Introduction to Systems Thinking

Facilitators: Anne LaVigne
              Alan Ticotsky

Facilitator Introductions
Introductions

- Name
- School/job assignment
- Email: What do you hope to take away from this experience?

Polling Question
A little about you...

Which of these most closely matches your work?

1. Teacher — Elementary
2. Teacher — Middle/High School
3. Educational support or Administration
4. Business and/or consulting
5. Non-profit organization
6. Other
General Information

- Facilities
- Breaks/lunch
- Materials
- Other details

Food for Thought

“Having to know the answers puts us in terrible positions from which to learn.”

D. Kim

Assembled by Anne LaVigne and Alan Ticotsky
for Intro Session at 2014 CLE Conference using materials from Waters Foundation and Creative Learning Exchange

©2014 Permission to use for non-profit, educational purposes
Circles in the Air

Adapted from: The Systems Thinking Playbook
By Linda Booth Sweeney & Dennis Meadows

Mental Models

Mental models are deeply ingrained assumptions, generalizations, or even pictures or images that influence how we understand the world and how we take action.

Peter Senge, The Fifth Discipline, 1990
Learning Goals

Participants will be able to describe, identify examples, and apply:

- characteristics of a system
- habits of a systems thinker
- systems thinking concepts and tools
- Classroom, school, and organizational applications
Efficacy $n$. 

- Power or capacity to produce the desired effect
- Ability to achieve results
- Effectiveness

Behavior Over Time Graphs

Career Efficacy

![Graph showing behavior over time](image)
Behavior Over Time Graphs

✓ What is changing?
✓ How is it changing?
✓ Why is it changing?
✓ So what?

Asking Good Questions

“My mother made me a scientist without ever intending to. Every other Jewish mother in Brooklyn would ask her child after school, ‘So? Did you learn anything today?’ But not my mother. ‘Izzy,’ she would say, ‘did you ask a good question today?’ That difference - asking good questions - made me become a scientist.”

Isidor Isaac Rabi
Stories to Graphs

- Prices are now rising more slowly than at any time during the last five years. (PRICE)

- After the concert, there was a stunned silence. Then one person in the audience began to clap. Gradually, those around her joined in and soon everybody was applauding and cheering. (NOISE LEVEL)

- In the spring, my lawn grew very quickly and needed cutting every week. But since we have had this warm spell, it needs cutting less and less frequently. (LENGTH OF GRASS)

Stories to Graphs (continued)

- When doing a jigsaw puzzle, I usually spend the first half hour or so sorting the edge pieces. When I have collected all the ones that I can find, I construct a border around the edge of a table. Then I start to fill in the border with the center pieces. At first this is very slow going but the more pieces I put in, the fewer there are to sort through so the faster I get. (NUMBER OF ‘CONNECTED’ PUZZLE PIECES)

- A “typical” season for your favorite sports team. (GAMES WON)
Examples

The Tortoise and the Jackrabbit
Persistence

Assembled by Anne LaVigne and Alan Ticotsky
for Intro Session at 2014 CLE Conference using materials
from Waters Foundation and Creative Learning Exchange  ©2014 Permission to use for non-profit,
educational purposes
The Bicycle Room’s Rate of Learning

Science Inquiry
Growing Plants
Artistic Expression & BOTGs

System Dynamics Computer Models

Assembled by Anne LaVigne and Alan Ticotsky
for Intro Session at 2014 CLE Conference using materials
from Waters Foundation and Creative Learning Exchange

©2014 Permission to use for non-profit, educational purposes
Use an article as a practice field – Traffic as an issue of concern.
Connections

What are some connections you can make...

✓ to curriculum and assessment?
✓ within your team, school, or organization?
✓ to your coursework?

Characteristics of a System
Connection Game
Discovering characteristics of a system

Stand in a circle, facing inward.
Hold up your numbered “name tag.”
Choose two people to be your references. Keep your reference points secret.
Once the facilitator says, “Go,” you must move to be equidistant from both of your references. If the reference(s) move, you must move as necessary to maintain equidistance.

