The CREATIVE LEARNING Exchange
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STUDYING *THE LORAX* WITH FEEDBACK LOOPS

by Rob Quaden and Alan Ticotsky

The Lorax, by Dr. Seuss, is a classic children's book that appeals to all ages. Told in a fanciful style, the story relates how an ambitious businessman named the Once-ler exploits all the resources of a small country. Despite the warnings of a character named the Lorax, all the truffula trees are cut down and made into fast-selling products called thneeds. At the end of the story, the Once-ler regrets his actions, but is it too late?

Several important themes are central to *The Lorax*. Citizenship lessons include the importance of environmental stewardship and the necessity for businesses to practice sustainable use of resources. While the characters are portrayed pretty broadly as black and white heroes or villains, in reality there needs to be room for both natural environments and economic development, creating more gray areas. The characters are driven by individual attributes, such as deciding how to behave honorably and regretting excessive greed and selfish behavior. By using systems thinking tools, the children can start to see shades of grey instead of black and white. The story presents teachers with an opportunity to bring these and other important concepts into the classroom.

With a new movie version having debuted in March, 2012, many students will be revisiting *The Lorax*, or experiencing it for the first time. A rich lesson can be made even more powerful for first-time readers by comparing the original text and drawings to the new version.

Multiple state and national standards can be addressed through *The Lorax*, as well as local curriculum topics. In this lesson, students will

- Evaluate complex information and ideas
- Express logical arguments
- Understand systems
- Consider sustainability and environmental issues in relation to business growth

HOW IT WORKS

Many themes interact in the book. The natural growth cycle of business dominates for a while. The Once-ler makes lots of money, uses it to expand his business and employ his relatives, and makes even more money. But growth cannot continue forever, and natural resources become depleted. Pollution plagues the country and the tree population declines until it is no longer possible to produce thneeds. The Lorax's voice of dissent is ignored until the treasures of the land are spoiled.

In this lesson, students read *The Lorax* and then develop a connection circle and causal loops to understand and illustrate the themes of the story.

***Lorax** continued on page 3*

THIS ISSUE AT A GLANCE

EDITORIAL

Here at the Creative Learning Exchange we now look out on a burgeoning spring, full of new life. This year's "non-winter" seems to be over, although we can never discount a snowstorm in March. With the advent of warmer weather, we have many new and interesting projects, curricula, and, of course, the biennial conference this year.

This newsletter contains curriculum from one of the major projects we have worked on over the past year and a half, the Characteristics of Complex Systems Project. Initiated by Jay Forrester, the project, designed for all age groups, focuses on curricula which illustrate the Characteristics of Complex Systems that Dr. Forrester delineates in his paper, *Learning through System Dynamics as Preparation for the 21st Century* (available on the CLE website). The first lessons of the curricula that we are creating address the characteristic that the cause of a behavior is within the system. The curricula use oscillatory systems as a means to look at the structure causing the behavior. The lesson in this issue of the newsletter is on a simple oscillatory system, a spring, and is designed for ages 5-9.

Another new lesson, *Studying "The Lorax" with Feedback Loops*, was developed by Rob Quaden and Alan Ticotsky, authors of the Shape of Change lessons and book. Now, with the recent release of the movie, *The Lorax*, we think this lesson, with a tie-in to a popular film, will be especially engaging for students. The lesson uses connection circles to access the feedback loops within the story and give students a broader perspective.

Last, but by no means least, we have our ST/DM conference* (http://www.clexchange.org/news/conference/2012conference.asp) in June. The draft program is in this issue of the newsletter. The sessions will address timely issues such as Critical Thinking, STEM, and the Common Core Standards, and we think you will find them interesting and pertinent. As always, we will have experienced educators from both the K-12 and the system dynamics worlds to share their perspectives and learn from your experiences. Multiple scholarships are available, so please apply!
We look forward to seeing you all here in the Boston area this year!

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

*For those of you unable to make it to our conference, Camp Snowball is another wonderful learning opportunity. Camp Snowball will be held in Tucson, AZ, July 9-13. http://campsnowball.org/

Teaching Characteristics of Complex Systems in K-12 Education

The Characteristics of Complex Systems in K-12 Education project was initiated by MIT Professor Emeritus Jay W. Forrester, and is administered by the Creative Learning Exchange. The immediate goal of the project is to create online curriculum materials for K-12 students and interested adults that will illustrate the characteristics of complex systems first enunciated by Forrester in 1969, specifically:

- Cause and effect are not closely related in time or space.
- Action is often ineffective due to application of low-leverage policies (treating the symptoms, not the problem).
- High-leverage policies are difficult to apply correctly.
- The cause of the problem is within the system.
- Collapsing goals results in a downward spiral.
- Conflicts arise between short-term and long-term goals.
- Burdens are shifted to the intervener.

Initial funding has supported a pilot project to address the 4th characteristic: "The cause of the problem is within the system." Five interdisciplinary areas are covered in a series of lessons, utilizing a family of models that all generate oscillation. Oscillation in real-world systems is often considered problematic rather than a consequence of system structure. The progression of lessons will help students understand that undesirable behavior can be a consequence of system structure and not a result of outside, uncontrollable influences. In other words, a system that oscillates does so because it has an inherent tendency to do so. Together, these lessons will enable students to recognize that a particular behavior pattern, for example, time-series data on fluctuating deer populations or food prices, is generated by systemic forces. Such understanding is the first step toward fundamental, rather than superficial, corrective action.

Lorax

continued from page 1

Students will investigate how cycles compete for dominance, and think about how the needs of business and natural resources can collide.

MATERIALS

- Copy of *The Lorax* by Dr. Seuss

For each team:

- Copies of the Connection Circle template

PROCEDURE

1. READ THE STORY

The teacher should decide the best method appropriate to his or her class—read aloud, shared reading, etc.

