the growth is slowing as the number of infected people approaches the total number of players in the game. As more people became infected, there were fewer and fewer healthy people left to infect, until finally everyone in the class was infected (at point E). The growth in the number of infections in this graph segment appears to be *approaching a goal.* Growth that approaches a goal is caused by a balancing loop. Goal-seeking is the distinguishing feature of all balancing loops.

All balancing feedback loops are goal-seeking.

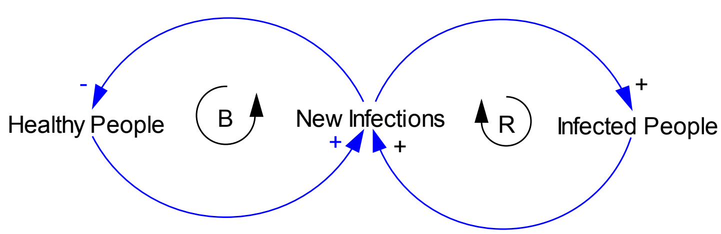
A **balancing loop** must be causing the **leveling off** of the infected population in the Infection Game. Maybe a loop like this one was also at work:

Thinking About Feedback Loops

We have studied our graph looking for clues as to what feedback loops could be causing the S-shaped growth we observed in the game. Based on what we have learned in previous lessons about basic feedback loops and stocks and flows, we have hypothesized that a reinforcing loop could be causing the initial growth in infections until a balancing loop takes over to slow the growth, and we have drawn very rough sketches of those feedback loops. Next, we will construct a stock/flow map to think much more carefully about how this system actually works, why it produces the behavior we observe, and how we could use that understanding to effect change.[2]

That's the general idea. Of course, students will have difficulty recognizing the signs of reinforcing and balancing loops or drawing initial causal loop diagrams until they have practiced understanding basic examples like exponential growth and decay in a variety of systems.

If your students are not ready to draw these feedback loops at this point, then just discuss the graph in terms of what loops might be involved (without drawing causal loop diagrams) and build the stock/flow map to uncover them. The goal is to help students build an intuition about how feedback systems work. With practice, they will strengthen their understanding of how the structure of a system creates its behavior.

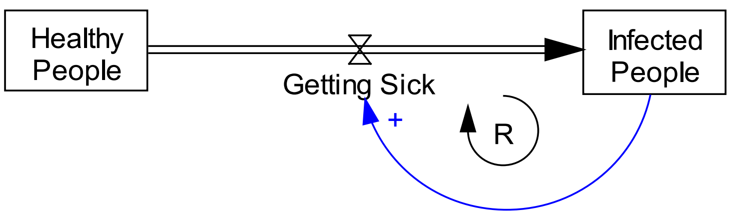


An increase in new infections caused a decrease in the number of healthy people. Fewer healthy people led to fewer New Infections because an infected person was less likely to encounter a healthy person to infect. Healthy People still decreased, but at a slower and slower rate.

4. Ask students to identify one or more stocks in the game. Students generally will come up with "Infected People" and "Healthy People."

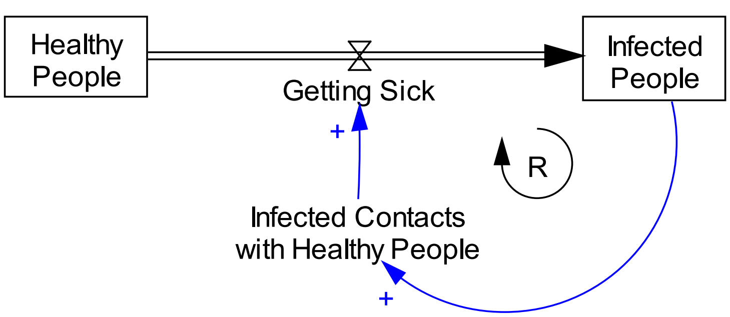
5. Ask what happened in the game and how to show that on the map. Again, students will have no difficulty seeing that there was a flow of people from Healthy to Infected. They may describe the flow as "people getting sick" or "catching the disease." Draw a flow from one stock to the other one.

6. Refer back to our graph of players infected with zero. Let's think first about what could be causing the accelerating growth at the beginning of the game. As more people became infected the rate of getting sick increased. Ask students to suggest a structure for the growth in infections.



