**What is a Stock and Flow?**
**Stock/Flow Diagrams to Simple Models**
ST/DM Conference – June 25, 2016

You may have heard the phrase, "Be the ball!" from a variety of popular movies. Now you can "Be the system!" Experience simple systems, then create and play with the simple models to go with them. Make connections to a variety of contexts including math, science, and literature.

Facilitator:    Anne LaVigne
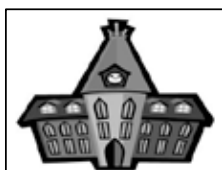
Creative Learning Exchange    Waters Foundation

## Introductions

- ✓ Name
- ✓ School/job assignment
- ✓ Write (then read) one-three words that describe what you hope to gain from this session.

*The Beginning*

## General Information

- ✓ Schedule
- ✓ 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

## More Food for Thought

"If you can think it,
you can model it."

Jay Forrester

## 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

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## 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
- Sysdea.com – Online modeling software
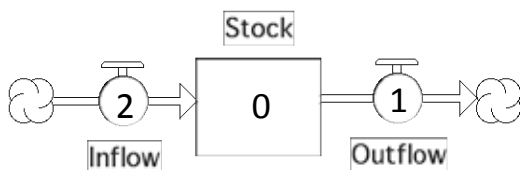
## In and Out Game

Materials:
- Large display area (easel pad, display board, or chalkboard)
- Large easel graph pad
- Colored markers and chalk
- Rope or tape to mark out areas of the classroom floor

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

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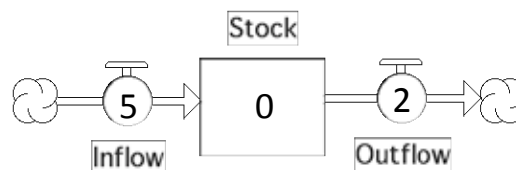
## In and Out Game



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

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

## 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?

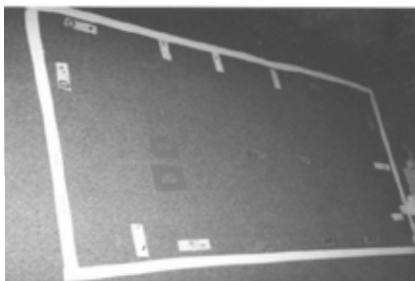Materials, instructions and debrief from Quaden and Ticotsky, *The Shape of Change*

## In and Out Game
## Model and Simulation



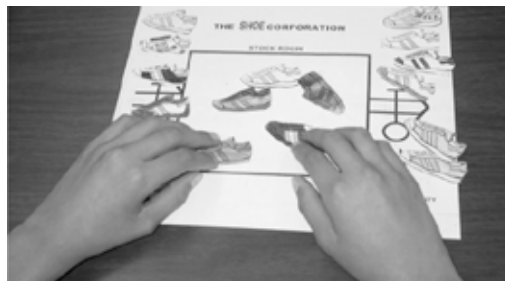http://www.clexchange.org/curriculum/shapeofchange/soc_1_InOut.asp

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## We're Going to the Zoo



## Shoe Stockroom



## Friendship Game



## Friendship Game

Materials:
- Large display area (easel pad, display board, or chalkboard)
- Large easel graph pad
- Markers, chalk
- Set of name cards of class members in a paper bag or container

Goal:
Experience the difference between linear and exponential growth.
Reinforce the goal of including everyone.

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

## Friendship Game

Procedure for **Game 1**:
1. Chose two students to begin the game as the "Friends Team".
2. On a signal from the teacher, the rest of the students close their eyes and each member of the "Friends Team" draws a name card from the container and silently tags those students to come and join the team.
3. For rounds 2 and following the newly selected "Friends Team" members repeat the procedure above.
4. After a round or two ask students to predict the pattern of growth.
5. Play the game until everyone is included.

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

## Friendship Game 1– Debrief

- What do you notice?  What happened to the number of friends?  Why is the line straight?

- Why does it slant upwards diagonally?

- What would happen if you had another class join and you kept playing for 5 more rounds? 10 more?

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

## Friendship Game

Procedure for **Game 2**:
1. Chose two students to begin the game as the "Friends Team".
2. On a signal from the teacher, the rest of the students close their eyes and each member of the "Friends Team" draws a name card from the container and silently tags those students to come and join the team.
3. Record total number of friends on a chart and a graph.
4. For rounds 2 and following **all members** of the "Friends Team" repeat the procedure above.
5. After a round or two ask students to predict the pattern of growth.
6. Play the game until everyone is included.

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

## Friendship Game 1– Debrief

- What do you notice? What happened to the number of friends? Why is the line straight?