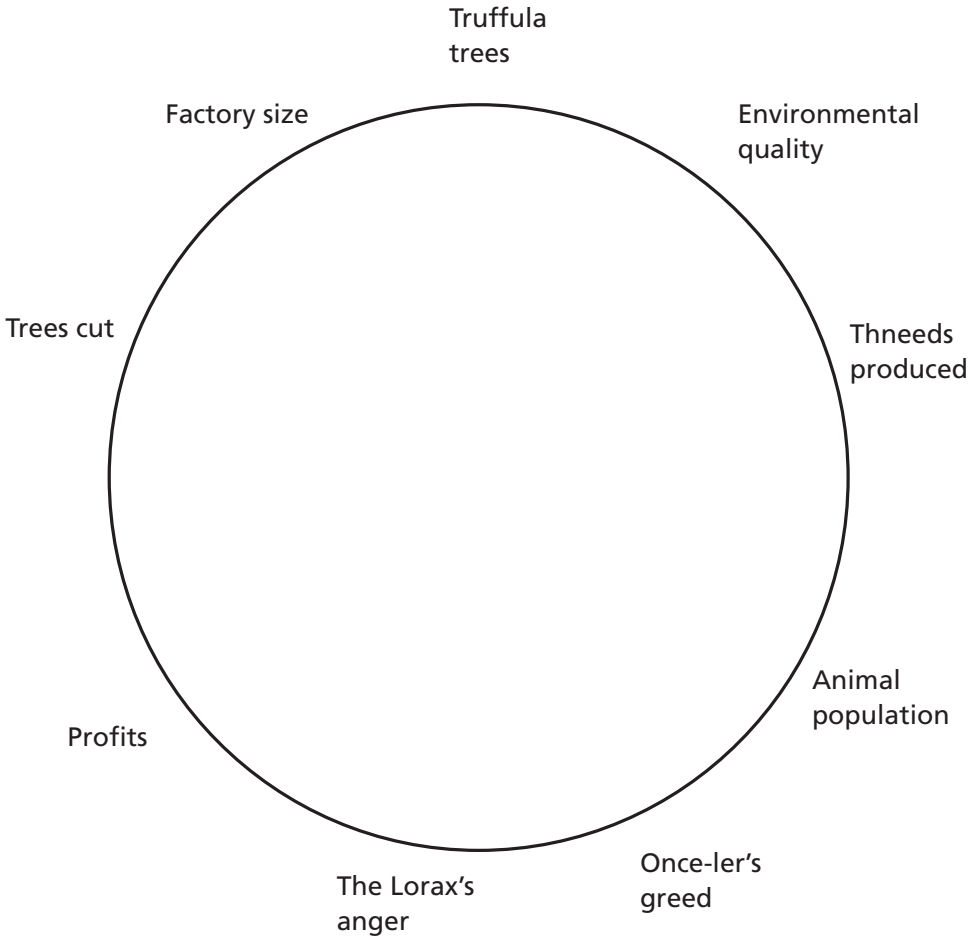
2. PREPARE THE CONNECTION CIRCLE

If students have never used connection circles before, go over the rules for finding the elements of the story as listed on the template at the end of this lesson plan. Each student can use a copy of the template or they can draw their own circles. We suggest working in teams to encourage sharing of ideas. (For a full explanation, see *The Shape of Change*, by Rob Quaden and Alan Ticotsky, Creative Learning Exchange, 2004, available on the CLE website.)

> "I believe we should give students a more effective way of interpreting the world around them. They should gain a greater and well-founded confidence for managing their lives and the situations they encounter."
>
> **Dr. Jay Forrester, 1994**

3. CHOOSE THE ELEMENTS

Without too much prompting, students should identify the important elements that change in the story. Encourage them to talk in teams while each student in the team creates his or her own connection circle. Possible elements include truffula trees, thneeds, pollution, Once-ler's greed, Once-ler's profits, the Lorax's anger, factory size, and other things that change quantitatively during the story. It may help to bundle the animals affected by the habitat degradation into one element rather than listing them individually. After students have worked in teams for a short time, lead a whole class session, allowing students to share the elements they have chosen. The teacher can build a composite circle on the overhead or a chart pad. Each team may have a different interpretation, so the circle produced by the whole class may have more elements than individual team circles. Building connection circles can help represent and clarify divergent thinking.



Sample of elements around a connection circle

Lorax *continued on page 4*

Lorax

continued from page 3

4. Next, ask students to identify an element around the circle that changes quantitatively in the story and causes another element to change. Draw an arrow from the cause to the effect. You may label the direction of the change by putting a + or – sign near the arrow head. Use a + sign when the change is in the same direction and a – sign when the change is in the opposite direction.

In the example below, the link from "Thneeds produced" to "Profits" is + because producing thneeds adds to profits. The link from "Trees cut" to "Truffula trees" is – because cutting trees reduces the number of trees.

> Students may be confused at first when using + and – because the signs do not always mean more and less. In the link between "thneeds produced" and "profits," when production goes down, profits go down also. That's still a positive (+) causal relationship because the elements move in the same direction. When the elements move in opposite directions, the causal relationship is negative (–).
>
> A trickier example is births and population. Even when the number of births decreases, "births" to "population" is a positive (+) causal relationship, since any birth increases the population. Both elements move in the same direction.

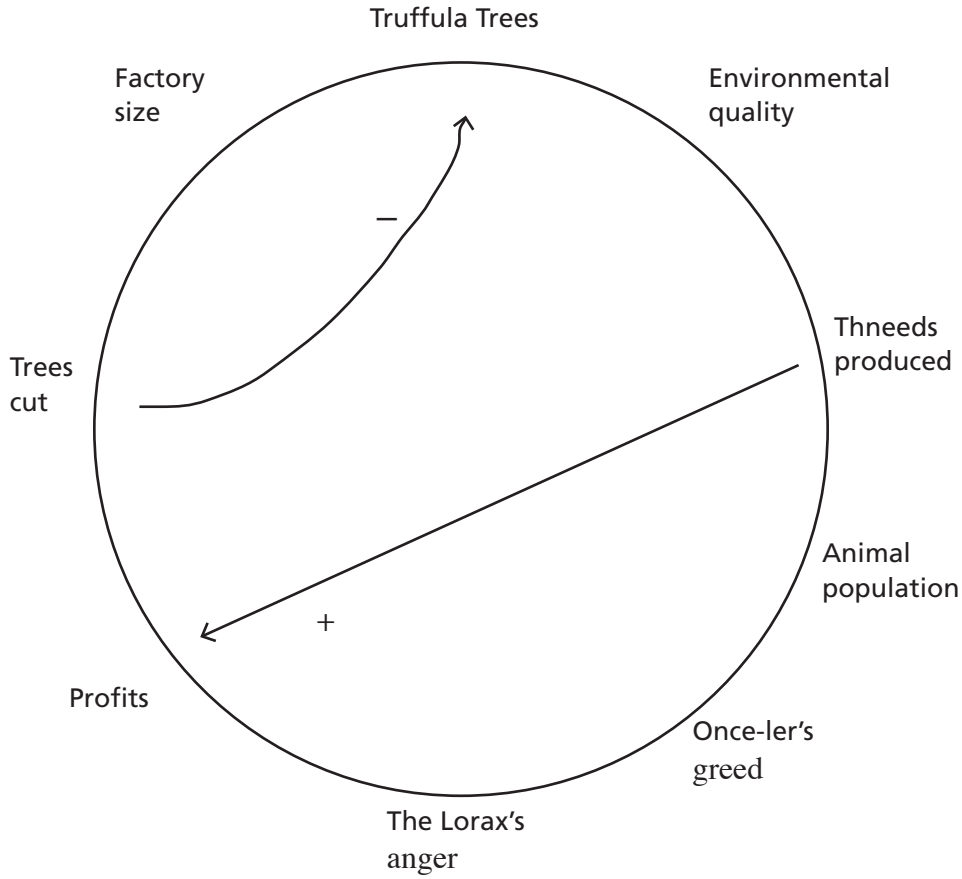
One or two examples should be enough to get students started. Have them work in teams as each student draws his or her own connections.

