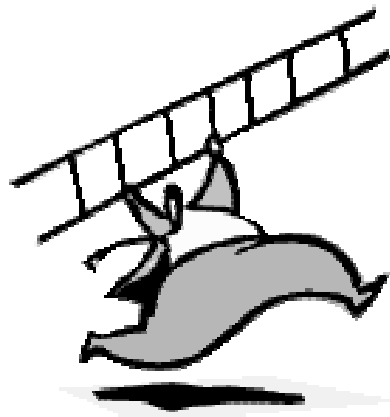


SYSTEMS THINKING: Visual Tools for Increasing Student Learning

Systems Thinking and Dynamic Modeling Conference
June 29, 2002

Mary Scheetz, Portland Public Schools, Portland, OR
Joan Yates, Catalina Foothills School District, Tucson, AZ

Connections with Best Practice



- Classroom Instruction That Works
- Dimensions of Learning



INSTRUCTIONAL STRATEGIES THAT AFFECT STUDENT ACHIEVEMENT

Identifying similarities and differences

Summarizing and note taking

Reinforcing effort and providing recognition

Homework and practice

Nonlinguistic representations

Cooperative Learning

Setting objectives and providing feedback

Generating and testing hypotheses

Questions, cues, and advance organizers

Source: Marzano, Pickering, and Pollock, *Classroom Instruction That Works: Research-Based Strategies for Increasing Student Achievement* (Alexandria: ASCD, 2001)



INSTRUCTIONAL STRATEGIES THAT AFFECT STUDENT ACHIEVEMENT

NONLINGUISTIC REPRESENTATIONS

Visual Tools

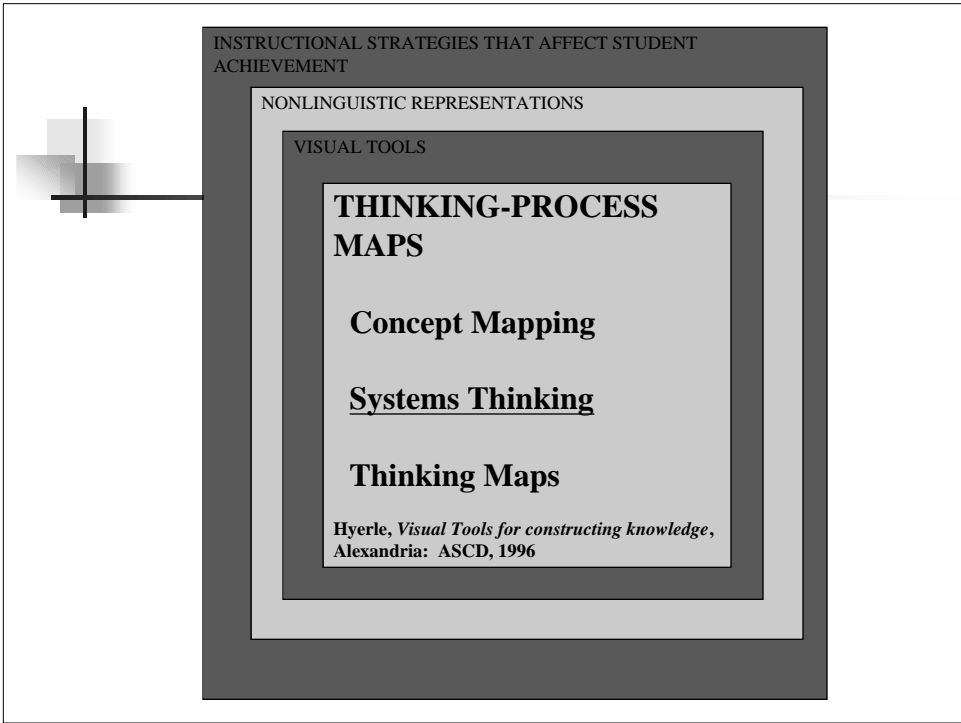
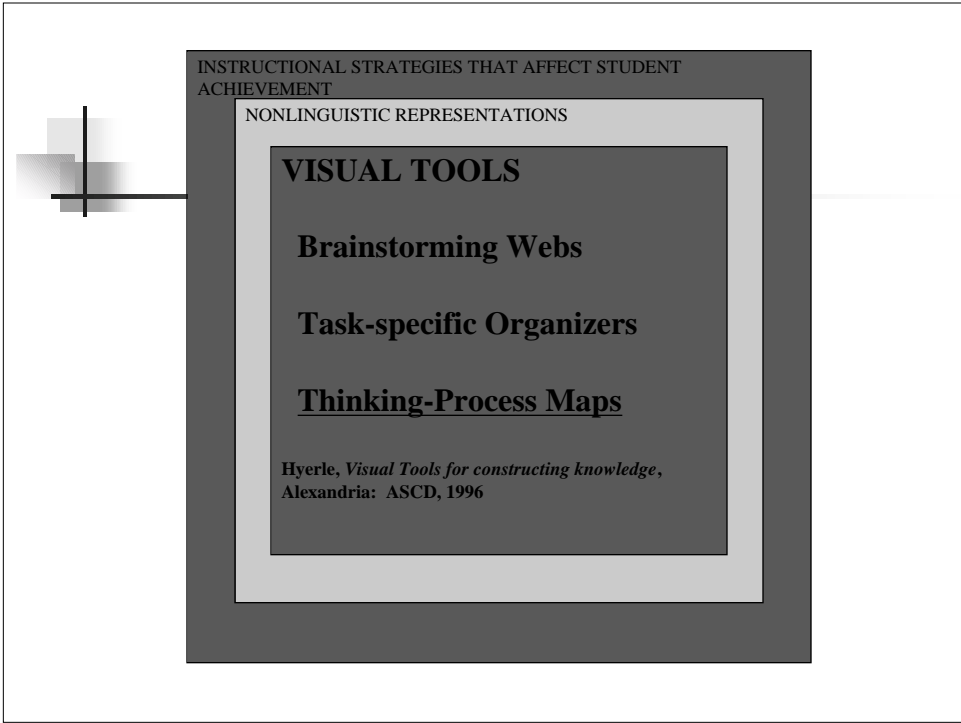
Physical Models

