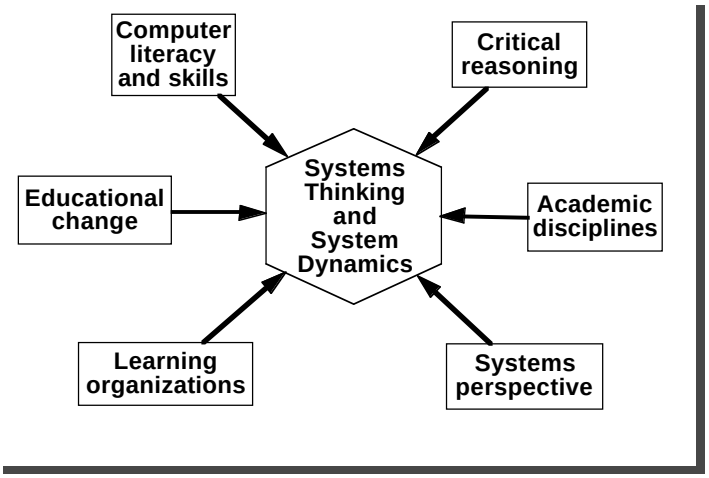
‘...to enable Freshmen to do what once strained Newton’s powers...’

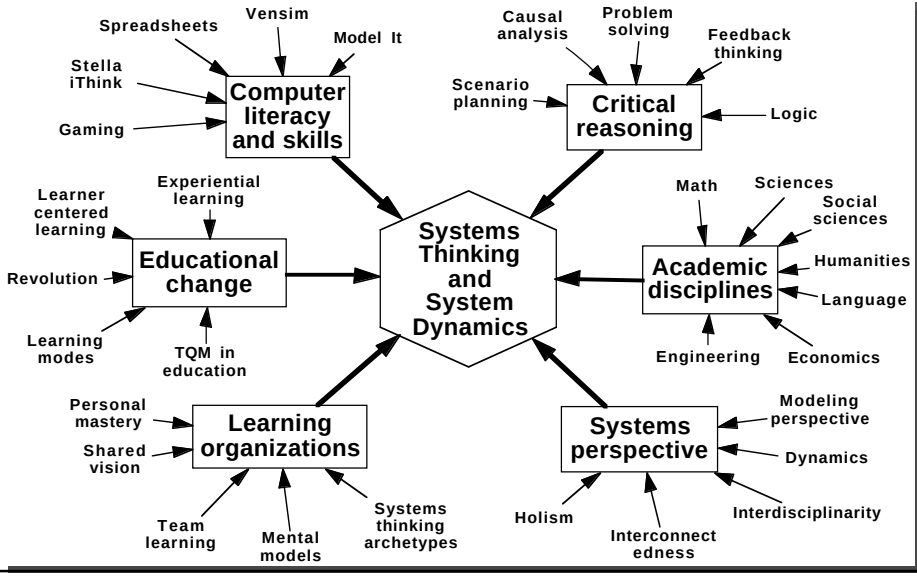
Why are we here?

- What are “systems thinking” and “system dynamics”?
- Why do we think kids can, or should, acquire the capabilities they involve?
- How can we acquire these capabilities?
- How can we best enable kids to acquire them?

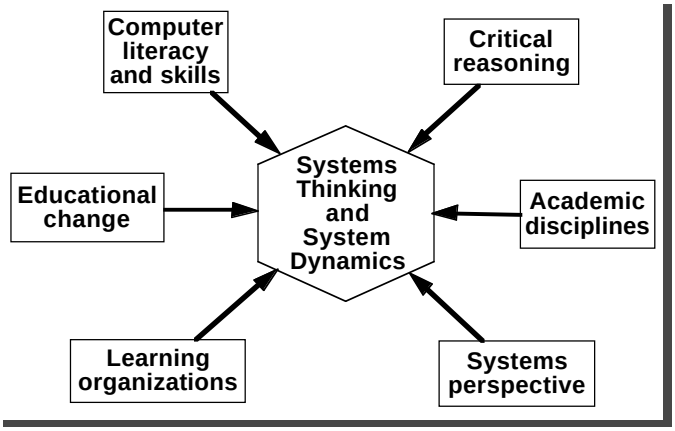
We come from different places...



...with lots of axes to grind...



Systems thinking and system dynamics in the schools involve all of these...



Systems thinking is ...