This is a **reinforcing feedback loop**. As more people got sick, there were more infected people, leading to even more people getting sick.

7. However, in the game this exponential growth did not keep going forever. Refer again to the graph and ask students to relate what happened. As more people got sick, there were fewer and fewer encounters with healthy people to infect. In the end, it was hard for an infected person to find a healthy person at all—everyone was already infected. The rate of Getting Sick depended on an infected person meeting a healthy person.



Conserved Flows

We know that stocks can be changed only by flows. In some one-stock models such as the In and Out Game and the Mammoth Game, inflows originate from cloud symbols. The source of the flow lies outside the boundary of the map. Similarly, outflows often drain into clouds. When players leave the In and Out Game, or after mammoths die, we no longer track their behavior.

The Infection Game has two stocks, and players move from one to the other during the simulation. The total number of players always remains the same. People in the game are either healthy or infected, but they do not leave the game. The flow that links the stocks conserves the number of players at a constant level.

8. Infected people encountered fewer and fewer healthy people as the game went on. Ask students to think about how and why Infected Contacts with Healthy People changed.

Think of the game. How likely was it for an infected person to meet a healthy person when nearly everyone was still healthy at first, or when only a few people were healthy at the end of the game?

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The Infection Game

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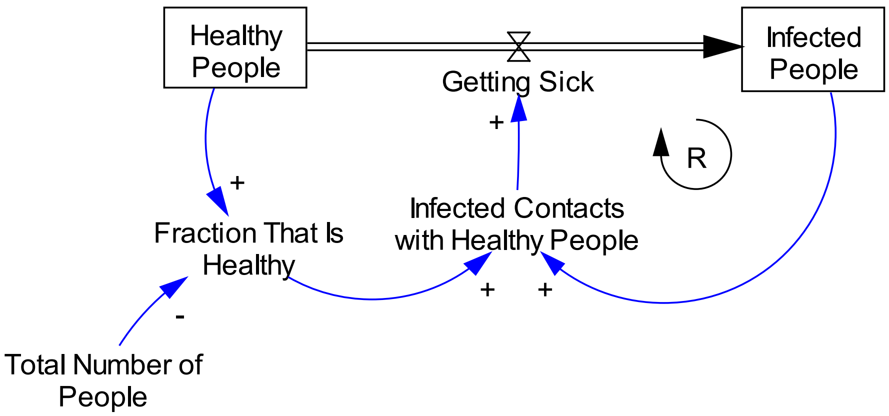
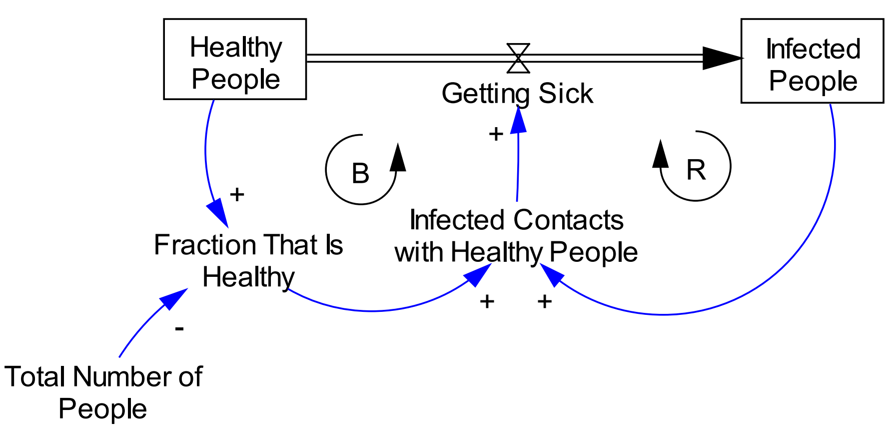
Using numbers, and assuming there were 50 players in the game, how likely was it when 40 out of 50 were healthy, when 25 out of 50 were healthy, or when only 5 out of 50 were still healthy? The number of Infected Contacts with Healthy People depended on the proportion, or fraction, of the class that was still healthy. When a larger fractio of the class was healathy, the chance of an infected person meeting a healthy person was higher.