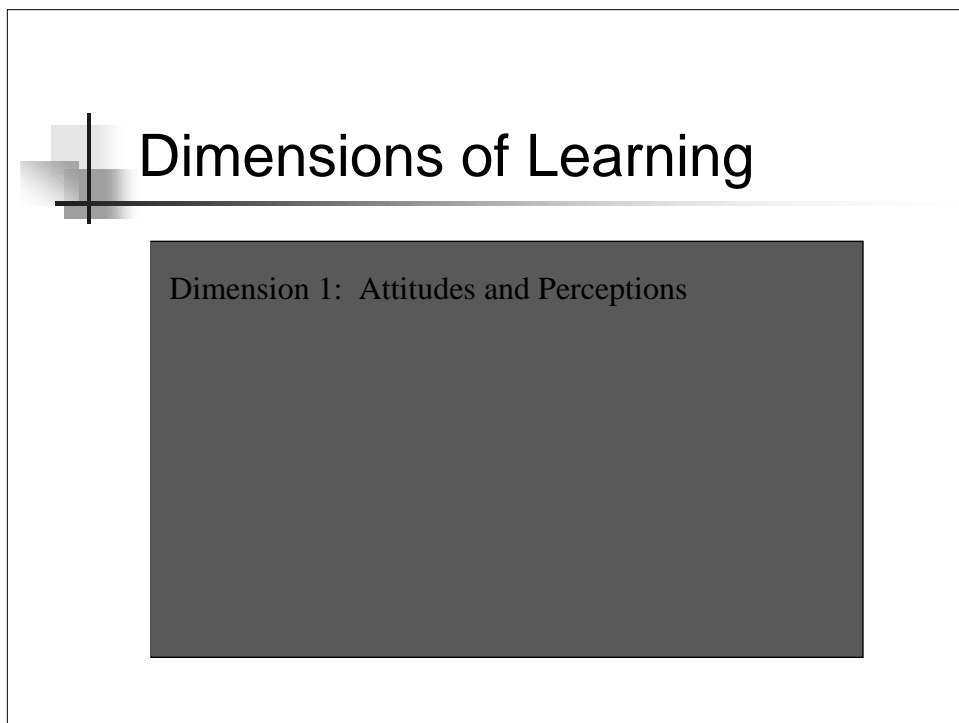
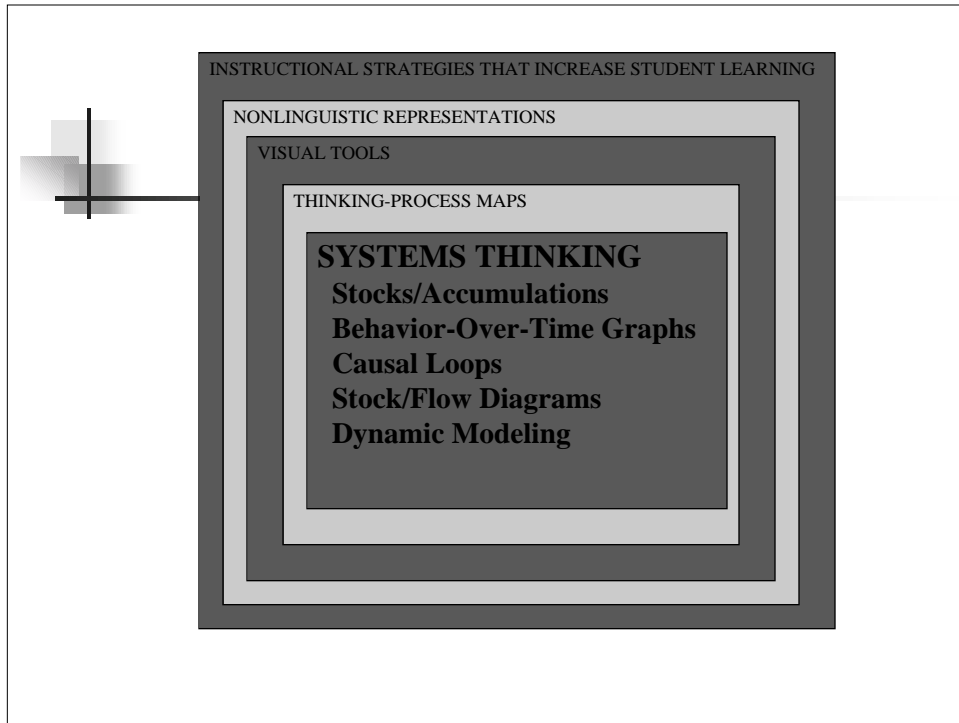
Mental Pictures

Pictures and Pictographs

Kinesthetic Activity

Source: Marzano, Pickering, and Pollock, *Classroom Instruction That Works: Research-Based Strategies for Increasing Student Achievement* (Alexandria: ASCD, 2001)







Dimensions of Learning

Dimension 1: Attitudes and Perceptions

Dimension 2: Acquire and Integrate Knowledge



Dimensions of Learning

Dimension 1: Attitudes and Perceptions

Dimension 2: Acquire and Integrate Knowledge

Dimension 3: Extend and Refine Knowledge



Dimensions of Learning

Dimension 1: Attitudes and Perceptions

Dimension 2: Acquire and Integrate Knowledge

Dimension 3: Extend and Refine Knowledge

Dimension 4: Use Knowledge Meaningfully



Dimensions of Learning

Dimension 1: Attitudes and Perceptions

Dimension 2: Acquire and Integrate Knowledge

Dimension 3: Extend and Refine Knowledge

Dimension 4: Use Knowledge Meaningfully

Dimension 5: Productive Habits of Mind

Dimensions of Learning

Dimension 4: Use Knowledge Meaningfully

Decision Making

Dimensions of Learning

Dimension 4: Use Knowledge Meaningfully

Decision Making

Problem Solving

Dimensions of Learning

Dimension 4: Use Knowledge Meaningfully

Decision Making

Problem Solving

Invention

Dimensions of Learning

Dimension 4: Use Knowledge Meaningfully

Decision Making

Problem Solving

Invention

Investigation

Dimensions of Learning

Dimension 4: Use Knowledge Meaningfully

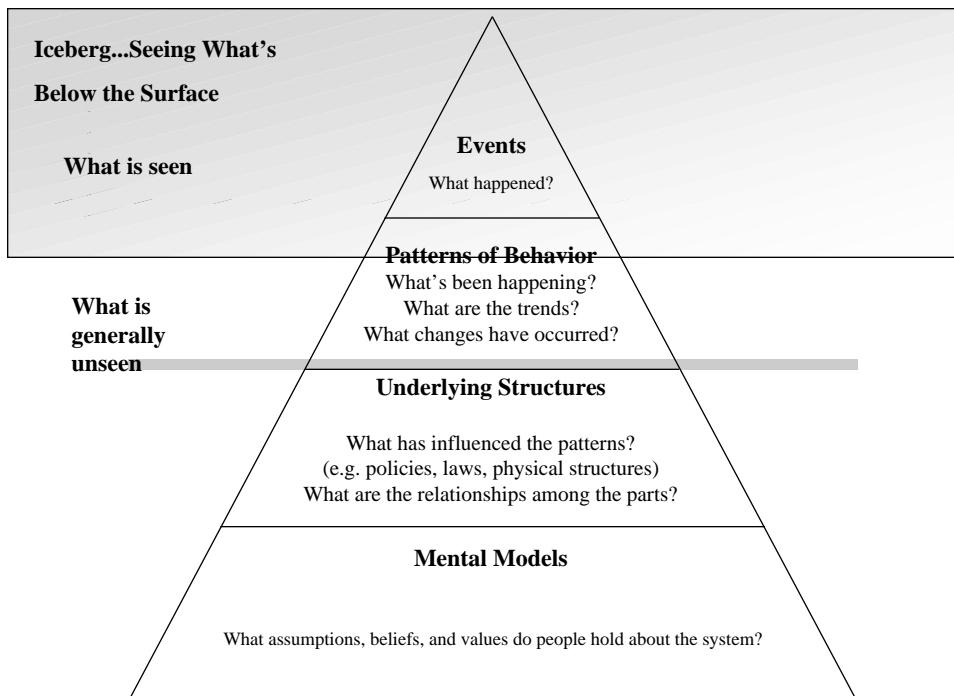
Decision Making	Problem Solving
Invention	Investigation
Experimental Inquiry	