- the mental effort to uncover endogenous sources of system behavior...
- **!?**

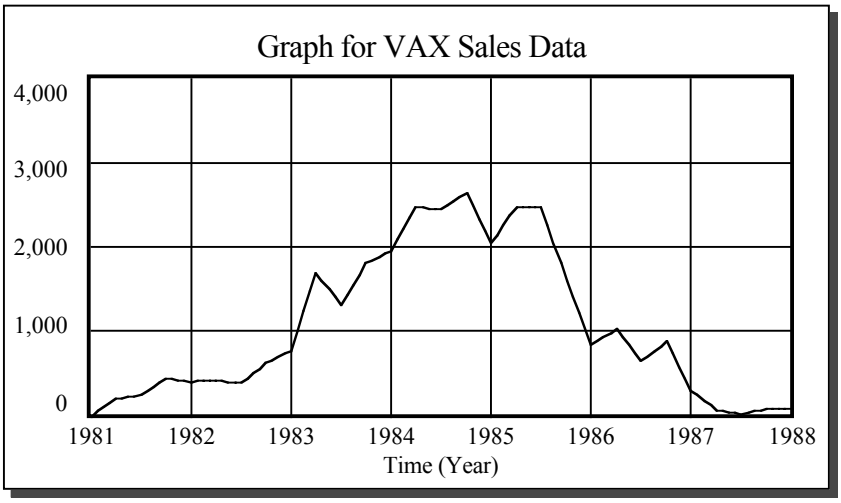
You can define anything simply if you use big enough words...

- Network:
- “Anything reticulated and decussated at equal distances with interstices at the intersections.” [Dr. Samuel Johnson]
- But I digress...

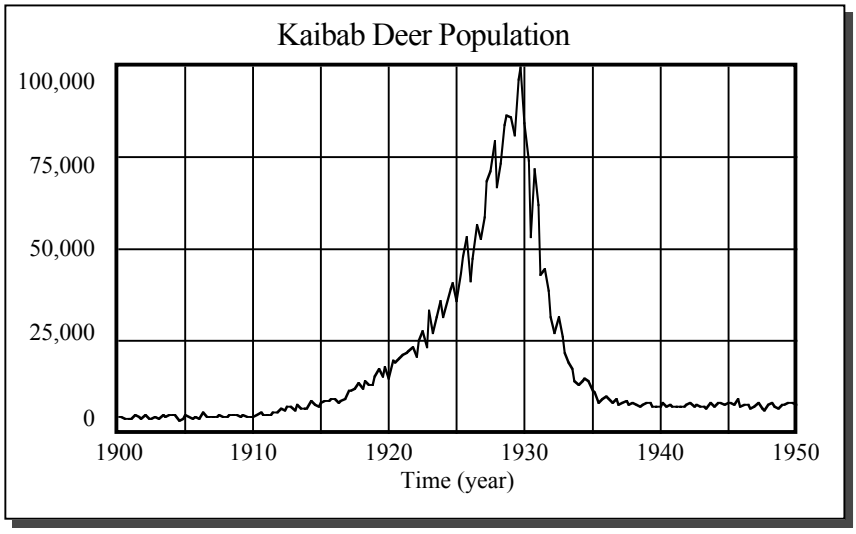
Systems thinking is ...

- the mental effort to uncover endogenous sources of system behavior...
- ...“endogenous”?!
- ...“system”?!
- ...“behavior”?!

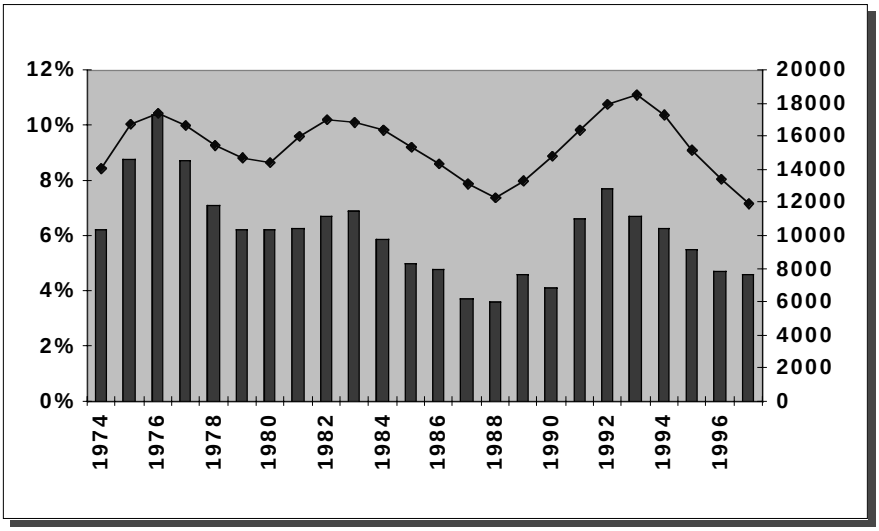
‘Behavior’ means ‘dynamic behavior’ — how things change over time