The Fraction That Is Healthy is the fraction of the whole class that is still healthy. It represents the likelihood that an infected person will meet a healthy person. The higher the fraction healthy, the more infected contacts with healthy people. ("Infected Contacts with Healthy People" equals the number of "Infected People" times the "Fraction that is Healthy.")

9. Ask students to trace this loop and tell its story, using up and down arrows if that helps. As the fraction of the population that is healthy grows smaller, there are fewer infected contacts with healthy people, causing fewer new people getting sick. The rate of Getting Sick slows down. As long as any people are still getting sick, the number of healthy people is decreasing, but at a slower and slower rate until there are no healthy people left.

This is a **balancing feedback loop** causing the number of healthy people to approach zero (and, consequently, the number of infected people to approach the total number of people).



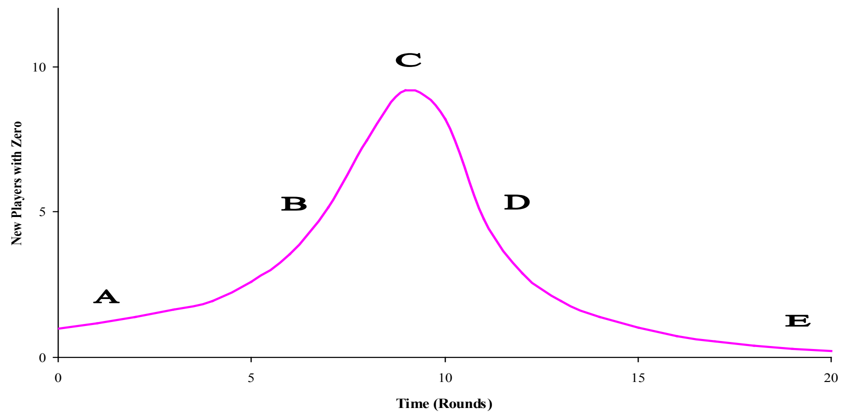
Two feedback loops caused the infection to spread through the class in a pattern of S-shaped growth. Were both loops active all the time?

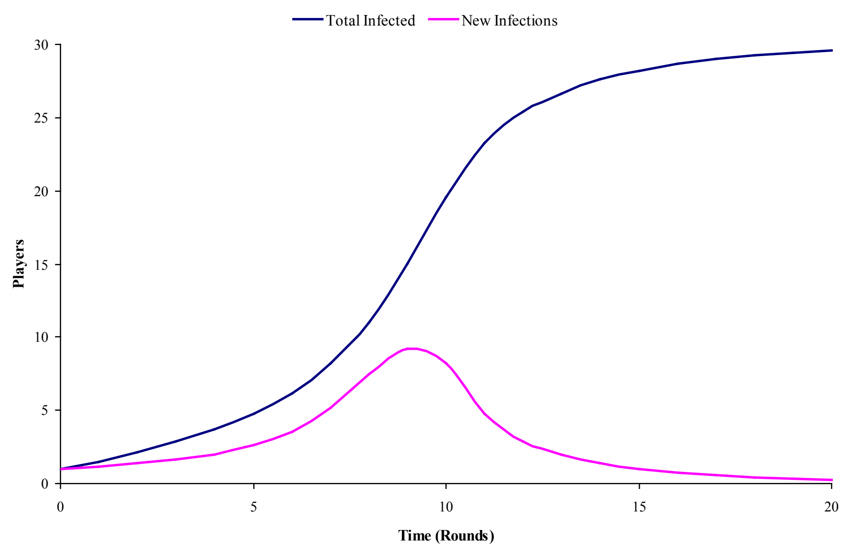
Yes. The reinforcing loop caused healthy people to become infected. This loop was dominant at first because there were plenty of healthy people to infect; the infected population could grow more and more rapidly. The balancing loop limited that growth, but its effect did not dominate until there were fewer and fewer healthy people left to infect. People were still becoming infected, but at a slower and slower rate.

The shift in dominance from the reinforcing to the balancing loop occurred at point C on our graph. We also saw this on our graphs of new infections on page 5.

The number of New Infections (or New Players with Zero) is the number of people getting infected each round. In our stock/flow map, we labeled that flow Getting Sick Total infected is the stock of Infect ed People that have accumulated over time as a result of the flow.