Dimensions of Learning

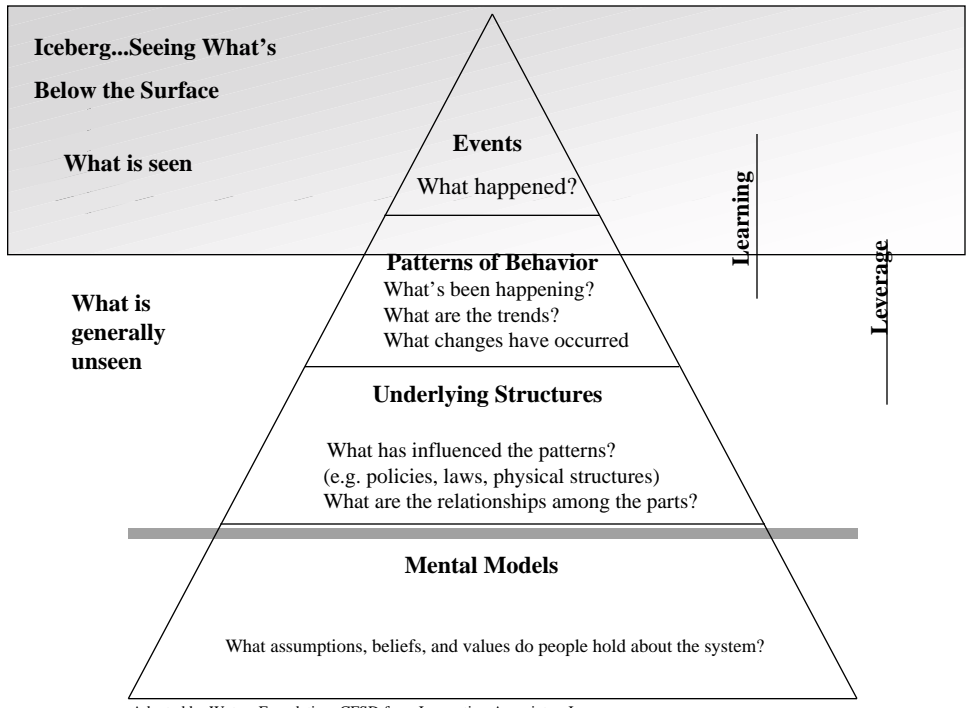
Dimension 4: Use Knowledge Meaningfully

Decision Making	Problem Solving
Invention	Investigation
Experimental Inquiry	Systems Analysis

Systems thinking: Seeing what's below the surface

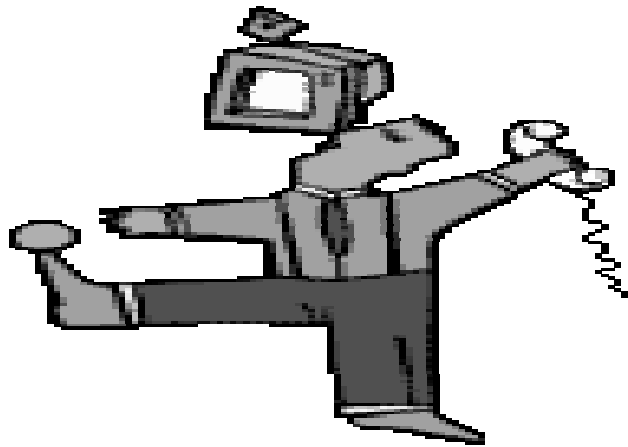


Adapted by Waters Foundation, CFSD from Innovation Associates, Inc.
2/99



Adapted by Waters Foundation, CFSD from Innovation Associates, Inc.
2/99


Balancing Tubes Activity





Systems Thinking and Dynamic Modeling Concepts

- Change over time
 - patterns and trends
 - accumulations
- Circular Causality
 - interdependencies
 - reinforcing and balancing relationships
- Leverage
 - structure generates behavior
 - short and long term consequences
 - trade-offs
 - temporal and spatial boundaries



Systems Thinking/Dynamic Modeling Tools & Corresponding Concepts

- Behavior-over-time graph (BOTG)
 - change over time / trends / patterns of behavior
- Causal loop diagram (CLD) (incl. systems archetypes)
 - circular causality / feedback relationships
- Stock/flow diagram (S/F)
 - interdependencies / accumulations
- System dynamics computer model
 - "What if..." / quantitative
- ST/DM games & activities
 - characteristics of complex systems

Accumulations/Stocks

Things and States of Being



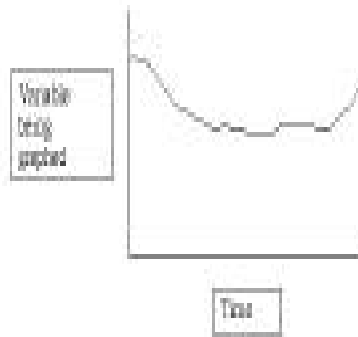
- Nouns, in the STELLA language, are called “stocks.”
- ...are represented by rectangles.
- Examples: Water, Population, Cash, Anger, Hunger, Trust, Commitment

Accumulations in the story

- What aspects/variables within the story change?
 - List aspects/variables.

Behavior-Over-Time. . . Graphs

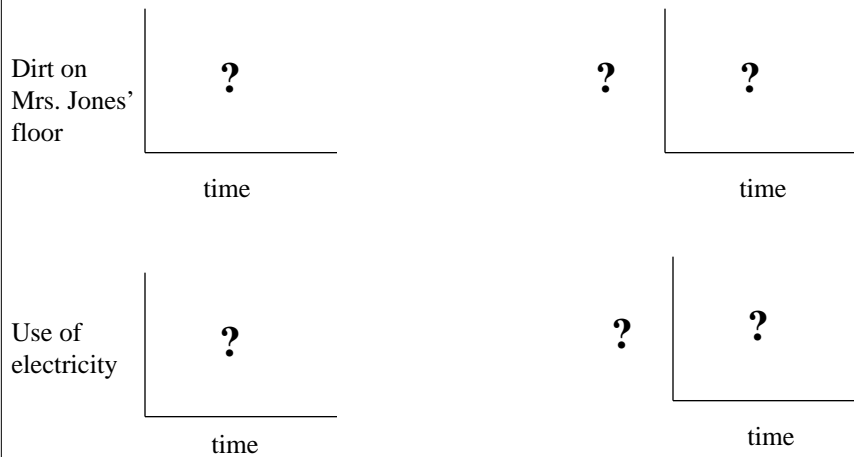
- ...show the trend or pattern of change of a variable over time.
- X axis is always time
- Y axis is always the variable being graphed
- ...can be drawn on a separate graph form or within stocks.



BOTGs from the story

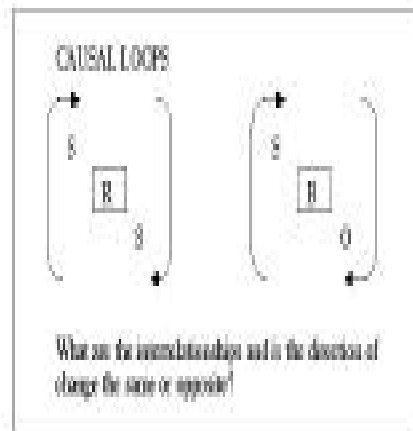
- What aspects/variables within the story change?
 - List aspects/variables.
- How does each aspect/variable change?
 - Draw a BOTG of how each aspect changes.