*Adapted from The Systems Thinking Playbook, by Linda Booth Sweeney and Dennis Meadows
Debriefing the Connection Game

Some Characteristics of Systems

Elements or Parts
Examples include physical objects, living things, resources.

Interconnections or Relationships among the Parts
A system consists of interconnected parts. Interconnections can be influenced by laws, rules, culture, polices, beliefs, etc.

Goal or Purpose
All systems have goals or purposes. Some goals are explicit and others are implicit.

Dynamics
Systems tend not to stand still and continually change and adjust over time.
So, what is a system?

A system is a collection of elements that interact with each other over time to function as a whole.

What is Systems Thinking?

Systems thinking utilizes habits, tools and concepts to develop an understanding of the interdependent structures of dynamic systems for the purpose of finding leverage points to solve problems.
What is Systems Thinking?

“Systems Thinking is a vantage point from which you see a whole, a web of relationships, rather than focusing only on the detail of any particular piece. Events are seen in the larger context of a pattern that is unfolding over time.”

High Performance Systems, now isee systems

Why Systems Thinking?

The world is made up of dynamic, interdependent systems. We have an obligation to provide students the skills and tools needed to be successful in this world.

Peter Senge – *Schools That Learn*, 2000
Pedagogy

- Active
- Simulations
- Constructivist
- Hands-On
- Inquiry
- Learner Centered
- Team Work

Science, Technology, Engineering and Math (STEM)

Using System Dynamics and Systems Thinking Tools and Learning Strategies to Build Science, Technology, Engineering, and Math Excellence

Assembled by Anne LaVigne and Alan Ticotsky
for Intro Session at 2014 CLE Conference using materials from Waters Foundation and Creative Learning Exchange ©2014 Permission to use for non-profit, educational purposes
The Habits of a Systems Thinker

1. Seeks to understand the big picture
2. Observes how elements within systems change over time, generating patterns and trends
3. Recognizes that a system’s structure generates its behavior
4. Identifies the circular nature of complex cause and effect relationships
5. Changes perspectives to increase understanding
6. Surfaces and tests assumptions
7. Considers an issue fully and resists the urge to come to a quick conclusion
8. Considers how mental models affect current reality and
   changes perspectives to increase understanding
9. Uses understanding of system structure to identify possible leverage actions
10. Considers both short and long-term consequences of actions
11. Finds where unintended consequences emerge
12. Recognizes the impact of time delays when exploring cause and effect relationships
13. Checks results and changes actions if needed: “successive approximation”
Habits Sort

✓ Sort your cards into 3 piles:
  o Habits you understand and practice on a daily basis
  o Habits you understand yet need practice using on a daily basis
  o Habits that you do not fully understand

✓ Share with 2 or 3 people at your table:
  o One of the habits you understand from the first pile OR one question you have about a habit from the last pile

Cartoon Practice

Which habits are the “characters” using or could they use to help them?
Habits of a Systems Thinker Collage

Habits Wall

Assembled by Anne LaVigne and Alan Ticotsky for Intro Session at 2014 CLE Conference using materials from Waters Foundation and Creative Learning Exchange ©2014 Permission to use for non-profit, educational purposes
Reading the News

Integrating current events

Web of Life

What accumulations can you identify within the radio report?

“Air Pollution Grows in Tandem with China’s Economy” by Louisa Lim
Connection Circles

Connection circles are thinking tools designed to help students understand complexity. Using connection circles as graphic organizers, students generate ideas about changing conditions within a system. They choose the elements they think are most important to the change and draw arrows to trace cause and effect relationships. Quaden and Ticotsky, *The Shape of Change*

Creating your own CONNECTION CIRCLES

1. Draw a large circle.

2. List important elements around the circle.
   - Restrict the number to between five and ten.
   - All elements should be nouns or noun phrases.
   - Elements can increase or decrease.