This stock/flow map captures the dynamics of the Infection Game. Its two feedback loops are both necessary and sufficient to explain the s-shaped growth behavior we observed.



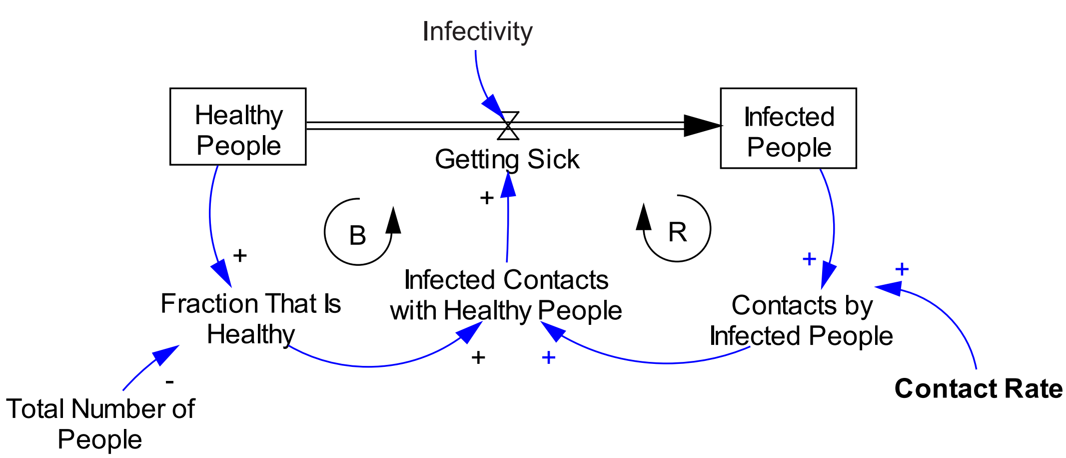


Our stock/flow map explains what happened in our Infection Game, but the game and the map are a simplifications of real-life epidemics. What else is missing?

We have made two important simplifying assumptions in the Infection Game.

*First, we assumed that every contact of an infected person with a healthy person resulted in transmission of the infection. In the real world, infectivity is rarely, if ever, 100%. You do not catch a cold every time someone sneezes near you. In reality, only a fraction of exposures result in an infection, with some illnesses being catchier than others. We would show this in our stock/flow map by showing that **Infectivity** of the illness affects the flow of people getting sick.*

*Also, in the game, every person contacted one other person during each round. In the real world, infected people may have different numbers of contacts, depending on whether they stay home or go to school when they are sick, for example. We would show this on our map by adding a **Contact Rate**.*



It is interesting to note that neither of these additions would change the underlying behavior of the system. The reinforcing and balancing loops would still work in the same way to produce S-shaped growth, although the changes would happen more or less quickly depending on the different contact and infectivity rates.

***Infection Game** continued on page 12*

The Infection Game

continued from page 11

What else is missing?

Students may suggest many other differences between the game and reality. For example, in real life, some people may recover from an illness while other people may die. People can develop immunities to some illness but not to others. New people may enter the population through births, for example. There may be delays in incubation times. There might be vaccines or quarantine policies.

Use our basic stock/flow diagram as a springboard to discuss all these issues. However, we do not need to add all these complexities to our stock/flow diagram to explain the basic dynamics of an epidemic.

From the K-12 Listserve Discussion

A response to a question about activities for very young children

I can only speak to experiments with my own children (who are 5 and 8) over the last few years. When they were 3 and 6, I had some limited success. I built simple causal loop diagrams with smiley faces and other simple artwork to demonstrate certain common issues we were dealing with. We called them games. Here are two examples.

1. The telling the truth game: How telling the truth builds trust which builds respect which leads to more privileges and rewards, which should make you feel good and encourage you to tell the truth. However, lying erodes that trust, which then causes more supervision needs, takes more time, means less time for TV; also affects the next time when you DO tell the truth but there is a lack of trust…

2. Doing things right the first time game: I ask you to wash your hands, you come out in 2 secs, I ask if you used soap, you get upset that I send you back in to wash again, results in a tantrum, I get upset… The cycle repeats the next day. But if you do it right the first time, I am proud of you, I am not upset, after dinner treats may increase, we have more time, can do fun things together.