5. After students have had a short time to work in teams, bring the class together to share some of the connections. The circles may look cluttered with arrows at this point. (See Partial Diagram on next page.) Ask if students can trace a path so that they can start at one element, travel along the arrows to at least one other element, and return to the starting point.

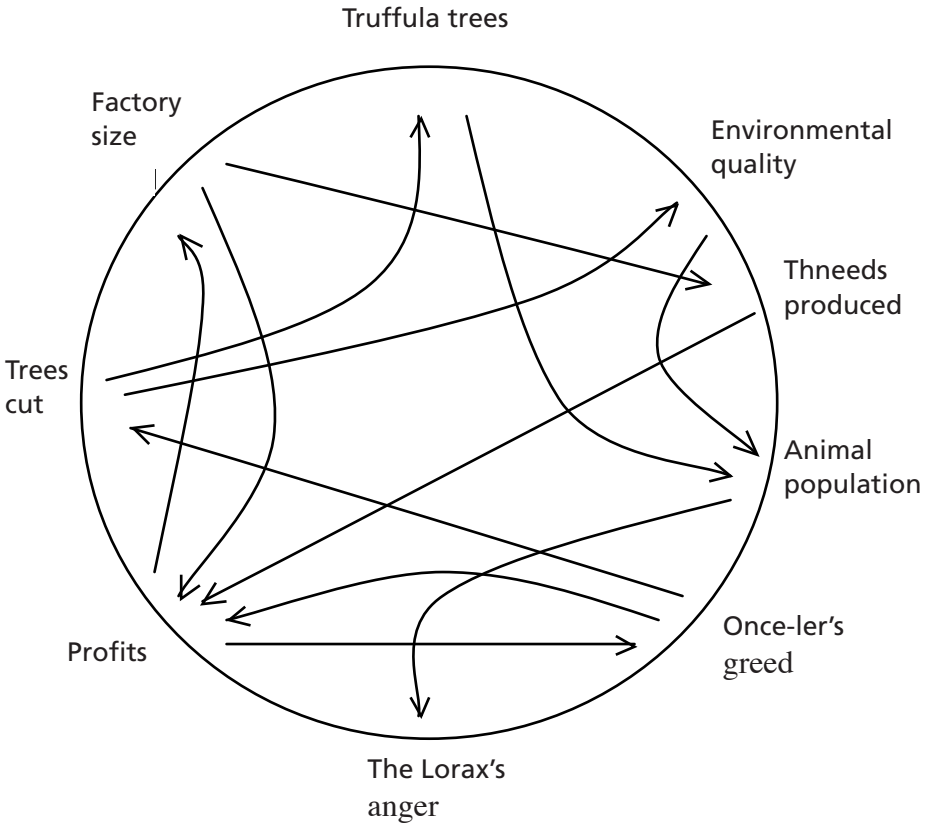
6. Instruct students to trace over the pathways using highlighting pens or colored pencils.

7. Have them copy the pathways they have traced onto a separate page, drawing them as loops. Choose representatives to draw these loops on the board or on overhead transparencies in order to share them with the class. Name the loops for reference. Students should gain insight as they look at loops and find leverage points within the story.

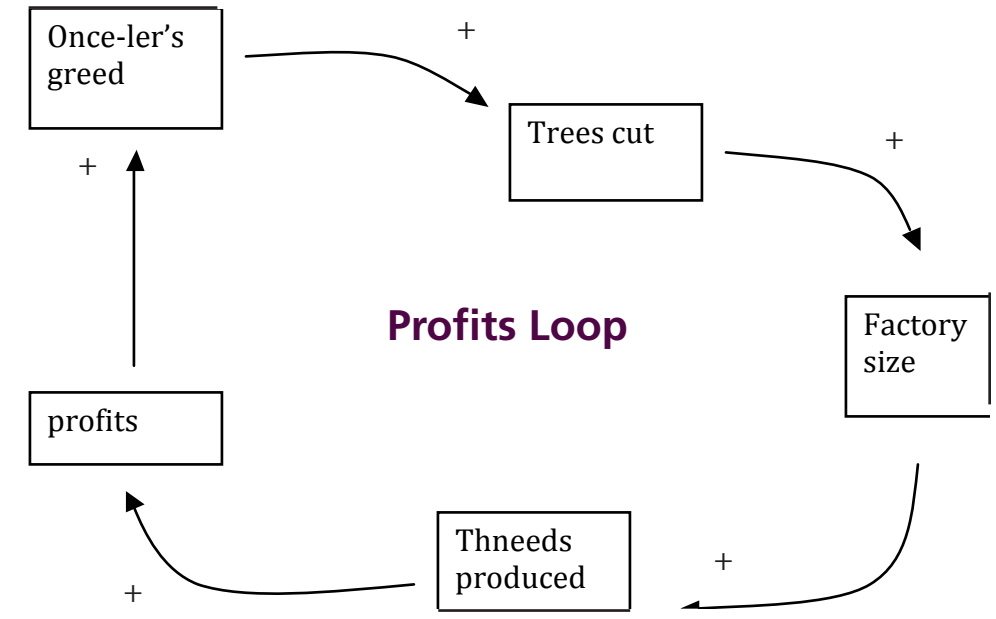
Elements around the circle with arrows in only one direction (coming in only or going out only) indicate that students have not identified feedback loops containing that element. In some cases, the element is not central to the story, or the information available doesn't tell us enough to make another connection. Sometimes students need to add an element to the circle to complete a loop.