BOTGs from the story

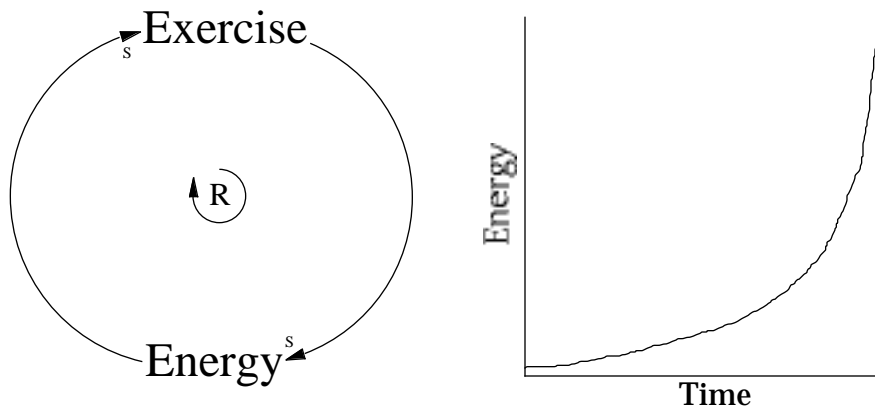


Circular Causality: Causal Loops

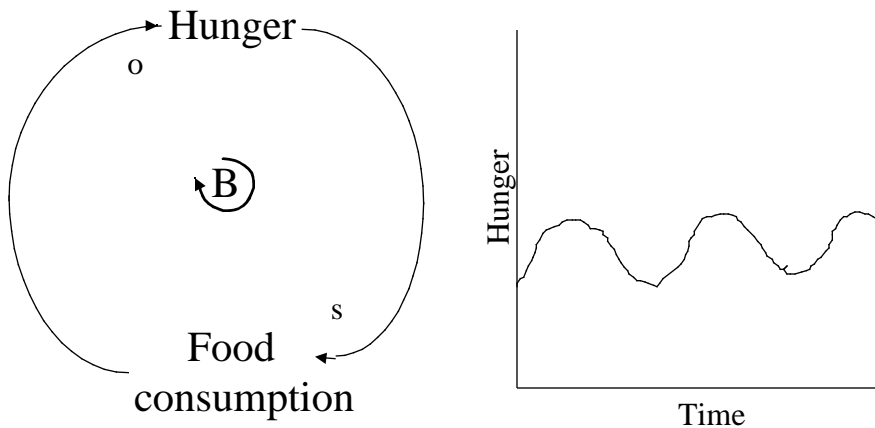
- ...show causal relationships and circular feedback within a system.
- A cause becomes an effect, becomes a cause, becomes an effect, and so on.
- Two types: reinforcing and balancing



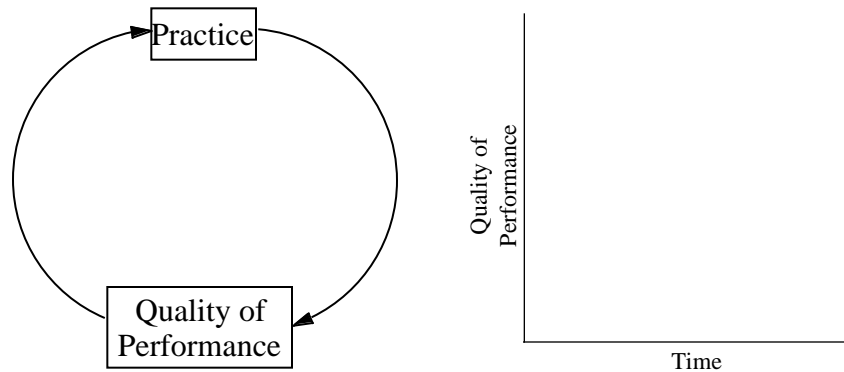
Reinforcing Causal Loop Diagram



Balancing Causal Loop Diagram



Reinforcing or Balancing?



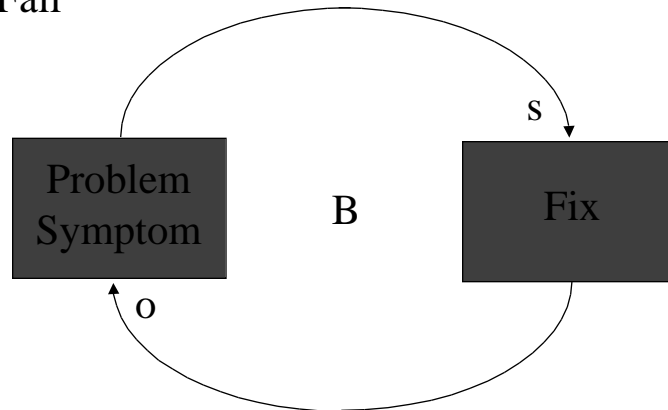
Causal Loop Diagrams from the story

- What aspects/variables within the story change?
 - List aspects/variables.
- How does each aspect/variable change?
 - Draw a BOTG of how each aspect changes.
- How do the identified aspects/variables affect each other?
 - Draw a CLD representing how aspects of the story affect each other. (Refer to the BOTGs/Stocks worksheet.)

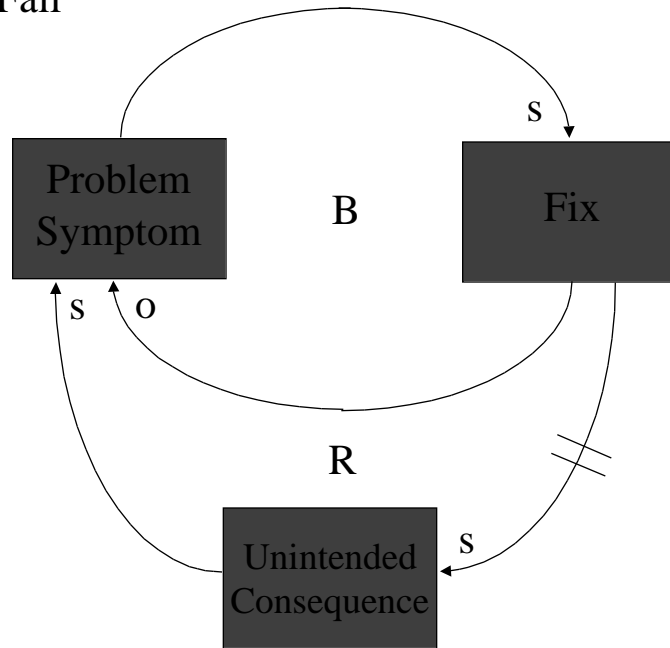
Fixes that Fail Archetype

Problem
Symptom

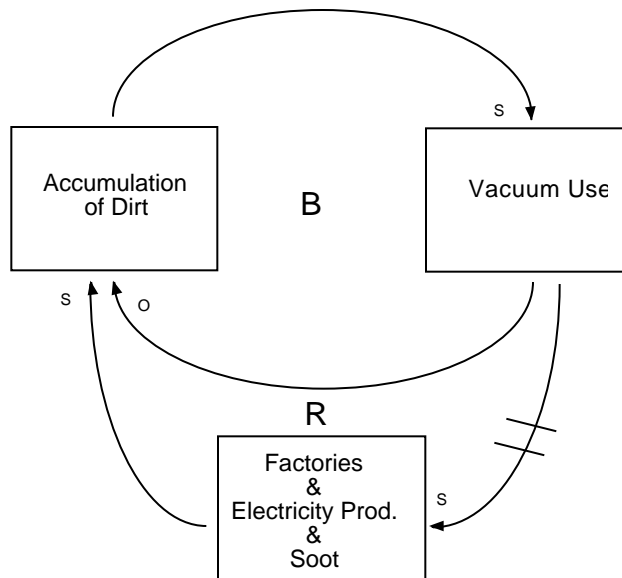
Fixes that Fail Archetype



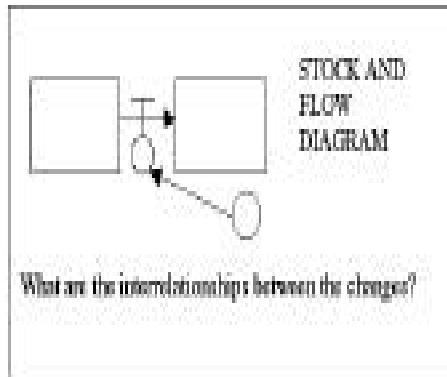
Fixes that Fail Archetype



Fixes that Fail from *Mrs. Frisby and the Rats of NIMH*



Circular Causality: Stock/Flow Diagrams



- ...show interdependencies and feedback within a system by identifying major accumulations and the factors that increase and decrease over time.
- Icons, which come from dynamic modeling, may also include connectors and converters.