In my heavily biased and small scale experiment, I believe I saw:

- A recognition for cause and effect, separated a little more in space and time; e.g., my actions before dinner resulted in less time for games before bedtime, not because daddy said no, but because not washing my hands properly the first time + tantrum took up that precious time between dinner and bedtime.

- A calming effect from looking at the diagrams. When there was a meltdown, I would ask "do you want to look at the 'do it right game'?" and there was a calming effect as we walked through the loops to see how the actions from a few minutes ago had resulted in a negative outcome.

- The ability for them to walk me through the "game"with minimal prompting. It was also good for some laughs as the reasoning wasn't always how I had intended.

I hope that helps. I would love to hear if others have tried someting like this. If not, give it a try and then let me know how it goes. I would recommend only using it on very meaningful problems for them, nothing abstract.

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The object of the Infection Game is to understand, in its simplest form, how an epidemic spreads. How do the reinforcing and balancing feedback loops control the behavior? Can we use this understanding to change the system?

Does this remind you of other contagions?

Students may suggest many different examples including the spread of a computer virus, a fad, a social movement, or a rumor. All of these "infections" have the same basic structure and behavior.

1 The Infection Game is adapted from the Epidemic Game developed by Will Glass at the Catalina Foothills School District, Tucson, Arizona, 1993. The "Epidemics Game Packet" includes the original game, a system dynamics model and student exercises for older students. It is available from the Creative Learning Exchange at www.clexchange.org

2 Students can gain valuable insights and inquiry skills approaching a problem in this way. For an even more rigorous analysis, the next step would be to build a system dynamics computer simulation of our stock/flow map, see if it can actually generate the graph's behavior, and use it to experiment with policies to change the behavior. But, that is far beyond the scope of this book—a challenge for another day!

Thanks to Jan Mons of the GIST Project in Brunswick, Georgia for her suggestions.

A New Mental Model of Teaching and Learning

By Richard Turnock

In the spirit of Richard Plate's effort to foster discussion, this is my attempt to avoid criticizing the many hours of useful work on an assessment methodology that I agree is needed. For several years, I taught elementary and high school teachers how to integrate systems thinking and dynamic modeling into their curriculum. As implied in the article, we were using the infection model to get teachers to adopt systems tools and skills; however, this approach has not succeeded. By infection model, I mean our mental model of how to integrate systems concepts into the education system.

Parker J. Palmer described the decades-long situation in teaching and learning: "Our dominant mental models of teaching and learning are individualistic and competitive…they are derived from models [based on objectivism] of reality and of knowing." In this environment, "teaching and learning will mean delivering data to students" regurgitating it on tests to compete for scarce grades[1]. The same situation was described by the references from 1957 and 1958 cited by Richard Plate in his article.

At a K-12 conference[2], Peter Senge asked 150 educators, "In the absence of a major crisis, how many of you would expect to see a major change in the structure of the education system?" A few people raised their hands. Then he asked, "Given a real crisis in the operation of the education system, how many people think major changes would be implemented?" This time a few more people raised their hands. However, this was not the response Senge expected. In a business setting, everyone raises their hand in response to the second question. Finally, an educator in the audience said, "The educational system will not change, even in the face of a major crisis!" and everyone laughed. Now Senge understood what educators think about educational reform imposed by legislators and the impact of technology on the education system. This view of making changes to the educational system is also supported by J. R. Llanes using a system dynamics model[3].

Experiments in using technology in the classroom deal primarily with the techniques of teaching and learning without considering the mental models teachers have of teaching and learning. Our current mental model of knowledge is of a solitary individual, a knower, who uses their senses and intellect to gather data and interpret objects of knowledge. To understand a new model of teaching and learning, we need to reconsider our theory of how we know things.

By representing knowing as a system of interaction using feedback, we can test a new mental model as a foundation for a better way of teaching and learning. What is going to hinder our effort to get people to learn a new mental model? Well, what hinders learning?

- Cause and effect separated in time and space
- Misperception of feedback
- Poor interpersonal and organizational inquiry skills
- Insufficient time for reflection.

Implementing a new mental model for integrating teaching and learning theory with technology requires teaching teachers how to create a system of interaction using feedback. However the current higher education system does not teach this skill to teachers and K12 schools do not assess students or teachers to find out if they understand systems concepts.