Sample of elements around a connection circle, with a few arrows from cause to effect



Partial Diagram: Sample of elements around a connection circle, with many arrows from cause to effect



Complete Loop

Benefits of Systems Thinking

- **Makes student thinking visible**
- **Helps students make connections**
- **Allows students to explore multiple ways to solve problems**
- **Develops reading and writing skills**
- **Increases student engagement**

The examples that follow demonstrate one complete loop and one incomplete loop. The complete loop (below left) tells that as the Once-ler's greed increased, he cut down more trees. That led him to increase the factory size. More thneeds were produced, which increased profits. As profits grew, the Once-ler's greed grew as he continued to seek more wealth. This might be named the "profits" loop or the "greed" loop.

Stocks

Once the important loops are identified, it is good practice to put a rectangle around the elements and talk with the students about the fact that the elements in the story are stocks.

Elements or units that go up and down, that can accumulate or diminish, are called stocks. (See Quaden,Ticotsky and Lyneis, "In and Out Game," from *The Shape of Change*, available from the Creative Learning Exchange website, www.clexchange.org.)

***Lorax** continued on page 6*

Lorax

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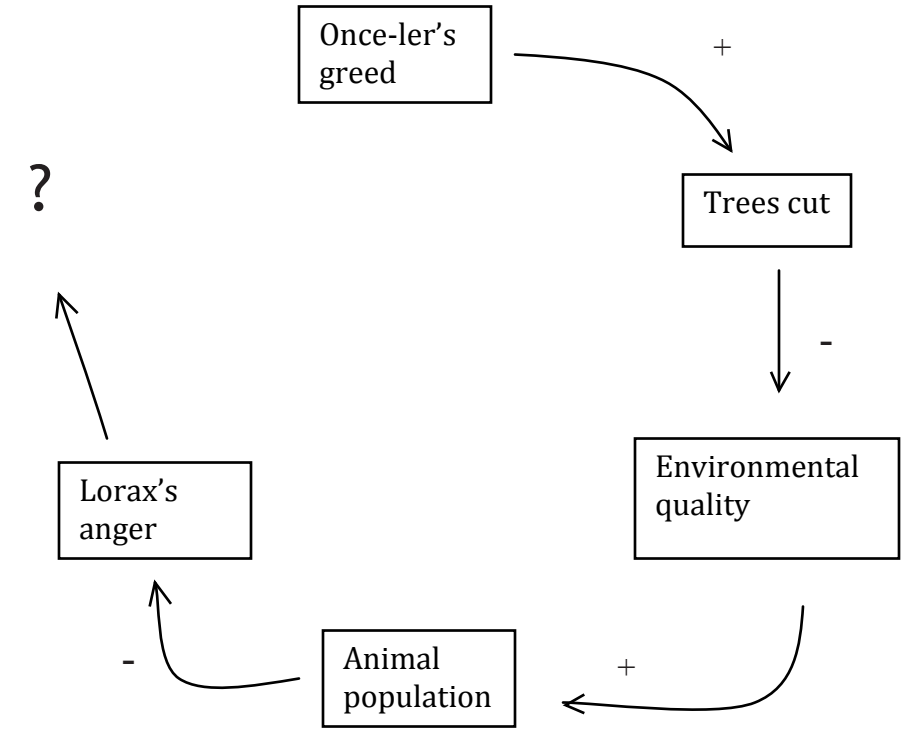
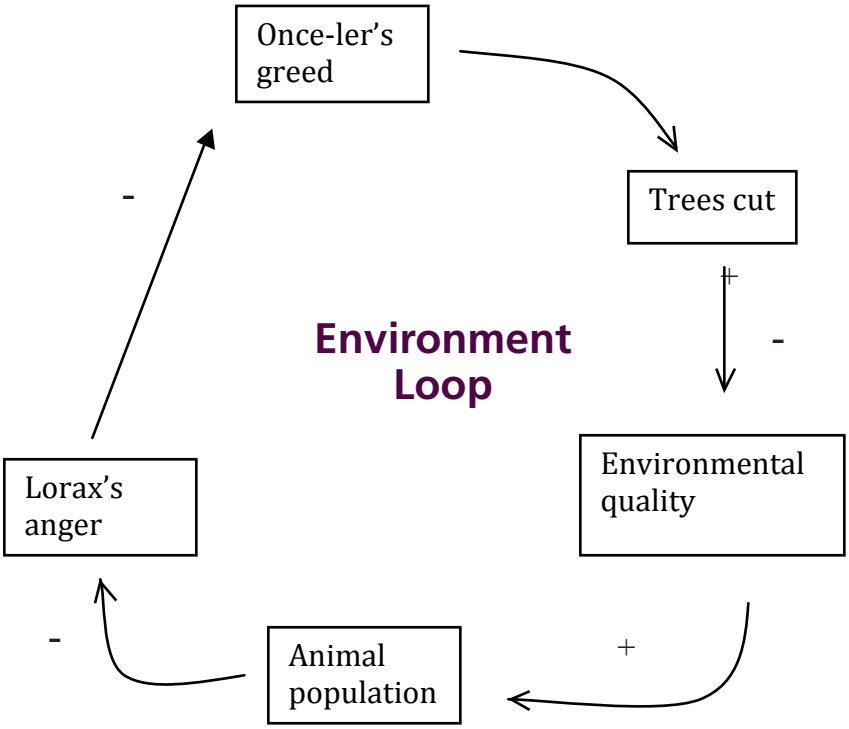