3. Identify an element that causes another element to increase or decrease.
   - Draw an arrow from the cause to the effect.
   - Make sure that the causal connection is a direct one.
   - Identify polarity of arrow and label at the arrow head.

4. Continue to identify elements with causal connections.
Finding Feedback within a Connection Circle

Feedback shows circular causal relationships within a system

Reinforcing Feedback

- “Things are getting out of control!”
- “I can’t keep up!”
- “We are really on a roll now!”
- “It’s spreading like wild fire!”

R-Reinforcing Loop
B-Balancing Loop
+/s – adds to or same direction
-/o – subtracts from or opposite direction
Balancing Feedback

- "We are experiencing some subtle ups and downs."
- "I can sense that things are beginning to settle down."
- "We seem to be achieving balance and stability."
- "Our system is close to reaching our goals."

Stocks and Flows
Stocks and Flows

Stock and flow diagrams show the nature of change in a system (i.e. dynamics) and the interdependencies that influence the changes.

Water Dynamics: Get with the Flow

For each challenge, start with all the extra water in the inflow “cloud.” Before beginning, graph the goal (what the water should do over time). Then, graph what actually happens in a different color. After completing a challenge, continue with the next one. Feel free to repeat any challenge to improve results.
Water Dynamics: Get with the Flow

Challenge #1
Start with 200 ml of water in the cylinder, then raise the water from 200 ml to 800 ml while water is always going in and always going out.

Water Challenge #1 Results

ml of water in cylinder
800
500
200
Time (in seconds)

Water Dynamics: Get with the Flow

Challenge #2
Start with 800 ml of water in the cylinder, then lower the water from 800 to 200 ml, while water is always going in and always going out.

Water Challenge #2 Results

ml of water in cylinder
800
500
200
Time (in seconds)
**Water Dynamics: Get with the Flow**

**Challenge #3**
Start with 500 ml of water in the cylinder, then keep the water at the 500 ml level for at least 30 seconds, while water is always going in and always going out.

**Water Challenge #3 Results**

<table>
<thead>
<tr>
<th>Time (in seconds)</th>
<th>ml of water in cylinder</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>800</td>
</tr>
</tbody>
</table>

**Water Dynamics: Get with the Flow**

**Challenge #4**
Create the water level shown on the graph while water is always going in and always going out.

**Water Challenge #4 Results**

<table>
<thead>
<tr>
<th>Time (in seconds)</th>
<th>ml of water in cylinder</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>800</td>
</tr>
</tbody>
</table>
Water Dynamics: Get with the Flow

Challenge #5
Start with 500 ml in the cylinder. Predict on the graph: What will happen if you adjust the inflow and outflow as shown? Notice the outflow stays the same while the inflow starts at slow and gets faster over time. Use the graph on the right to predict and then record what actually happens over time.

Water Dynamics: Debrief

Reflection: Match the graph to the description.

1. Inflow < Outflow
   Graph _______ describes this situation because

2. Inflow > Outflow
   Graph _______ describes this situation because

3. Inflow = Outflow
   Graph _______ describes this situation because
Water Dynamics: Reflection

Reflection:
Consider that the water in the cylinder is a stock and the water going in and out are flows.
• What else in your experience is similar to the stock of water?
• How do the flows work in that system?

Mammoth Game
Mammoth Game 1

1. A CALF IS BORN
2. MAMMOTH KILLED BY PREDATOR
3. MAMMOTH DIES OF STARVATION
4. MAMMOTH KEEPS LIVING ANOTHER YEAR
5. MAMMOTH KEEPS LIVING ANOTHER YEAR
6. MAMMOTH KEEPS LIVING ANOTHER YEAR

Mammoth Game 2

1. A CALF IS BORN
2. MAMMOTH KILLED BY PREDATOR
3. MAMMOTH DIES OF STARVATION
4. MAMMOTH KILLED BY HUMAN HUNTER
5. MAMMOTH KEEPS LIVING ANOTHER YEAR
6. MAMMOTH KEEPS LIVING ANOTHER YEAR
Mammoth Game
Building a model of the system