How can we define the problem so that we can see the educational system from an endogenous point of view as defined by George Richardson? How can we change the educational system so that a new mental model of teaching and learning is implemented?

1 Palmer, Parker J. "To Know As We Are Known, Education as a Spiritual Journey," HarperCollins Paperback, 1993. Preface, page xvi.
2 Anecdote from Ed Gallaher.
3 Llanes, J. R. (January-April 1996). Researching Quality: The Continuous Improvement Process (CIP). International Journal: Continuous Improvement Monitor, 1:1. Edinburg, TX, The University of Texas-Pan American, Center for Applied Research in Education.

2008 isee User Conference

Systems Thinkers from all over the world converged on Burlington, Vermont on October 9th to attend the first isee systems user conference. Titled "Making Connections," the conference immersed participants in networking sessions, presentations, round table discussions, lab practice, and fun.

"It's fitting that our first user conference came about through user suggestions," explains Joanne Egner, Managing Director of isee systems. "Workshop participants consistently recommend that we provide opportunities for Systems Thinkers from diverse disciplines to share their experiences and models. We decided to devote an entire event to that and the result was our first isee User Conference."

From "The Connector" December 2008 www.iseesystems.com

1st Annual Waters Institute Transforming Systems Thinking into Practice

June 28-July 1, 2009

Washington University St. Louis, MO

www.watersfoundation.org

You are invited to take part in the Waters Institute, an event that will bring together over 200 educators for dialogue, discussion, and training about the use of systems thinking in K-12 education. Join us at this inaugural occasion as we work together to transform systems thinking into practice. Sessions at the Institute will focus on strategies for utilizing the habits, concepts, and tools of systems thinking, empowering students and educators to create schools that offer every student a world-class education appropriate for our rapidly changing, increasingly diverse society. The Institute will engage international speakers, scholars, teachers, and other practitioners in deep exploration of the knowledge and skills needed to effectively implement systems thinking in instructional practices and school improvement strategies. Attendees not already experienced in systems thinking will attend a three-day introductory training. Experienced users of systems thinking will attend a three-day practitioners' training. Co-sponsored by the Waters Foundation, Washington University, and the Ritenour School District, this event is the result of collaborative partnerships and a shared commitment to increasing the use of systems thinking in schools. In addition to learning from experienced trainers, the Institute will also offer ongoing networking and professional learning opportunities. Mark your calendar and register now to attend this extraordinary event. We look forward to seeing you in St. Louis!

Keynote Speaker
Daniel Kim

A renowned thinker, author, and speaker in the fields of systems thinking and organizational learning, Daniel is committed to helping educators-develop classrooms, schools and districts that effectively utilize systems thinking in their quest for continual improvement.

LEVEL ONE

This three-day workshop will provide an introduction to systems thinking and its connections to other effective instructional practices and school improvement efforts.

During the workshop, participants will:

• develop skills and knowledge in the use of systems thinking habits, concepts and tools.

• experience, practice, and discuss interactive, inquiry-based instructional and school improvement strategies.

• use systems thinking tools to analyze complex issues and identify high leverage interventions.

• develop and share a plan of application relevant to their work.

Participants will be grouped to allow specialized focus on applications that are pertinent to the elementary, middle school, or high school classroom, or to organizational and administrative contexts.

LEVEL TWO

This series of workshops will involve participants in shared experiences and discussions related to systems thinking and its connections to other effective instructional practices and school improvement efforts. Participants should have completed Level I training or the equivalent and/or had some experience implementing the habits, tools, and/or concepts of systems thinking.

Day 1 Workshop:

With a focus on classroom uses of systems thinking, participants will learn about what's happening in K-12 settings in the U.S. and around the world, engage in practice and reflection sessions, and discuss leverage applications. These sessions will be facilitated by K-12 practitioners.