Incomplete Loop



Environment Loop

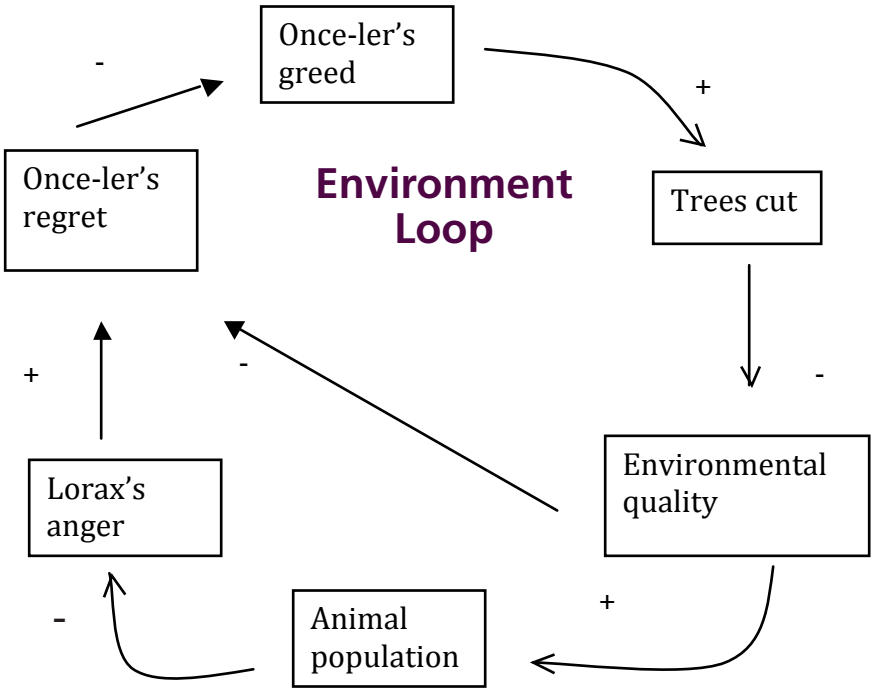
8. DEALING WITH INCOMPLETE LOOPS

Examine an incomplete loop with the students. In the example on the left, the Once-ler's greed grows, and more trees are cut down. Environmental quality decreases, causing a decrease in the animal population. As the animal population goes down, the Lorax's anger goes up. What does the Lorax's anger cause?

Students will probably face this question. Does the Lorax's anger affect the other elements of the connection circle? Or, to state the question from a systems perspective, is there any feedback resulting from the anger?

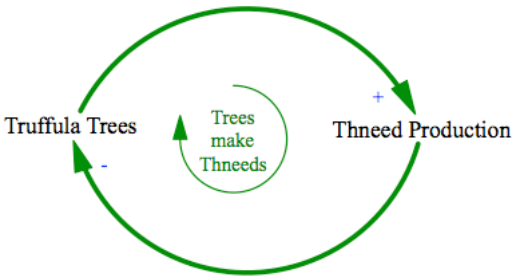
Some students will contend that the Lorax's anger actually makes the Once-ler greedier or at least more determined to exploit the Truffula trees. "Business is business" after all. Another interpretation is that there is a long delay in the story. After the environment is destroyed, the Once-ler finally feels regret. The "Lorax's anger" reduces "Once-ler's greed" as the ruined entrepreneur now understands what he has done. That closes the loop, making an Environment Loop (lower left) to contrast with the Profits Loop.

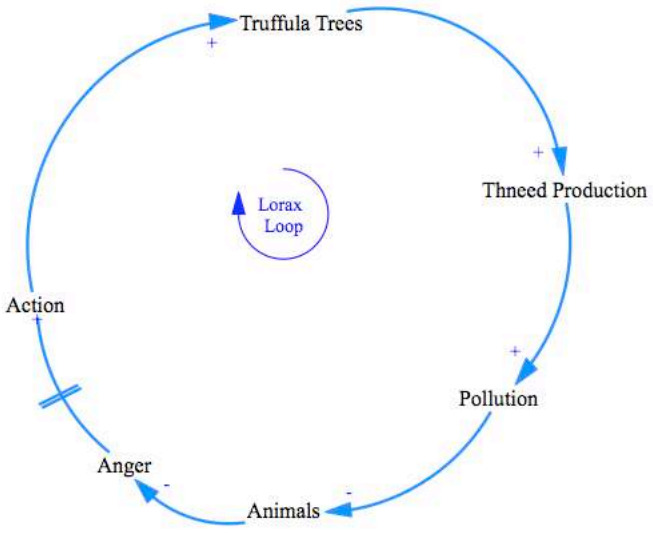
Sometimes a new element is needed to close a loop. Students may add a factor that does not appear on their connection circle. For example, "Once-ler's regret" may be an element that changes during the story, caused by the Lorax's behavior or the overall degradation of the environment, or both. Then the Once-ler's regret reduces or eliminates his greed. See the Environment Loop on the next page.

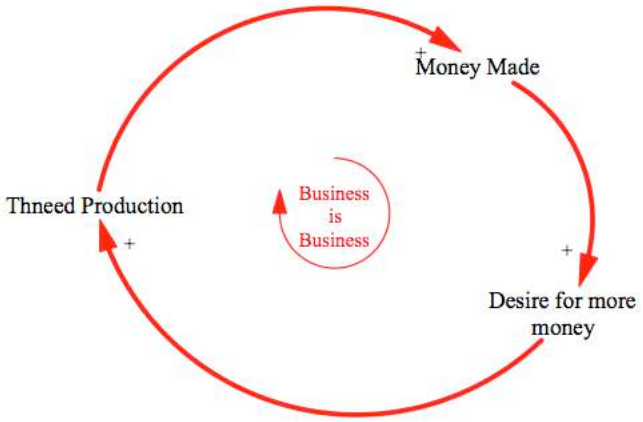


9. COMBINING THE LOOPS

Once students have developed two or three loops, check to see if an element is part of more than one loop. Where elements overlap, two loops can be combined. Students in one class developed three loops.