Behavior of a deer population when predators were decimated



Unemployment and welfare rolls in a NYState county



But there are ‘kid graphs’ too

- Sales per month of Beanie Babies (Cabbage Patch kids, Pet Rocks, ...)
- Number of live fruit flies over time in the class’s controlled experiment
- Hamlet’s indecisiveness, Macbeth’s resolve, Othello’s jealousy - all over time
- Monopoly players’ loot over time

You'll come to love BOTGs

- BOTG = Behavior Over Time Graph
- BOTGs are the simple tool for beginning to take a **Dynamic Perspective**
- Dynamics are essential for systems thinking.

A "system"...?

- ...is anything containing Entities, Attributes, and Relationships.
  - » [Almost as bad as Johnson's "Network"]
- ...suggests
  - generality of view
  - complexity
  - wholeness of perspective (holism).
- ...is close to impossible to define.

My favorite:

"Systems in many respects resemble machines.

- » A machine is a little system, created to perform, as well as to connect together, in reality, those different movements and effects which the artist has occasion for.
- » A system is an imaginary machine invented to connect together in the fancy those different movements and effects which are already in reality performed." [Adam Smith]

Smith said...

- 'A system is an *imaginary* machine
- invented to connect together *in the fancy*
- those different movements and effects which are *already in reality performed*.'
- A 'system' is a mental construct, an idea, a thing in our heads – a mental model.

Examples of systems

- Population, agriculture, capital investment, natural resources, pollution
- An economy
- A group of kids at work on a project
- A school system
- The criminal justice system
- An urban area

But each of these calls up different images in our brains

- Urban area
  - » Urban finances
  - » Urban population problems
  - » Urban air pollution
- School system
  - » Teachers, administrators, & the Board
  - » Students & teachers & curriculum
  - » ...

...and different dynamic problems...

- Urban area
  - » urban stagnation and decay
  - » urban crime
  - » ...
- School system
  - » declining test scores
  - » rising truancy
  - » resistance to change

We needn't worry about the 'system' in systems thinking

- The 'system' will emerge from our mental effort to understand some interesting or problematic dynamic behavior.
- If we've thought deeply and richly enough, what we have will be sufficient to explain the dynamics,
- and that collection of thoughts is the 'system'

Endogenous?

- Literally, 'born from within'
  - » from the Greek *endon,* within, and *genes,* born
- 'Endogenous sources of system behavior' are forces for change that arise from *within* a system.
- Systems thinking is the effort to look *within* and find the 'system as cause.'

More about 'endogenous'

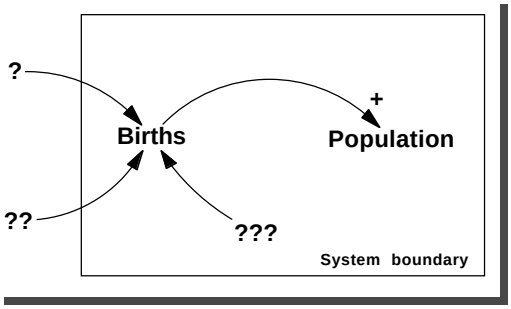
- 'The fault, dear Brutus, is not in our stars, but in ourselves...'

  [Shakespeare]
- 'We have met the enemy, and he is us.'

  [Pogo]
- An 'exogenous' point of view looks *outside* for sources of system change

The ‘endogenous point of view’

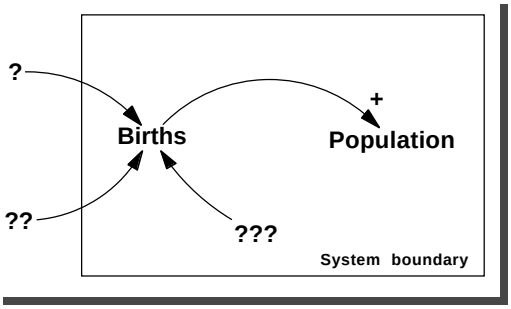
- ...requires we set a conceptual ‘system boundary’



- We look for sources of system change *inside* that system boundary.

