An Introduction to Systems Thinking and Dynamic Modeling

Framing and Mental Models

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“Types of thinking you want your students to do...”
General Information

- Facilities
- Time frame
- Breaks/lunch
- Materials
- Other details
Introductions

✓ Name
✓ School or Organization
✓ Position
✓ Write on a post-it, “What is one hope you have for this workshop?”
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
Polling Question
A little about you...

Choose one statement below that best matches your experiences with systems thinking (ST):

1. I haven’t yet applied ST to my work.
2. I have applied ST with students and/or my colleagues with some success.
3. I currently apply ST with my students and/or colleagues on a regular basis with success.
4. In addition to currently integrating ST into my work, I have taught others ST strategies.
Big Picture of the Day

• Framing and Mental Models
• Stock/Flow Maps, Graphs and Models
• Connection Circles
• Feedback Loops
• Throughout - Application/Implementation Ideas
Resources We’re Using

• *The Shape of Change*, Rob Quaden and Alan Ticotsky.
  • All materials in the book are downloadable from the Creative Learning Exchange website at [http://www.clexchange.org/cleproducts/shapeofchange_lessons.asp](http://www.clexchange.org/cleproducts/shapeofchange_lessons.asp)
• *The Systems Thinking Playbook*, Meadows and Sweeney
• *Systems in Motion*, Andersen and LaVigne
• Habits of a Systems Thinker, Waters Foundation
• Stella Online, isee systems
Goals

• experience and identify systems in the world.
• represent systemic structure and trends by using a variety of system dynamics tools.
• identify relevant educational standards.
• plan an initial implementation.
“Types of thinking you want your students to do...”
What is a system?

Two definitions by Donella H. Meadows

*Thinking in Systems*

A system is a set of things—people, cells, molecules, or whatever-interconnected in such a way that they produce their own pattern of behavior over time.”
What is a system?

Donella H. Meadows continued...

"A system is an interconnected set of elements that is coherently organized in a way that achieves something. If you look at that definition closely for a minute, you can see that a system must consist of three kinds of things: elements, interconnections, and a function or purpose."
Characteristics of a system?

✓ Elements
✓ Interconnections
✓ A function or purpose
✓ Production of patterns of behavior over time.
Choose a picture and describe the system.

Include: elements, interconnections, function/purpose, & something changing over time that is produced by the system.
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
Circles in the Air

Adapted from: The Systems Thinking Playbook By Linda Booth Sweeney & Dennis Meadows
Considering how we want to learn together...

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

Daniel Kim
The Great Thumb-wrestling Challenge

Find a partner.

Agree on a procedure/set of rules.

Goal: Collect as many points as you can in one minute.
Thumb-wrestling debrief

• What happened?
• Share: How many points did you collect as a pair?
• What are our mental models about thumb wrestling?
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.

Ladder of Inference

The ladder of Inference is a metaphor of our thinking process. It outlines how we derive our beliefs and actions from the data we perceive in our surroundings.

Adapted from the Ladder of Inference created by Harvard business professor Chris Argyris

Climbing the Ladder of Inference

Data & Experiences

Data selected

Meaning added

Assumptions made

Beliefs adopted

Action taken
Ladder of Inference Practice
Who Killed Lord Smythe?
Links

Identify possible links between using this tool and
• your work
• your team
• curricular goals
Behavior Over Time Graphs

- What is changing?
- How is it changing?
- Why is it changing?
How is an iceberg like a system?

About 7/8ths of an iceberg is below the surface of the water. What does that imply about what people typically see in a system?

As we describe the behaviors and structure of a system, we are representing our own mental models of how that system works.

Sharing representations of systems help us go beyond our own mental models to better find effective leverage for positive change.
Stocks and Flows with Behavior Over Time
In and Out Game

Goal: Make predictions about dynamics, based on different rules and compare results.
In and Out Game

Game 1
In the stock to start: 0 players
Inflow each round: 2 players going in
Outflow each round: 1 player going out

Materials, instructions and debrief from Quaden and Ticotsky, *The Shape of Change*
In and Out Game

Game 2
In the stock to start: 0 players
Inflow each round: 5 players going in
Outflow each round: 2 players going out
In and Out Game – Debrief

• How are the lines for Game 1 and Game 2 similar? How are they different?
• Which line is steeper? Why?
• How would the graph be different if there were some players in the stock at the start of the game?
• What happens when an outflow is larger than the inflow?
• What happens when the inflow and outflow are equal, say, 3 in and 3 out each round?
• What experiences in life resemble the In and Out Game?
In and Out Game – Extension

The In and Out Game
modified from *The Shape of Change*

Start

http://www.clexchange.org/curriculum/shapeofchange/Aoe_1_InOut.asp
Tree Game
Tree Game