Lorax *continued on page 8*

Lorax

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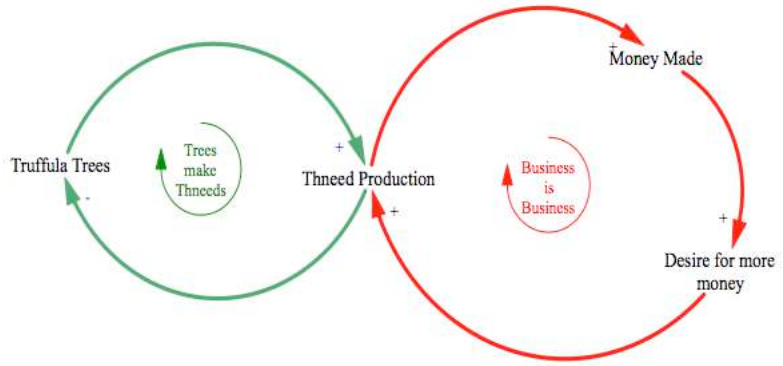
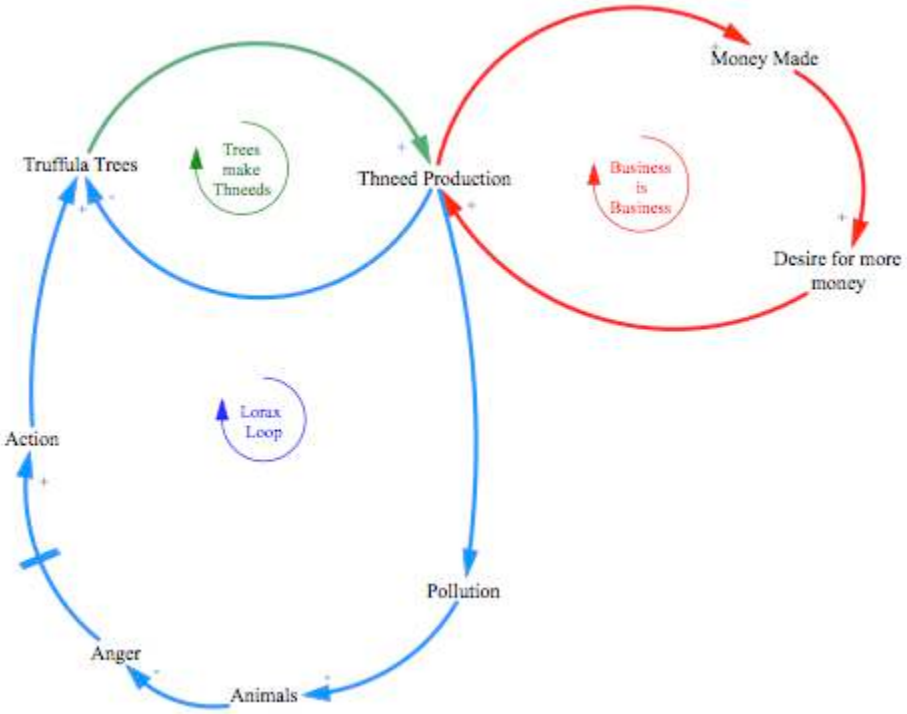
The element "Thneed Production" occurs in all three loops, so the loops can be combined:





Once the loops are combined in one diagram, encourage students to state the dynamics of the Lorax story in their own words. By referring to the different loops in the diagram, students can trace how different loops dominate at different points in the story. Seeing how loop dominance changes and affects complex systems is an important technique.

10. SUMMING UP

Use this lesson plan as an example, and expect that students will have differing opinions about *The Lorax*, as they will about any complex issue. Encourage students to use the connection circle tool to find feedback loops that will help explain and illustrate their arguments.

Stories and issues often hinge on conflicting loops. Dominance among loops may change and affect the story, as it does in *The Lorax*. The Profits Loop, the Production Loop, and the Lorax's Environment Loop are all connected. Students will see that the loops contain some elements in common. Wherever humans build, these loops will come into play. While there are no easy solutions, understanding the feedback loops helps us understand the situation and make more informed decisions.

The Lorax lesson is available on the CLE website, www.clexchange.org. It includes a "Connection Circles" worksheet.

2012 Systems Thinking and Dynamic Modeling Conference for K-12 Education

June 30—July 2, 2012

The Babson Executive Conference Center

Wellesley, MA

Draft Program

Friday, June 29

7:00-9:00 pm—Registration

Saturday, June 30

8:30-10:00—Registration/Continental Breakfast

10:00-12:00—Welcome and Introductions

Featured Speaker: George Richardson: *Creating Critical Thinking in our Students through System Dynamics*

1:30-5:00—Workshops to Learn and Explore

- Using the SD process to teach STEM
- Creating fertile ground for student/teacher learning with ST tools
- Using ST/SD tools in the classroom and administration of schools
- Practical tips on how to start with ST/SD in a school system.
- Using system dynamics principles to create a learning organization in a classroom
- Beginning modeling
- Intermediate modeling

5:30—Before-dinner reception: Chat with system dynamics pioneers, including Jay Forrester, George Richardson, Dennis Meadows.

7:00-8:30—Posters showcasing students' learning in systems thinking and system dynamics, as well as teacher-education students' work in integrating ST/SD into curriculum

Sunday, July 1

9:00-10:30—Specific curriculum demonstrations and special topic discussions

- Using Systems Thinking to Integrate Common Core and the STEM Process in Classrooms
- Five Important Feedback Loops from *Limits to Growth*—Dennis Meadows
- Use of Simulations: Oscillation Simulations from the Characteristics of Complex Systems Project
- Financial Literacy: Dollars and Sense II
- Integrating the New Science Common Core Standards Using ST/SD

Conference *continued on page 10*

ST and DM Conference

continued from page 9

- Critical Thinking Skills: A Discussion of Barry Richmond's Concepts of Critical Thinking Skills and Systems Thinking in K-12 Education
- Using System Dynamics to Attract More Students (and Teachers!) to Math and the Scientific Method
- What's the Buzz about STEM: How is SD Being Used to Frame Policy?
- Utilizing STELLA version 10—isee systems
- Building a 21st Century Learning Environment in Your Community
- Evolving from a Test-Based to a Curriculum-Based Approach in Evaluating a Systems Thinking Curriculum
- Leadership Workshop
- Playing to Learn: Using a Systems Game to Assess and Develop Systems Literacy—Linda Booth Sweeney
- How to Create ST/SD Curricula
- How to Get a Whole State Moving Ahead: Citizen Advocacy in Conjunction with New Washington State Standards and Initiatives

11:00-12:30—Panel: Embedding SD/ST into a School or School District

2:00-3:30—Specific curriculum demonstrations and special topic discussions (See above.)

4:00-5:30—Featured Speaker: Dennis Meadows: *Sustainability Games*

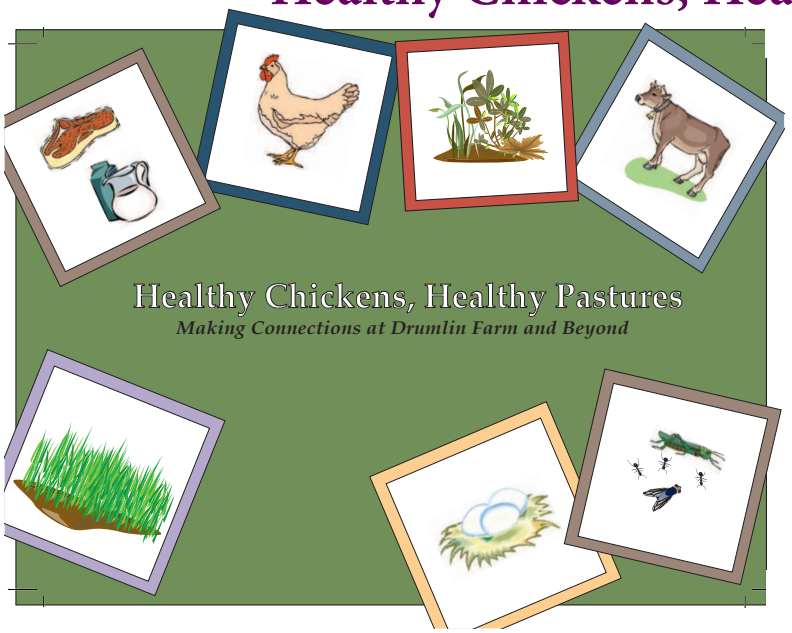
Dennis Meadows will conduct a set of games selected from *The Systems Thinking Playbook*, which he co-authored with Linda Booth Sweeney. He will briefly introduce and debrief each exercise to relate its principal lesson to the issue of sustainability.