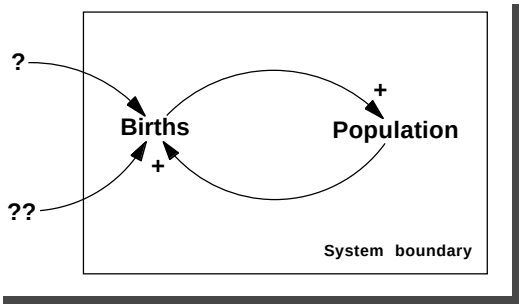
How can dynamics be generated from *within*?

- Population increases because of births
- but what *within* causes Births to increase?
- ...ah, Population itself!

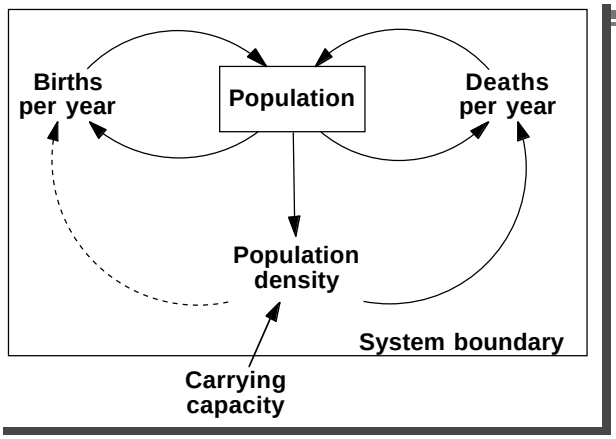


Endogenous sources of behavior are *circular* cause-and-effects

- Births increase population, and an increased population produces more births (other things being equal)



Thus, an endogenous point of view leads to feedback loops!



- Feedback loops enable the endogenous point of view and give it structure.

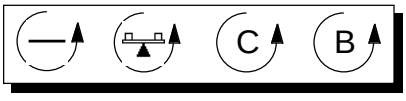
What is a feedback system? What are feedback loops?

- 'An information feedback system exists whenever the environment leads to a decision that results in action which affects the environment and thereby influences future decisions.' [Forrester]
- 'A feedback loop is a closed sequence of causes and effects, a closed path of action and information.' [Richardson]

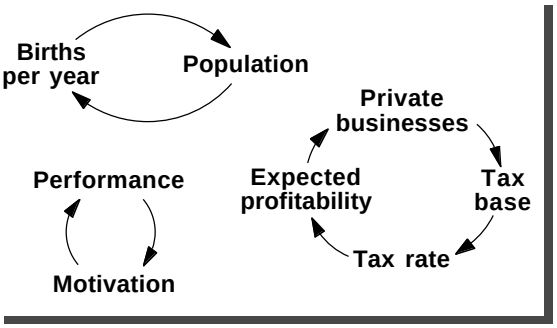
Two kinds of feedback loops

- **Positive** loops
  - » self-reinforcing
  - » growth producing
  - » destabilizing
  - » accelerating
  - » even number of –'s
- Symbolized by

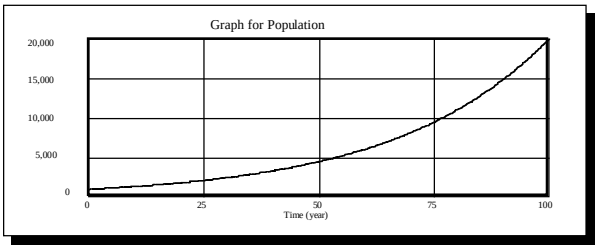
- **Negative loops**
  - » counteracting
  - » goal seeking
  - » stabilizing
  - » balancing
  - » odd number of –'s
- Symbolized by