Vacuum Use

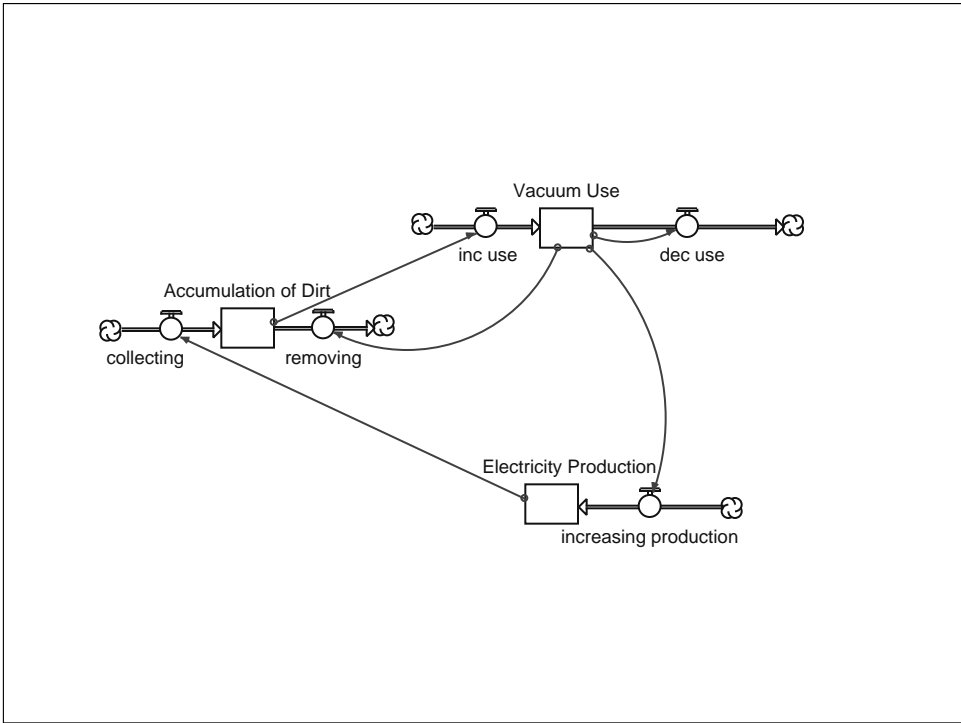
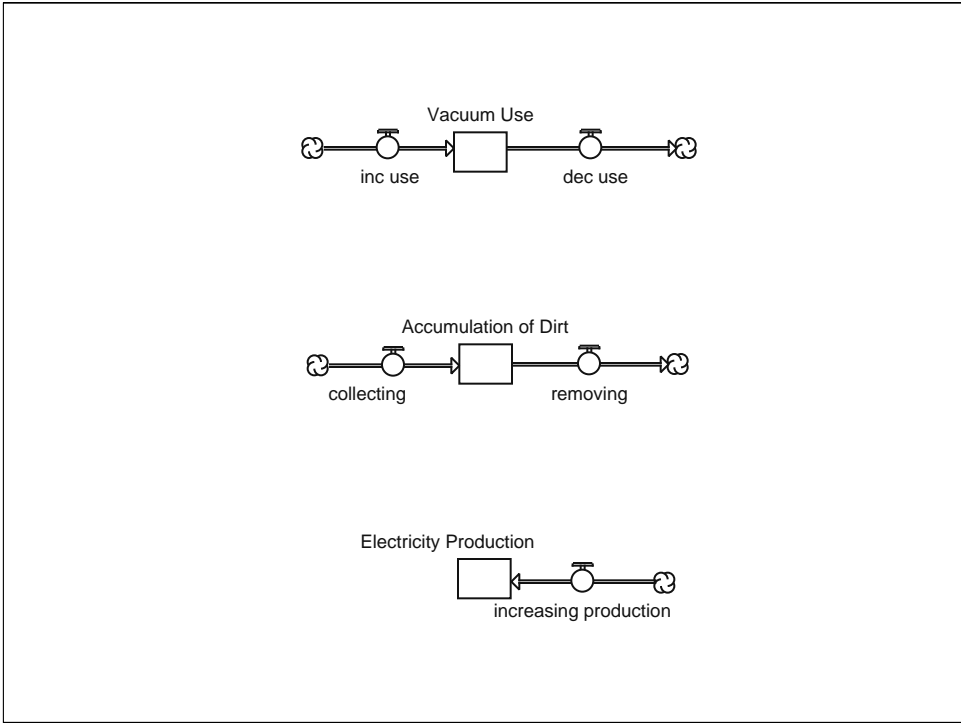