Stock and Flow – Compare and Contrast
Making Turkey Soup
The Dynamics of Illness in the Classroom

Elementary (Primary) Economics Example: Marker Scarcity
Water Pollution

High School World History II
French Revolution

Assembled by Anne LaVigne and Alan Ticotsky
for Intro Session at 2014 CLE Conference using materials
from Waters Foundation and Creative Learning Exchange

©2014 Permission to use for non-profit, educational purposes
Some Questions to Ask When Creating Stock/Flow Maps

- Does the converter (part) increase or decrease the stock (accumulation)?
- If a part increases the stock then does it open the inflow (increase the inflow rate) or close the outflow (decrease the outflow rate)?
- If a part decreases the stock, then does it close the inflow (decrease the inflow rate) or open the outflow (increase the outflow rate)?
- Does this factor directly affect the flow or does it connect to something else first?
- Look for feedback by asking, “Does the accumulation in the stock affect an inflow, outflow, and/or converters in the map?”

Use an article as a practice field.
The Habits of a Systems Thinker

Which habit(s) do you practice when you use stocks and flows?

Connections

What are some connections you can make...

- to curriculum and assessment?
- within your team, school, or organization?
- to your coursework?
Finding Feedback within a Stock/Flow Map

Feedback shows circular causal relationships within a system
Friendship Skills
First Grade
Problem-solving

Mean Words ➝ Hurt Feelings

Say “sorry”
Break up the group
Play a game with only one team

©2014 Permission to use for non-profit, educational purposes
Lesson on Ecosystems

Producers and consumers
in an ecosystem

Definition:
Class definition goes here.
(e.g. Herbivores...animals that eat plants.
Prey...animals that are hunted by other animals.)

Consumers
bobcats
clovers
rabbits
class definition goes here.
(hawks
spiders
rattle snakes
etc.)

Producers
consumers with mixed diets
coyotes
javalina
foxes
bear
mice
etc.

Consumers
with mixed diets
bobcats
clovers
rabbits

Producers

clovers
grass
cactus

Name________________

Definition:
Class definition goes here.
(e.g. Carnivores...animals that eat other animals.
Predators...animals that hunt other animals.)

Producers and consumers
in an ecosystem

Definition:
Class definition goes here.
Plants, also algae and cyanobacteria.
Organisms that produce their own food.

Name________________

Definition:
Key: O=opposite  S=same

Lesson on Ecosystems

Reinforcing Efficacy

Efficacy
“I believe I can succeed.”

Effort
“I try my hardest because I believe I can succeed.”

Achievement
“I have proof of my success.”

Assembled by Anne LaVigne and Alan Ticotsky
for Intro Session at 2014 CLE Conference using materials
from Waters Foundation and Creative Learning Exchange
©2014 Permission to use for non-profit, educational purposes
A Core Theory of Success

Use an article as a practice field.
The Habits of a Systems Thinker

Which habit(s) do you practice when you use connection circles and causal loops?

Connections

What are some connections you can make...

✔ to curriculum and assessment?
✔ within your team, school, or organization?
✔ to your coursework?
What else is “out there?”

Ladder of Inference

Next time, I tell him that his epidermis is showing.

I believe I understand the meaning of epidermis.

Epidermis must mean underwear!

I laugh when my friends and I talk about underwear.

I noticed that kids laughed when they said, “Your epidermis is showing.”

I do something based on my beliefs.

I develop beliefs based on assumptions I make.

I make assumptions based on the meaning I add.

I add my own meaning. (cultural & personal)

I notice certain information & experiences.

Information & experiences around me
Systems Archetypes

System archetypes use causal loop diagrams to capture “common stories” that occur repeatedly in diverse settings. They act as a lens, a perspective from which to see what creates behaviors in a system.

Implementation and Sharing
Closure

- What’s next?
  - Implement one idea
  - Look at WebEd
  - Locate resources

- Exit Survey
- Certificates