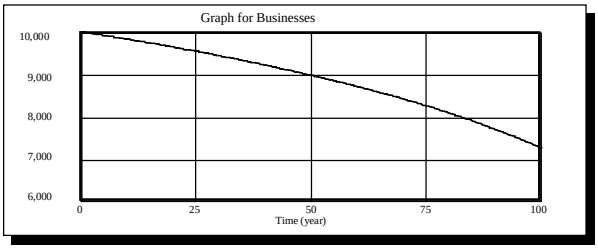


Some familiar ‘positive’ or ‘reinforcing’ feedback loops

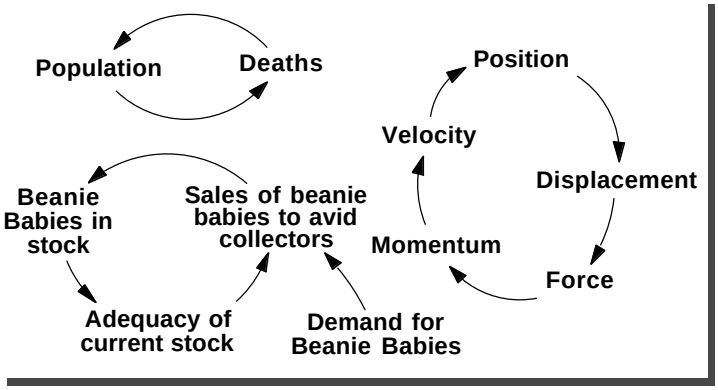


Typical positive loop behaviors

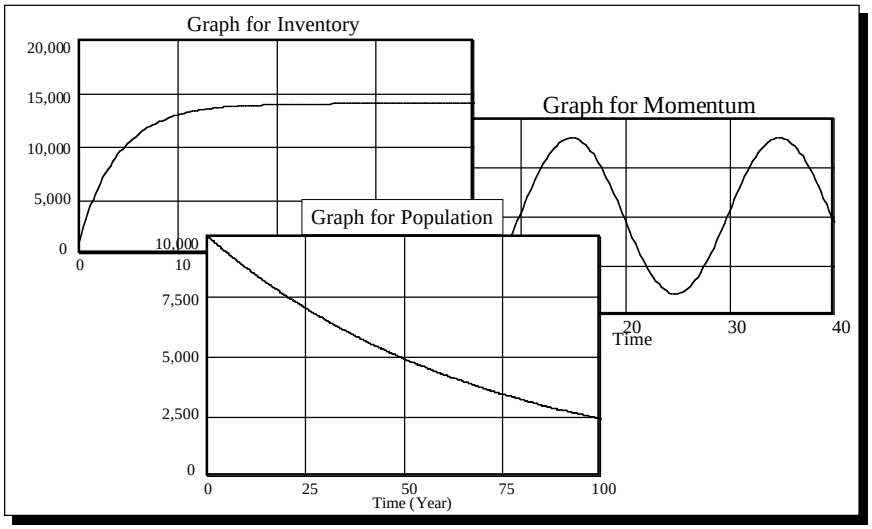




Some familiar ‘negative’ or ‘balancing’ feedback loops

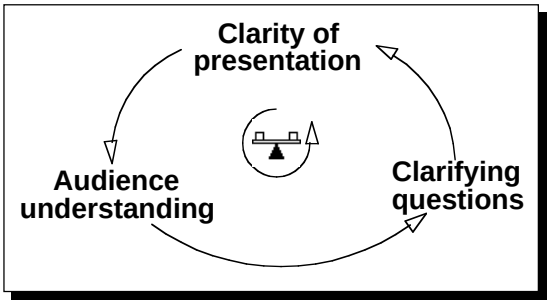


Typical negative loop behaviors

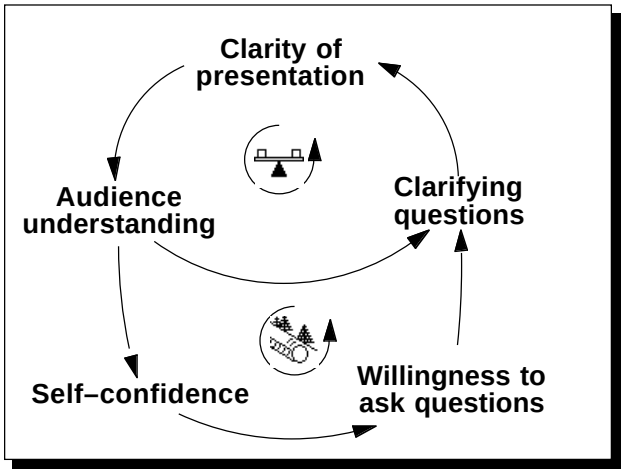


But it can be much more homey than those examples...