Waters Institute *continued on page 16*

ICSDS 2009 to Include a K-12 Program

The International Conference of the System Dynamics Society, to be held in Albuquerque, July 27-31, 2009, will feature a coordinated thread of activities designed to highlight the use of system dynamics and systems thinking in K-12 education. These activities will encompass:

1. **Parallel session(s) based upon full papers on Wednesday (July 29)**. These will be papers addressing the use of system dynamics in education submitted through the normal process of paper reviews.
2. **A special poster session where K-12 teachers and students will display their work (also on Wednesday)**. This may include poster presentations by K-12 teachers describing what is going on their classrooms, samples of education materials used for K-12 teachers and students, examples of student work, posters by high school students describing their system dynamics projects.
3. **A sequence of workshops tailored to the K-12 community on Thursday (July 30)**. These six workshops will be short, one-hour lessons taught by experienced teachers highlighting how teachers from primary school through graduate school make system dynamics accessible to their students. Three of the workshops will be a primary, a middle school and a high school lesson taught by experienced teachers from the Creative Learning Exchange and Waters Foundation Networks. The other three workshops will be given by experienced system dynamics teachers from higher education, including George Richardson. The sessions should be exciting and interesting to everyone who is interested in education at all levels.
4. **A round-table discussion to advance collaborations between the system dynamics and K-12 communities on Friday (July 31)**. This morning session will focus on the coordination between system dynamics practitioners and K-12 schools. There will be an opportunity for practitioners to brainstorm with teachers and K-12 education professionals to devise plans to increase the availability of SD expertise for our K-12 schools. The outcome of the session will be a plan to go forward with specific tasks for the coming year to increase the contact between K-12 and SD professionals.

We encourage K-12 educators and system dynamicists to join us at this exciting meeting and help to contribute positively to the utilization of system dynamics, a necessary critical thinking and problem solving skill for all students, in K-12 education.

There are scholarships available for K-12 participants to both the full ISDC program and the Wednesday-Friday education portion. Please contact Lees Stuntz (stuntzln@clexchange.org) at the CLE for more information.

Dennis Meadows wins Japan Prize

Dennis Meadows has been awarded the 2009 Japan Prize for his pioneering work on sustainability using system dynamics. The Japan Prize "is awarded to people from all parts of the world whose original and outstanding achievements in science and technology are recognized as having advanced the frontiers of knowledge and served the cause of peace and prosperity for mankind....Each Japan Prize laureate receives a certificate of merit and a commemorative medal.

A cash award of 50 million yen is also presented for each prize category....The Presentation Ceremony will be held in the presence of Their Majesties, the Emperor and Empress, in Tokyo, in April. The events are also attended by the Prime Minister, the Speaker of the House of Representatives, the President of the House of Councillors, the Chief Justice of the Supreme Court, foreign ambassadors to Japan, and about a thousand other guests, including eminent academics, researchers and representatives of political, business and press circles."

Dennis is recognized for his work on "Transformation towards a sustainable society in harmony with nature." He is Professor Emeritus of Systems Management, University of New Hampshire, and President, Laboratory for Interactive Learning. He lives in Durham, New Hampshire.

You can read about the prize at http://www.japanprize.jp/en/prize.html and the citation for Dennis at http://www.japanprize.jp/en/prize_this_year_prize01.html

Congratulations to Dennis!

1st Annual Waters Institute

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Day 2 Workshop:

With a focus on school improvement uses of systems thinking, participants will learn about what's happening in K-12 settings in the U.S. and around the world, engage in practice and reflection sessions, and discuss leverage applications. These sesions will be facilitated by K-12 practitioners.

Day 3 Workshop:

Utilizing the processes of systems thinking, participants will engage in discussion about and visual representation of various issues affecting K-12 education (e.g. the effects of NCLB on change in schools, the dynamics of maintaining balance between content knowledge and critical thinking skills). These sessions will be facilitated by researchers in the fields of system dynamics and the social sciences.

Newsletter Subscription Information

The Creative Learning Exchange newsletter is available in three different formats:


the Creative Learning EXCHANGE

Making Friends

- On the web site at www.clexchange.org
- As an attachment to an E-mail
- In paper format via US mail ($15.00 outside the USA)

Since we vastly prefer electronic distribution to paper because it is so much less expensive, please E-mail us at any time when you would like to have an electronic subscription.

milleras@clexchange.org

Interested In Investing?

If you would like to invest in our effort at *The Creative Learning Exchange*, your contribution would be appreciated. You may donate any amount you wish; perhaps $50.00 is a reasonable amount for a year. All contributions are tax-deductible.

Enclosed is ________________ to *The Creative Learning Exchange* to help invest in the future of K-12 systems education.

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