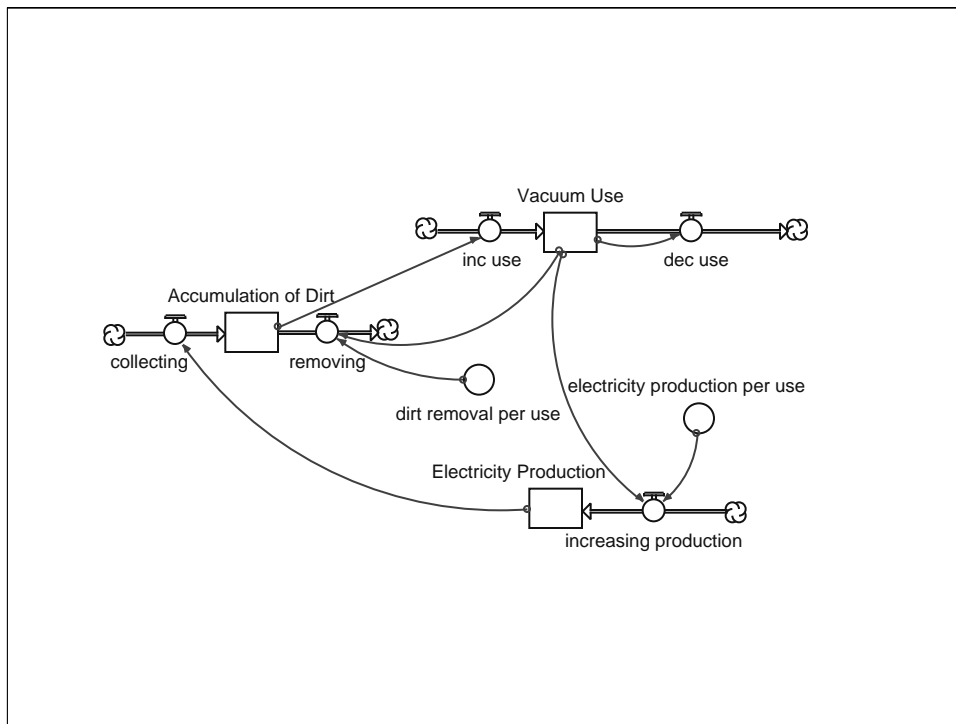
Accumulation of Dirt



Electricity Production





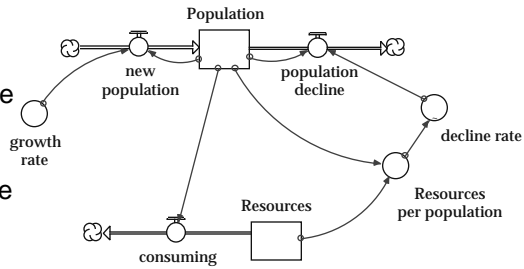


Stock/Flow Diagrams from the story

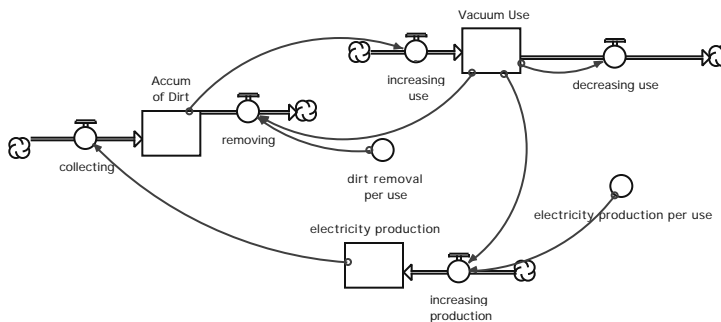
- What aspects/variables within the story change?
 - List aspects/variables.
- How does each aspect/variable change?
 - Draw a BOTG of how each aspect changes.
- How do the identified aspects/variables affect each other?
 - Draw a CLD representing how aspects of the story affect each other. (Refer to the BOTGs/Stocks wksht.)
 - Add to the Stock/Flow diagram representing how aspects of the story affect one another.

Dynamic Modeling

- "A computer model of a system is a stock/flow diagram with supporting mathematical equations which link the factors of the system. As changes are made to the factors in the system, the behavior of the system, as indicated by output graphs, changes."
 (STELLA, HPS-Inc.)



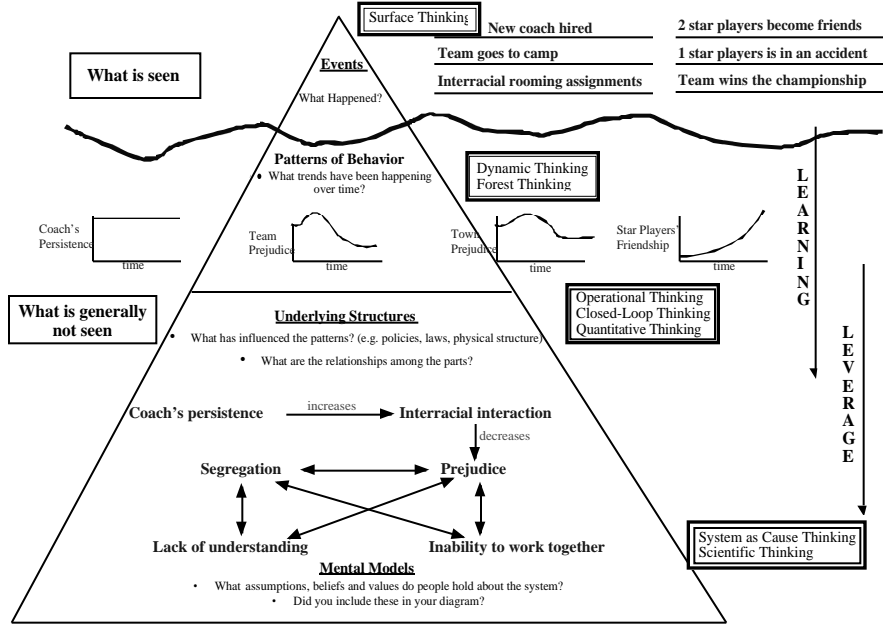
A Simple Dynamic Model from the story



Student Samples



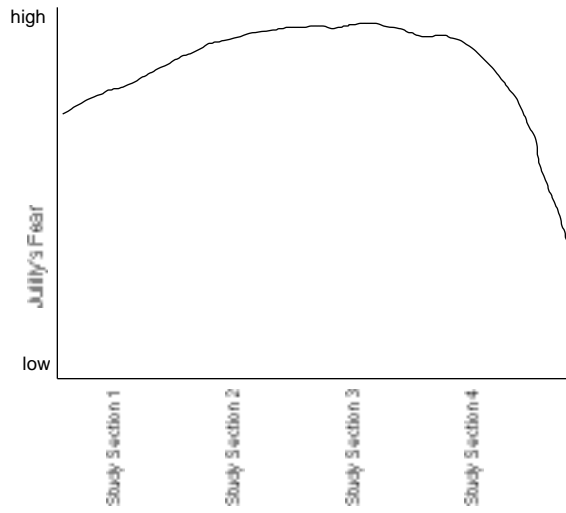
ICEBERG ANALYSIS SAMPLE - Remember the Titans



Systems Thinking & Dynamic Modeling Project © 2002 Waters Foundation

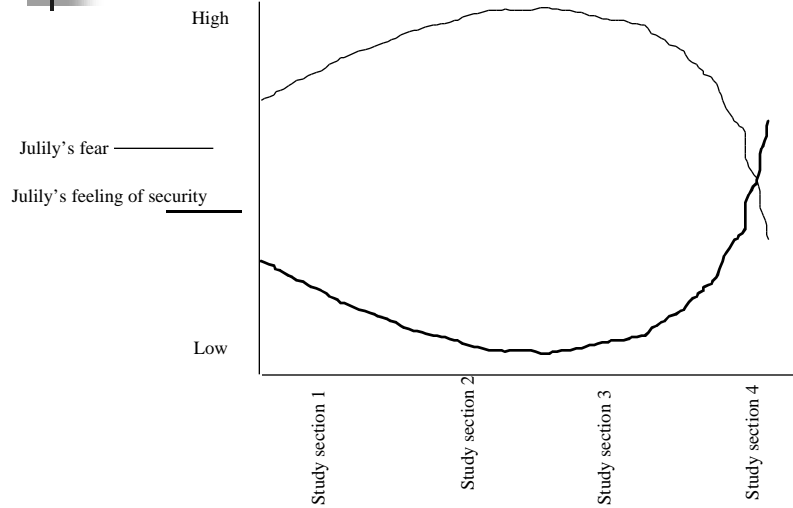
BOTG - Elementary School Literature

BOTG from the book *Run Away to Freedom* (5th grade)