- Presentation dynamics

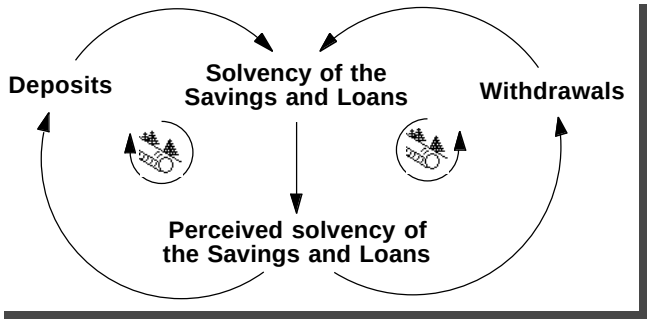


Presentation dynamics – Which loop dominates?

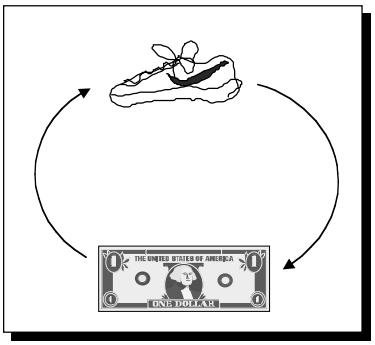


Even our cartoonists engage in feedback thinking

Savings and loans feedback loops



A first grader's feedback loop



- 'The more shoes Nike makes, the more money they make, so the more shoes they can make.'

Feedback thinking has been around for ages...

- 'For one good deed leads to another good deed, and one transgression leads to another transgression.' [Pirke Avot]
- '...action and counteraction, which in the natural and in the political world, from the reciprocal struggle of discordant powers draw out the harmony of the universe.' [Edmund Burke]

More wonderful quotes

- 'Man is not the creature of circumstances. Circumstances are the creatures of men.' [Benjamin Disreli]
- 'Everything an Indian does is in a circle, and that is because the power of the world always works in circles, and everything tries to be round.' [Black Elk]

An one more...

- 'It was during this study that I first came realize the inadequacy of the the equilibrium approach, and to understand that the essence of a social problem is that it concerns a complex of interlocking, circular, and cumulative changes.'

  [Gunnar Myral, An American Dilemma, 1944]

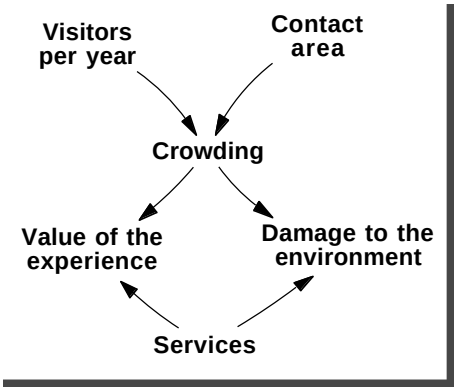
Systems thinking involves thinking in loops

- Great social scientists are feedback thinkers
- Great social theories are feedback thoughts

What has this to do with K-12 teachers (and university profs)?

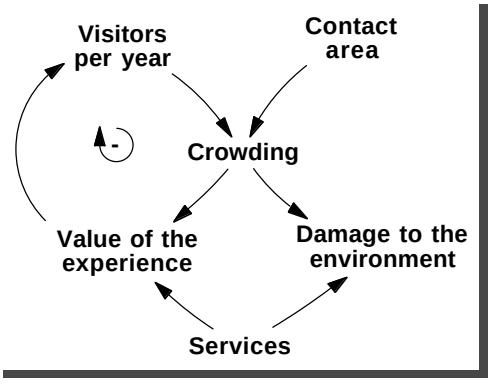
- 'The purpose ... is to enable Freshmen* to do what once strained Newton's** powers'
  - * 6th graders, 3rd graders, 1st graders, ...
  - **Adam Smith, Mill, Marx, Merton, Black Elk, Burke, Keynes, Lotka, ...
- 'Explicit knowledge accessible to intelligent beginners is obviously more efficient for a science than knowledge perceived by the intuition of its geniuses.' [Arthur Stinchcomb]