- Why does it slant upwards diagonally?

- What would happen if you had another class join and you kept playing for 5 more rounds? 10 more?

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

## Friendship Game
## Simulation and Model



"The Friendship Game" Simulation

http://www.clexchange.org/curriculum/shapeofchange/soc_2_Friendship.asp

## Mammoth Game



## Mammoth Game

Materials:
- 20 dice per team (plus a few extra for the teacher)
- Cardboard boxes for dice rolling
- Markers of the same two colors for each student
- One copy of the Mammoth Game Rules for each team
- Copies of two worksheets for each student:
- Keeping Track of Your Herd
- Graph of Your Mammoth Population

Goal:
Experience exponential decay.
Compare this system to others with similar behavior.

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

## 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

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## 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 – Debrief

- What happened? When did your mammoths go extinct for the two different games?
- Is this what you predicted? Why?
- Why are the lines curved?
- How are the lines for Game 1 and Game 2 alike? How are they different?
- What difference did the hunters make?
- Does this happen only to mammoths? Can you think of other cases?

## Mammoth Game
### Model



## Tree Game



## Tree Game

Materials:
- Approximately 150 wooden craft sticks for each team of students.
- One container to hold the sticks for each team.
- One copy of two worksheets for each team (pages 71-72).

Goal:
Experience the effect of exponential decay on an accumulation.

## 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 l 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)

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

## 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?

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

## Tree Game – Variation for Primary

- Start with a forest of 30 trees.
- One student is the forester who plants (hands out) trees.
- One student is the lumberjack who cuts (takes away) trees.

Game 1
- The forester hands out 30 trees.
- Plant 3 trees each year.
- Cut one more tree each year, starting with 1. The first year cut 1 tree, second year cut 2 trees, third year cut 3 trees, and so on.

## Tree Game –Primary Debrief

- What would happen if we did more rounds?
- Why did the forest go down?
- Why did it go up at first and then start going down?
- What happens if we cut more than we plant?
- Did the forest ever have the same number of trees for two years in a row? Why did this happen?

## Tree Game
### Simulation and Model



"The Tree Game" Simulator

Start

http://www.clexchange.org/curriculum/shapeofchange/soc_6_TreeGame.asp

## Some Additional Activities

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

## Infection Game

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
5. One copy of the Teacher's Class *Record Sheet*

Goal:
Connect the spread of an epidemic to other systems that behave in a similar way.

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

## Infection Game

- 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 is very important to this game.
- 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, exchange numbers, secretly multiply them together, and record the new product for the next round.
- Continue to do this until the teacher ends the game.

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

## Infection Game – Debrief

- What does the graph tell us? What happened to the number of students "infected" with zero during the game?
- How is this graph different from the team prediction graphs? How is it similar?
- Why does the line have an S shape? How does this relate to what was happening during the game?
- What was happening at region A in the graph? Why is the line flatter?
- What was happening at region B? Why is the line steeper?
- What happened at C? Does the curve change its shape?
- What was happening at region D?
- What was happening at region E? Why is the line flat?

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

## Infection Game – Debrief

- How is this like something else we are studying?
- 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.
- In what way is this simulation NOT realistic? What are limitations of the simulation?

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

## Infection Game – A Variation for Primary Students

1. Look at your paper. Do you have any red squares? If you do, you'll color red on your partner's paper. If you have no red squares, you color blue on your partner's paper.
2. Trade papers with someone.
3. Color the next square for that person and then give it back to the same person.

## Infection Game – Extension



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## Rainforest Game

## Rainforest Game

Materials:
- Large display board or overhead projector
- Markers or chalk
- One copy of three worksheets for each student
  1. What Happened to the Trees?
  2. Yearly Forest Inventory
  3. Mature Trees in the Forest graph

Goal:
Act out the lives of trees while following different planting and harvesting policies.
Experience delays involved in managing a renewable resource.

## Rainforest Game

Procedure:

STUDENTS AS TREES

Year 1 Seed – curled up
Year 2 Sprout – sitting
Year 3 Sapling – standing, hands at sides.
Year 4 Mature Tree – standing, hands clasped behind head, elbows out

POLICIES

Policy 1 for years 1-5 – plant 3 trees each year.
Policy 2 for years 6-8 – plant and harvest 3 trees each year.
Policy 3 for years 9-12 – plant and harvest 5 trees per year.

## Rainforest Game –Debrief

- What happened to the forest in this game? Why?
- How does your final graph compare to your original sketch?
- How can a forest manager be assured of having enough trees year after year?
- What would happen if we decided to harvest more than 5 trees in Year 9 (while also planting more seeds)?
- Are there other situations in which maintaining a steady supply of some resource is necessary?

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