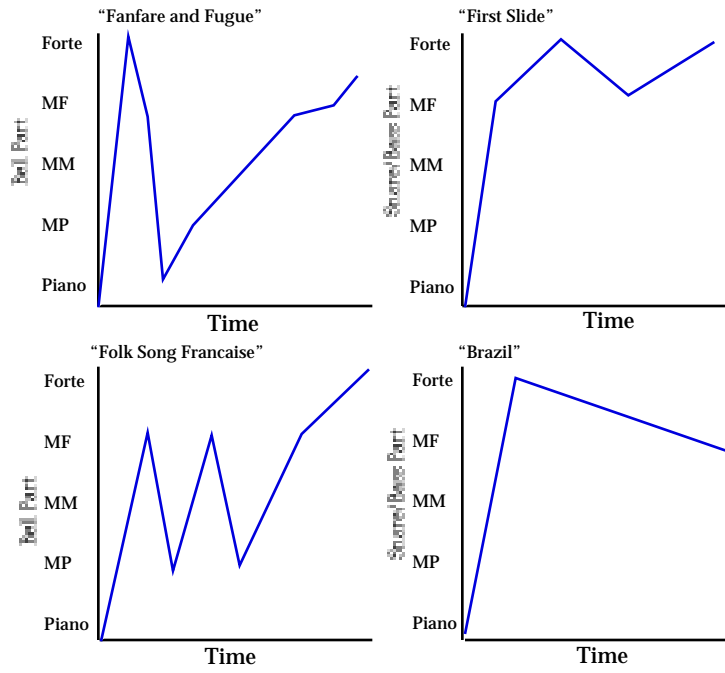


BOTG - Elementary School Literature

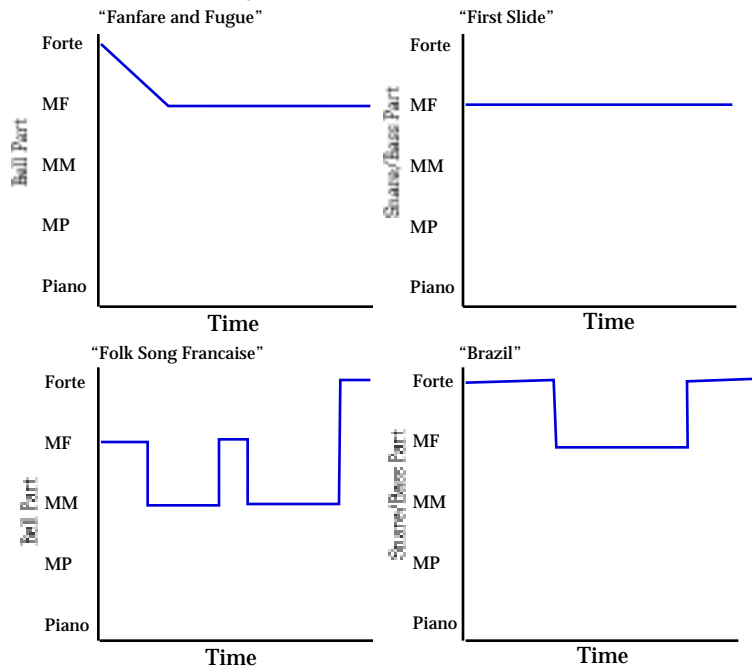
BOTG from the book *Run Away to Freedom* (5th grade)



BOTG - Middle School Band

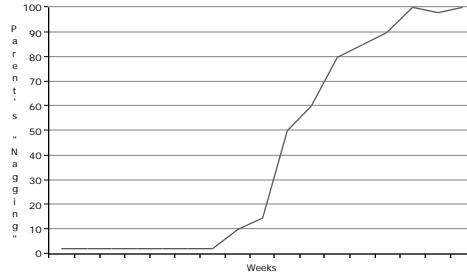


BOTG - Middle School Band - Page 2

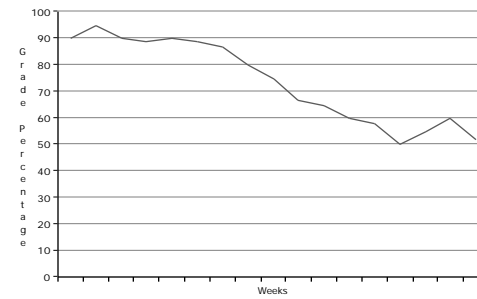


BOTG - Counseling Example

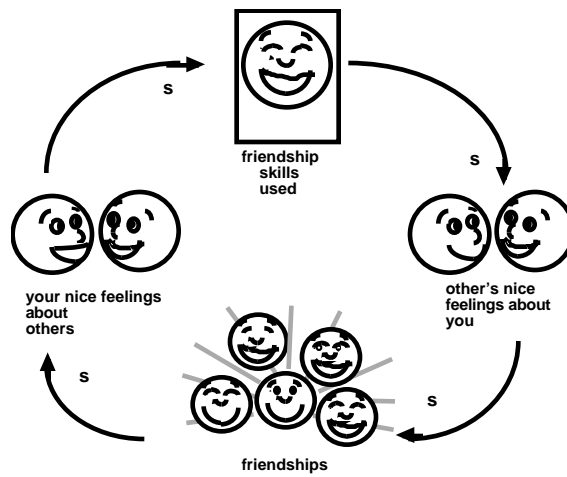
Parents' nagging



Grade percentage

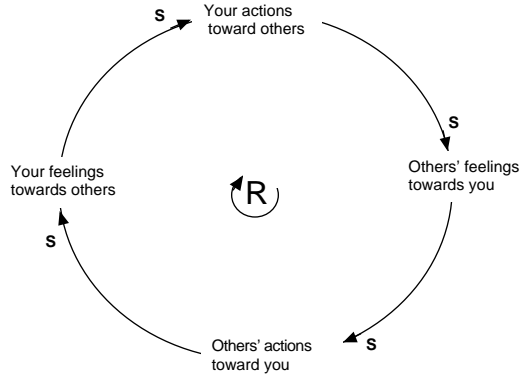


“friendship skills” causal loop diagram



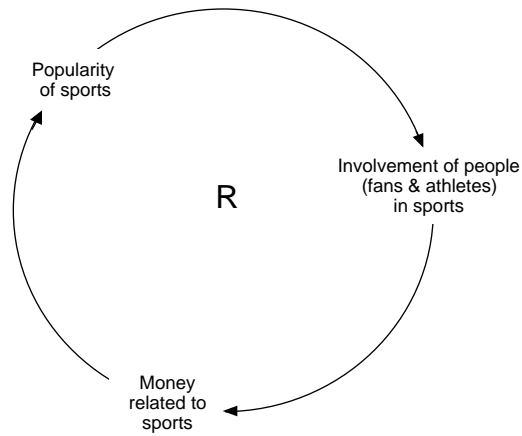
CLD - Elementary School Social Studies

After playing the Friendship Game, first grade students return to their classroom to debrief their experience. This reinforcing causal loop diagram is used with students during this debrief.