A personal experience – an 'open loop' view of Mt. Monadnock



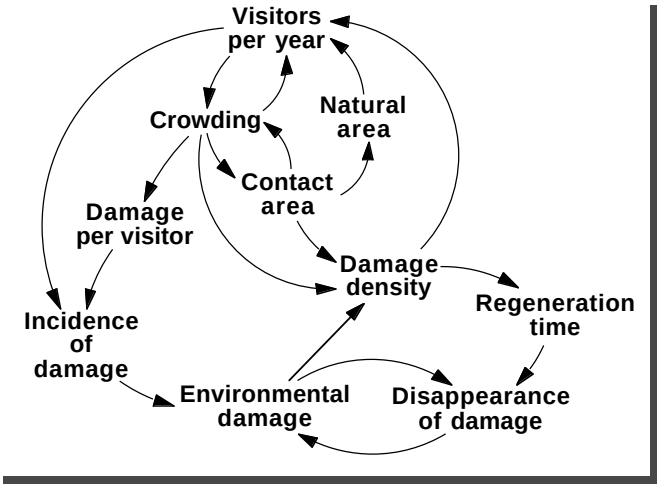
- ...leads to building parking lots for unused trails and increasing services...

Closing a feedback loop alters the policy view...



- The visitors loop *compensates* for the parking lot policy and defeats its purpose.

A full feedback view of Monadnock

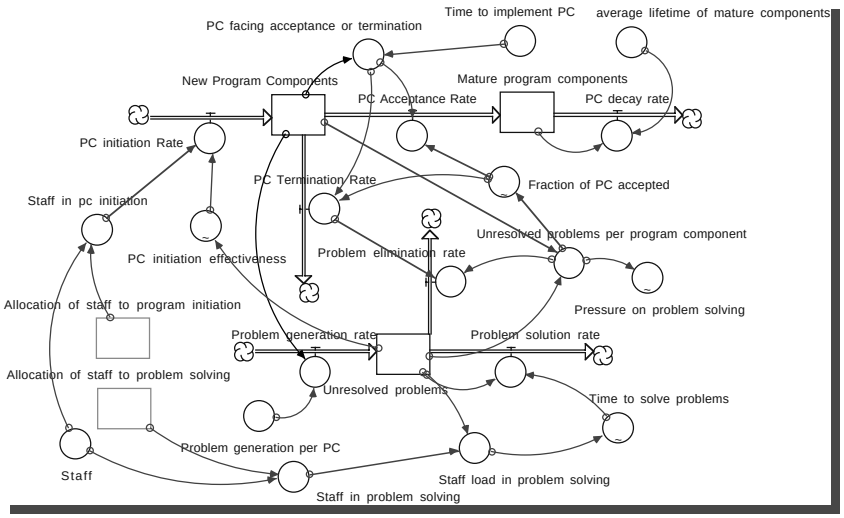


So, systems thinking is the mental effort to uncover endogenous sources of system behavior.

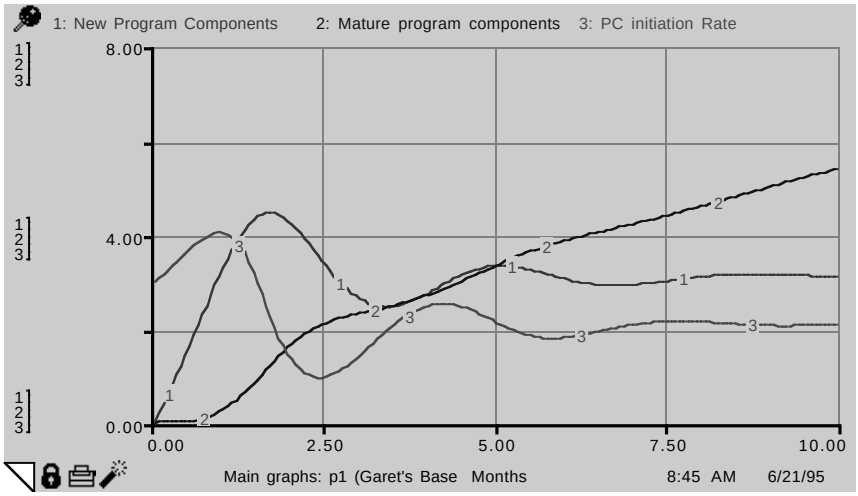
And what, then, is system dynamics?

- ...Computer simulation modeling in support of systems thinking...
- When feedback thoughts become too complex (which happens rather quickly!), we need cognitive support.
- A formal model of a feedback system can trace out dynamic behavior infallibly, without forgetting a thing.