7:30—Celebrate the 10-year anniversary of Barry Richmond's Keynote speech at the 2002 ST/DM conference: Video and discussion with educators who were influenced by Barry's vision.

Monday, July 2

8:30-12:00—Featured speaker and facilitator: Peter Senge: *Now What? How Do We Implement the Common Core Standards and the STEM Process Using Systems Thinking and System Dynamics in our Educational System?*

Healthy Chickens, Healthy Pastures Playkit



Healthy Chickens, Healthy Pastures
Making connections at Drumlin Farm and Beyond

Written by Linda Booth Sweeney and Renata Pomponi
Graphic design: Ann Jennings

This Playkit is a game to help students think deliberately about living systems in a farm setting and give students a mental framework to take home and apply in other contexts. Through this game, students explore the hidden interconnections and dynamics surrounding the "Egg Mobile," a portable chicken coop designed for sustainable farming at Drumlin Farm in Lincoln, MA. Students will answer the question: What's the connection between the Egg Mobile and a healthy pasture?

Healthy Chickens *continued on page 14*

Characteristics of Complex Systems Project
Lesson 1A: Fun with Springs

by Anne LaVigne and Jennifer Andersen in collaboration with the CLE

Overview

Students explore a simple spring simulation to see how springs behave, given different characteristics. Students can change the springiness, the resistance, and the amount of push or pull.

Learning Goals Level A – Ages 5-9

- Represent and interpret data on a line graph.
- Compare/contrast how different types of springs behave.
- Describe how a push or pull of a spring affects its motion and position over time.
- Identify and describe other examples that oscillate in a similar fashion as a spring.

Time

Two 45-minute sessions

Materials

- One computer for every 2-3 students
- Simulation online at http://forio.com/simulate/cle/L1SpringLevA
- Handouts
- Slinky® or other springs and rubber bands of different sizes to use for demonstration (optional)

Curricular Connections

- An object's motion can be described by tracing and measuring its position over time.
- The position and motion of objects can be changed by pushing or pulling. The size of the change is related to the strength of the push or pull.

Figure 1: Title Screen

Key system dynamics concepts and insights

- Springs move as they do because of how they are made; they have the potential to oscillate but can be at rest.
- Movement is affected by characteristics of the spring, such as mass and "springiness."

Student Challenge

Design a spring that behaves differently than the examples. Tell the story of how the spring's motion changes over time.

Lesson Details

Preparation

1. Create groups of two to three students each.
2. Copy included handouts for each student group.
3. Check computers to make sure you can access the simulation.

Session 1

1. Introduce students to springs and the key concepts in the simulation. You may also want to have actual springs in the classroom for students to explore (e.g., a Slinky®). These concepts should include:

   a. Springiness – How easy is the spring to pull apart? What if it were really hard to pull? Really easy?

   b. Push or Pull - How can we move the spring before releasing it? What will happen if we push it up? Pull it down?

   c. Resistance – Is there anything that slows down the spring? Does air slow down the spring? What if it were in outer space?

2. Show students the simulation in the classroom and read the introduction together (Figure 2 on next page) and go over the "Get Started" section.

3. Using the handouts, have students work in their small groups to "Make Decisions" (Figure 3 on next page).

Springs *continued on page 12*

Fun with Springs

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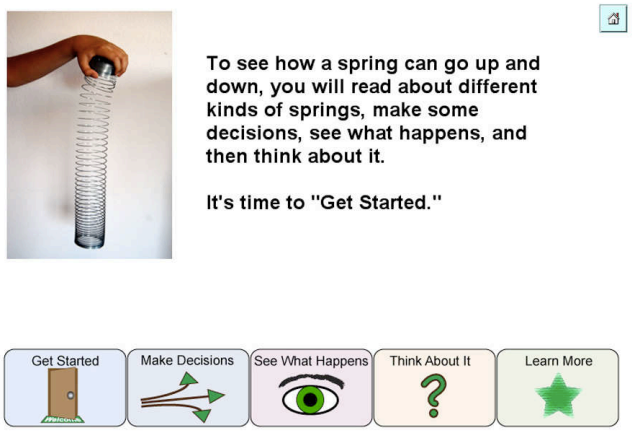

Figure 2: Introduction

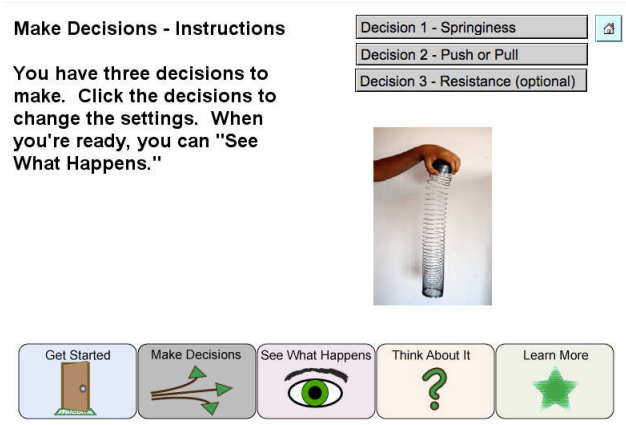

Figure 3: Make Decisions

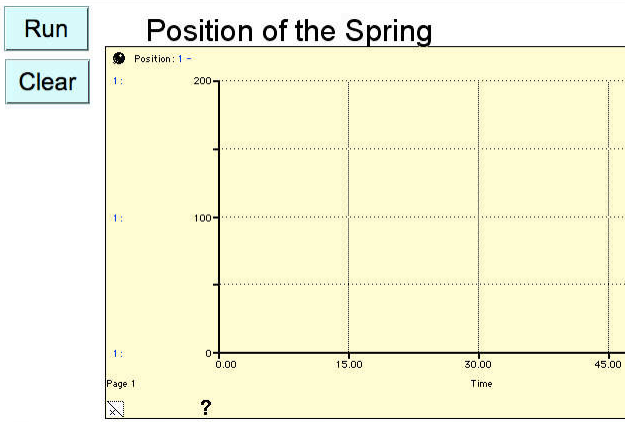

Figure 4: See What Happens

4. Have students continue to "See What Happens," recording data on the handout after the simulation run is complete (Figure 4). Students can run the simulation multiple times for different springs and record their data on the simulation handout for each one.