Procedure:
1. Count 120 sticks into your container.
2. The container represents a forest that will undergo some changes.
   • Each year trees will be added and removed according to a certain rule.
   • The stick added represent new trees. The sticks removed represent trees that are cut down.
3. Each person on the team will have a job.
   • Forest managers plant trees (add sticks)
   • Lumberjacks I cut down trees (remove sticks)
   • Record keepers record inventory.
Tree Game Rules

• Start with a forest of 120 trees
• Each year plant 4 new trees
• The first year cut 1 tree.
• The second year cut 2 trees; the third year cut 4 trees; and so on. In other words, the number of trees you remove from the forest doubles each year.
• Each year the managers add sticks and the lumberjacks take away sticks and the record keepers record the data on the Forest Inventory Table
• Be as accurate as possible. (MP 6)
Tree Game – Debrief

• How does the graph show what happened to the stock of trees in the forest over time?
• When did the forest grow? Why?
• When did the forest decline? Why?
• Did the forest ever stay the same? Why?
• Why did the forest grow and then start to decline?
• Why did the rate of decline increase as time went on?
• What caused the changes in the stock of trees?
Tree Game – Extension

"The Tree Game" Simulator

• [http://www.clexchange.org/curriculum/shapeofchange/soc_6_TreeGame.asp](http://www.clexchange.org/curriculum/shapeofchange/soc_6_TreeGame.asp)
Tree Game – Extension

https://exchange.iseesystems.com/models/player/creativelearningexchange/tree-game
Stock/flow Converters and links

D = All elements other than stock and flows
Practice Field: Macquarie Island

Macquarie Island on a misty day. (Photo: Richard Dakin)
Examples
How is an iceberg like a system?

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Links

Identify possible links between using this tool and
• your work
• your team
• curricular goals
Connection Circles
Connection Game

Working in K-12 education to develop Systems Citizens
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Materials, instructions and debrief from Quaden and Ticotsky, The Shape of Change
Connection Game

• Stand in a circle.
• Hold up your number in front of you.
• Look around the circle and choose two numbers. Try to do this randomly and keep it a secret.
• At the signal (and with no talking), start moving to stay equidistant* from the two numbers you chose.
• The game continues until all players are equidistant and movement stops – equilibrium.
• Your goal is to achieve equilibrium as soon as possible.

•* Define and demonstrate equilibrium for the group as needed.
Connection Game – Debrief

• Let’s draw out what happened first.
Connection Game – Debrief

• What happened when you tried to stay equidistant from your two numbers?
• Was it difficult to achieve the goal of equilibrium? Why or why not?
• What strategy did you find most effective? If you played again, what would you do differently?
• How did one person’s change in position affect others in the group?
• Can you think of an example of one behavior causing many other unexpected things to change?
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*
Whale Video

- Watch the video.
- Write key words that you think are important variables in the system that go up and down over time, e.g., number of sea otters.
- Choose what you feel are the most important variables (no more than 9) and write these around the outside of the circle.
Practice Field: How Whales Change Climate
Drawing Causal Links

**Guidelines**
Draw cause → effect linkages between the variables. The arrow shows the direction of causality. The arrowhead is labeled to show the relationship between the variables.

**Examples**
- Sugar intake → New cavities (s or +)
- Brushing teeth → New cavities (o or −)

Adapted from materials provided by the Social System Design Lab at Washington University, St. Louis.
Creating your own Connection Circles

1. Draw a large circle and list 5-10 important elements (that can increase and decrease) around the circle.

3. Identify an element that causes another element to increase or decrease.

4. Draw an arrow from the cause to the effect. Make sure that the causal connection is a direct one.

5. Identify polarity (+ or −) of link and label at the arrow head.

6. Continue to identify elements with causal connections.

7. Identify feedback loops and tell emerging “stories.”
A Connection Circle Template
How is an iceberg like a system?

As we describe the behaviors and structure of a system, we are representing our own mental models of how that system works.

About 7/8ths of an iceberg is below the surface of the water. What does that imply about what people typically see in a system?

Behavior of a System

Systemic Structure

Events

Sharing representations of systems help us go beyond our own mental models to better find effective leverage for positive change.
Links

Identify possible links between using this tool and

• your work
• your team
• curricular goals
Feedback Loops
Living Loops

Trial 1

- Stand in a line.
- Hold your right hand flat toward the ground.
- Place your left hand in a fist under the hand of the person to your left.
- You are a + link. Whatever happens to your right hand, repeat that same action with your left.
Living Loops

Trial 2

• Stand in a circle.
• Hold your right hand flat toward the ground.
• Place your left hand in a fist under the hand of the person to your left.
• You are a + link. Whatever happens to your right hand, repeat that same action with your left.
Living Loops

Trial 3

• Stand in a circle.
• One person receives an “−” link.
• Hold your right hand flat toward the ground.
• Place your left hand in a fist under the hand of the person to your left.
• If you are a (+), repeat with your left hand what happens to your right. If you are a (−), do the opposite with your left hand in comparison to your right.
Finding Feedback within other representations