A portion of a view of innovation in schools



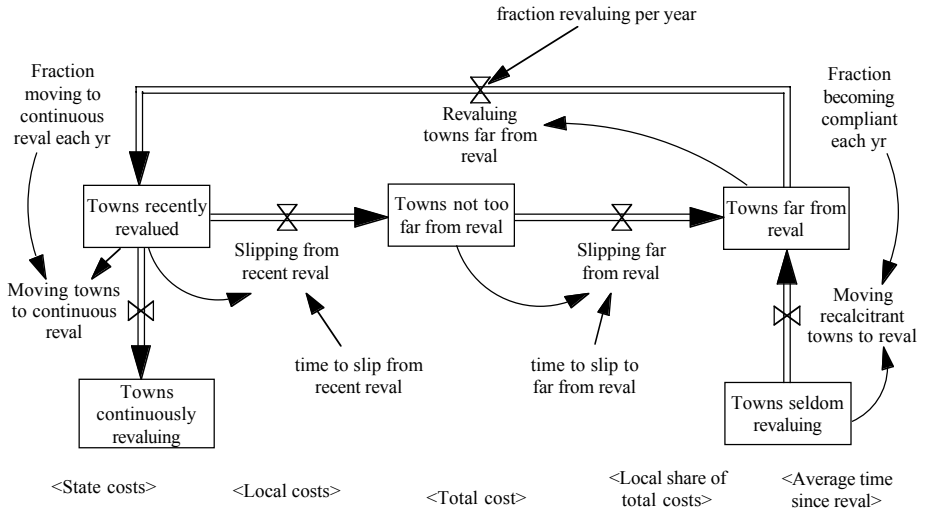
...which generates dynamics we could not see from the diagram...



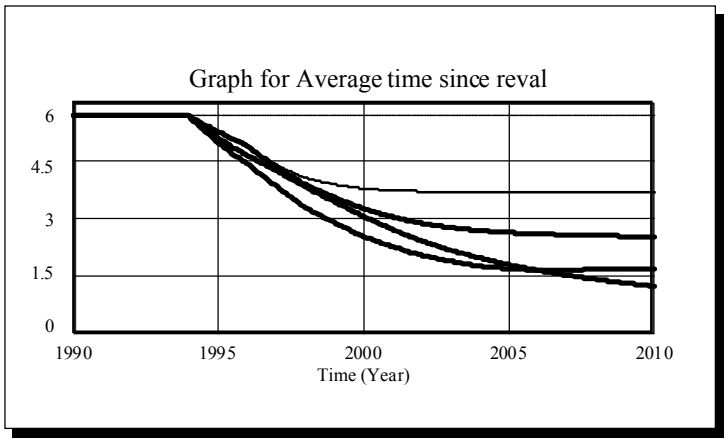
And all this makes a difference!

- Solving the insolvency of medical malpractice insurers in NY
- Curing Medicaid cost overruns in VT
- Understanding global climate change
- Integrating vocational services for clients in the mental health system in NY
- Welfare reform in NYS counties [ongoing]
- Re-engineering the Office of Real Property services in NY [ongoing]

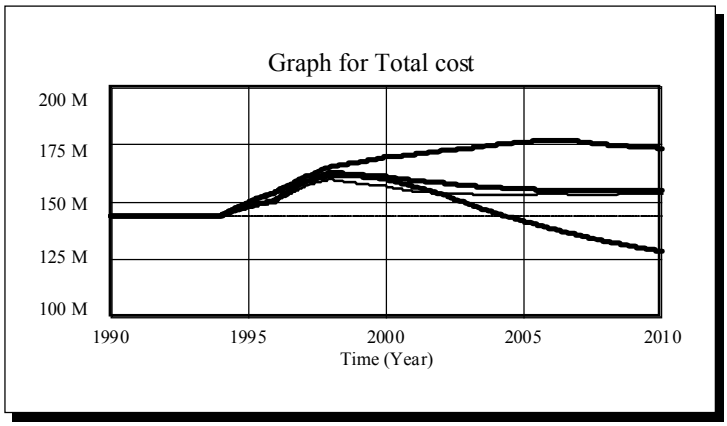
A simple ‘all towns’ view of real property assessment in NYS



...which taught us we could improve equity...



...but cost is prohibitive unless you change the way it's done...



Why systems thinking and system dynamics?

- Thinking dynamically moves us beyond separate events and decisions toward understanding.
- Feedback thinking improves how you think about the world and how you think about changing it.
- The endogenous point of view is personally empowering.