Session 2

1. If needed, have students complete the simulation within their small groups.
2. After running the simulation multiple times, students can continue to the "Think About It" section (Figure 5). Depending on student age and reading level, students may need guidance with this section.

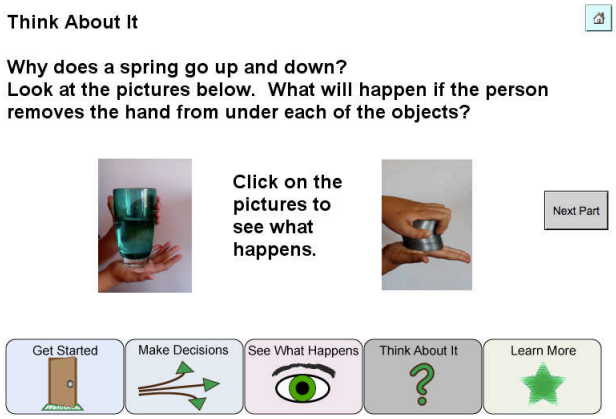

Figure 5: Think About It

3. Debrief the simulation experience using ideas for bringing the lesson home and assessment. You can also explore additional models described in the "Learn More" section (Figure 6).

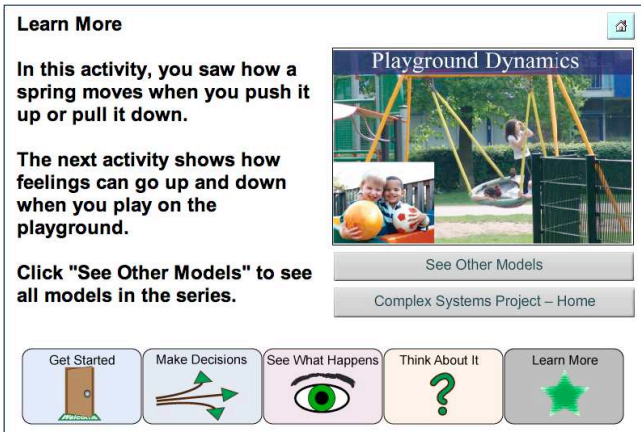

Figure 6: Learn More

Bringing the Lesson Home

Run some experiments back in the classroom. Ask students to give you settings for a spring that would move in different ways:

- very fast
- very slowly
- very high/low
- start near the floor
- stop moving over time
- never stop moving over time
- others?

Discuss why the spring behaves the way it does for each experiment.

Test the simulations and lessons from the Characteristics of Complex Systems Project and earn a *full scholarship plus room* for the ST/DM conference.

In the doldrums post testing this spring, give your students an interesting challenge and test our new simulations with lesson plans for the Characteristics of Complex Systems Project. We will have simulations and lessons available for students aged 5-9, 8-12 and 11-adult on Springs, Relationships, Animal Populations, Predator-Prey and Predator-Prey-Food. We will appreciate help in making these lessons student-worthy! For more information contact Lees Stuntz (stuntzln@clexchange.org).

Assessment Ideas

- Have students complete the assessment section of the handout.
- Have students create a picture of another example of something that oscillates like a spring.

The Spring Oscillation lesson for ages 5-9 is Lesson 1A from the Characteristics of Complex Systems Project, and is available on the CLE website, www.clexchange.org. The lesson includes student worksheet handouts.

10th Biennial Systems Thinking and Dynamic Modeling Conference
Babson College, Wellesley, MA, June 30- July 2, 2012

Critical Thinking: Using Systems Thinking and System Dynamics to Address Common Core and STEM Standards

Join leading educators to investigate and apply best practices for implementing Common Core Standards and expanding STEM education. Explore approaches that can help our students (and adults) think critically about the systems around us, and how they change over time. Our schools face many challenges educating students for a rapidly changing and undoubtedly complex future. Be part of the conversation, and share insights with leaders in K-12 education, as well as experts in organizational learning and systems.

Strategies for classroom teaching, administration, citizen advocacy, and policy techniques will be discussed in a variety of formats at the conference. Activities will include keynote addresses, hands-on workshops, panel discussions, interactive presentations, and plentiful opportunities for networking and informal connections. Attend this biennial international conference and contribute your ideas and opinions about how to move our education system forward. Help frame the dialogue using systems thinking and system dynamics in classrooms and across school districts to advance the goals of the Common Core Standards and a stronger STEM pipeline.

Whether you are a teacher, administrator, policy maker, curriculum developer, education trainer, or interested citizen, you will find plenty to learn at the 10th Biennial Systems Thinking and Dynamic Modeling Conference.

Register here.

Can't come to the ST/DM conference? Join us at Camp Snowball in Tucson, AZ, July 9-13. Camp Snowball is a four-day, multi-faceted learning event that features practical systems thinking and sustainability education workshops for adults and students entering grades 7-12.

Learn more at the Camp Snowball website, http://campsnowball.org/.

Healthy Chickens, Healthy Pastures

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The eight-page Playkit contains everything you need in order to play the Healthy Chickens, Healthy Pastures, "Making Connections" game. This includes a contextual introduction for playing the game, instructions for playing, and a set of Wikki Stix that can be pressed onto accompanying cards to represent causal connections.

Use this game to encourage your students to look for connections within the pasture, to see the people, land, and wildlife in and around farms, not as a set of interesting but disconnected parts, but as components of vibrant, living systems.

We created a Playkit curriculum guide to use with groups of students to help them think deliberately about living systems in a farm setting and to give them a mental framework to apply in other contexts. Through the discussions, system mapping activities, and games in this unit, students will explore the interconnections and dynamics surrounding the "Egg Mobile." Concepts such as feedback loops, time horizon, and stocks/flows are illustrated through a study of the relationships between elements of a farm pasture: chickens, cows, soil, plants, manure, etc. The unit can include outdoor exploration if you have access to a local farm that raises chickens, or you can bring the farm into your classroom using photos, videos and the Internet.

For more information and to order The Playkit, go to www.clexchange.org.

Interested In Investing?

If you would like to invest in our effort here 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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- In paper format via US mail ($15.00 outside the USA)

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