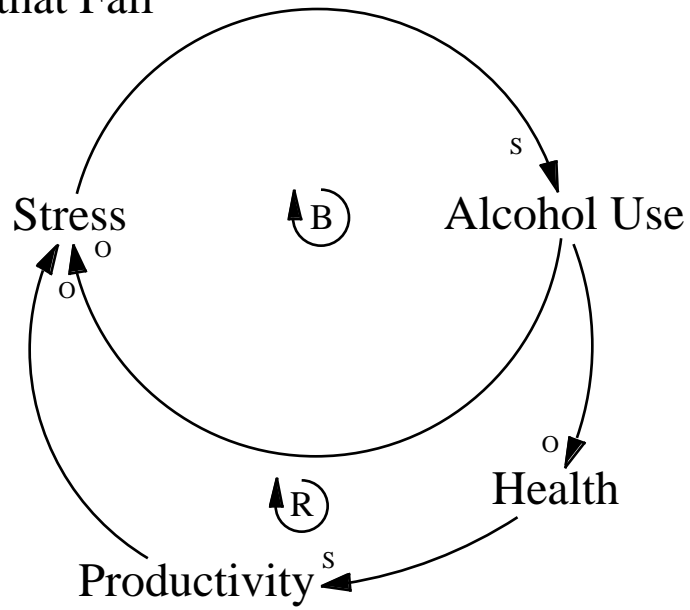


CLD - Elementary School Social Studies

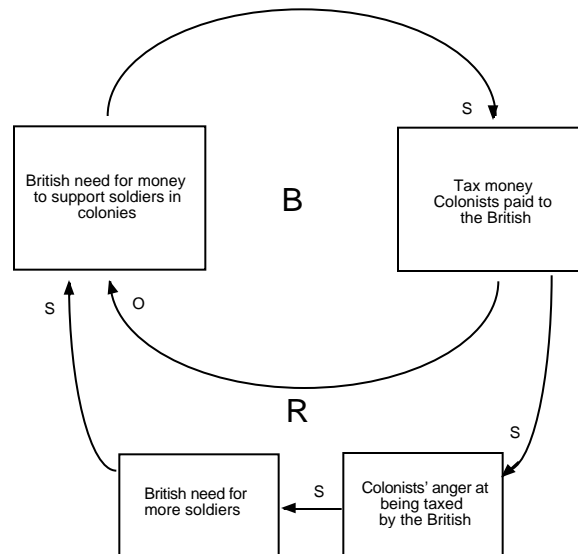
After creating a BOTG which showed the exponential growth of sports in the 1900s, students created a reinforcing causal loop diagram to explain their thinking.



Fixes that Fail

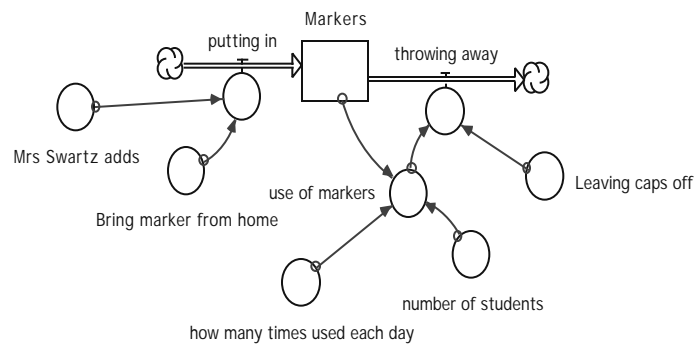


Systems Archetype (Fixes That Fail) :

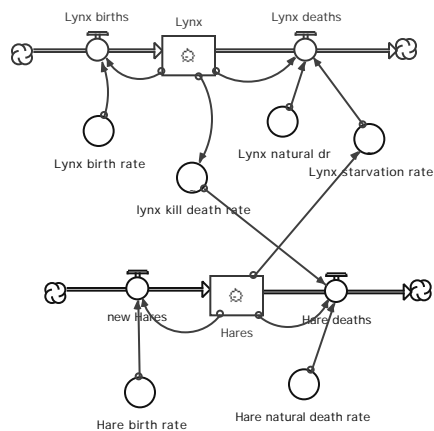


Stock/Flow Map - Elementary School Social Studies -2nd Grade Mini Society Unit

One objective of the Mini Society unit is for students to understand the concept of scarcity. This S/F map was used to examine the accumulation and drain of markers in the 2nd grade classroom.



Lynx and Hares Simulation- Middle/High School





Action Research

- “The students demonstrated their understanding of the concept of archetypes and were able to identify examples and analyze connections between the past and the present. The results indicate that the use of systems tools is very beneficial to students’ ability to identify and make connections between the past and the present and thus ‘learn’ from history.” (7th grade social studies)
- “...overall, parents seemed to have a sense of what their children are capable of in terms of higher level thinking and presenting to an audience.” (7th grade literature)
- “It is clear, however, that STELLA enhanced my pre-calculus students’ understanding of the fundamental natures of each of the types of functions.” (High school pre-calculus)



Action Research (cont.)

- “Over 90% of my students indicated that using SD modeling helped them or greatly helped them understand linear concepts.” (6th grade math)
- “ ...70% of the students met the criteria of performing at a 4 or better on the assessment rubric, the noted increase from 30% demonstrates significant growth proving this is without a doubt a powerful way to assist students in integrating inferences, interpretations, and conclusions into their writing.” (6th, 7th, 8th grade math)
- “Feedback in water systems is a highly abstract concept, and while many students struggled to understand the multiplicity of feedback loops here, they were able to grasp the idea of at least 2 successive effects from one initial water chemistry imbalance within their case study.” (High school chemistry)
- Using STELLA modeling to assess environmental impact, 100 % rated at meets or exceeds standard - change from over 50 % not meeting during pre-assessment. (High school field study)



Student Quotations

- “Can we use BOTGs for our next writing assignment? It makes writing so easy.”
- “It helps doing the simulation because I understand the book better.”
- “...that math is a very important part of graphs and the simulations. It is like a language in a way. Math isn’t just numbers. It is actually saying something.”
- “Patterns are recognizable everywhere and it’s easy to notice them. We can relate our lives to these patterns to help ourselves.”



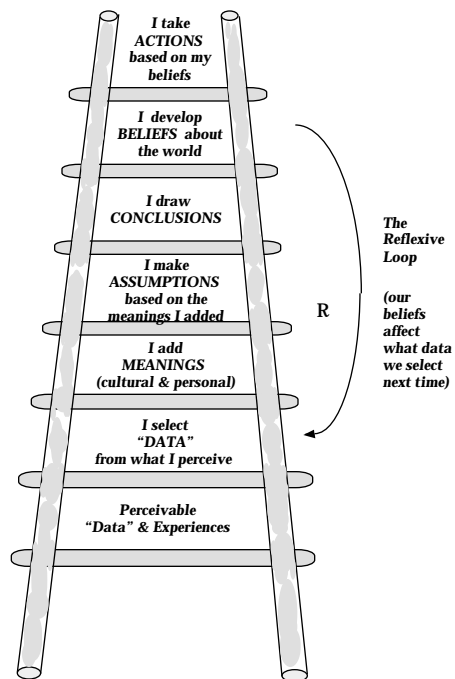
STUDENT QUOTATIONS (cont.)

- “You can do anything if you set your mind to it, no matter how young you are or how many problems you run into.”
- “It improves the life skills of basic problem solving and interacting with co-workers and family because you are better at perceiving behaviors.”
- In the past three years, an average of 74% of the seniors (in CFSD) surveyed in the spring answered yes to this question: Was using SD concepts/tools/simulations an effective means for you to learn class material?

WAYS TO LEARN MORE

- Web Sites
- Resource Materials
- Training and Workshops
- Site Visits
- Conferences

Ladder of Inference



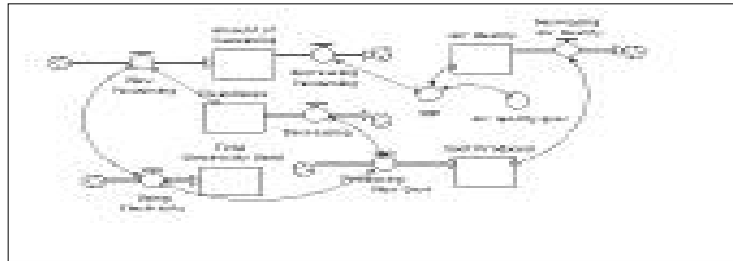
Adapted from The Fifth Discipline Fieldbook Last modified - 1/1999

THE STORY OF MRS. JONES AND HER VACUUM CLEANER
 Examples of causal loops and stock and flow diagrams



Causal Loop Diagrams

R = reinforcing feedback
 B = balancing feedback



Stock and Flow Diagram

Uses icons of dynamic modeling but can be drawn on paper.
 Reinforcing and balancing interrelationships are represented in a more explicit manner.