

Celebrating the Writing Metaphor
Accelerating Learning of Systems Thinking
by De-coupling the Learning Curves

A Hands-on Workshop

facilitated by

Barry Richmond

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Skamania Lodge, WA

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**Four Fundamental Truths
about Models**

Four Fundamental Truths about Models

Truth 1: We all construct *mental models* of the realities with which we must deal.
(we've been doing so from the get-go)

Truth 2: We all mentally *simulate* these models in order to...

+ “make meaning”

(figure out why s/he did that, why that happened)

+ make predictions

(evaluate the implications of alternative decisions and courses of actions you are considering)

Four Fundamental Truths about Models

Truth 3: “*All models are wrong...
some models are useful.*”

W.E. Deming

The Hawkins Corollary: “*No model is ever ‘complete’.*”

J. Hawkins

Four Fundamental Truths about Models

Truth 4: “Though *all* models are *wrong*,
and no model is ever complete,
we have *no choice* but to use them.”

B.M. Richmond

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Selecting a Genre
Dynamic Thinking

Overview

1. Selecting a Genre
2. Defining *Dynamic Thinking*
3. Building Dynamic Thinking Skills
 - Recognizing elemental patterns
 - Recognizing complex patterns
 - Developing a Reference Behavior Pattern

1. Selecting a Genre

- We begin with behavior patterns because they constitute the phenomena to be explained.
- Behavior patterns “tell a story.” Hence, the models you construct will be analogous to the plot of a story or screenplay.
- *Dynamic Thinking* is the first thinking skill you’ll need to be effective in “writing” in this genre.

2. Defining *Dynamic Thinking*

- Seeing not just how things *are* currently, but also the path they took to get that way, and possible paths going forward into the future.

- Contrasts with: *Static/Equilibrium or Point-in-time Thinking*.

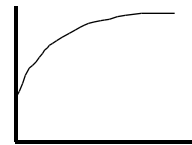
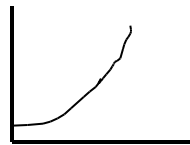
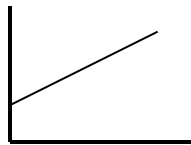
- The “so what:” *Provides a basis for hypothesis-generation with respect to what produced the current situation—which, in turn, provides a basis for understanding what needs to be done, how to do it, and how long it will take to improve the situation.*

3. Building Dynamic Thinking Skills

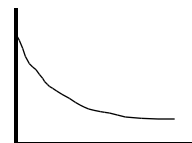
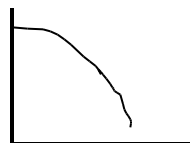
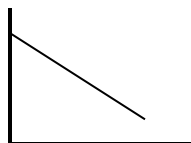
Recognizing elemental patterns

There are only three *elemental* behavior-over-time patterns...

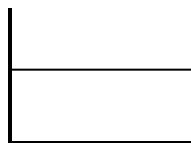
Growth



Decline

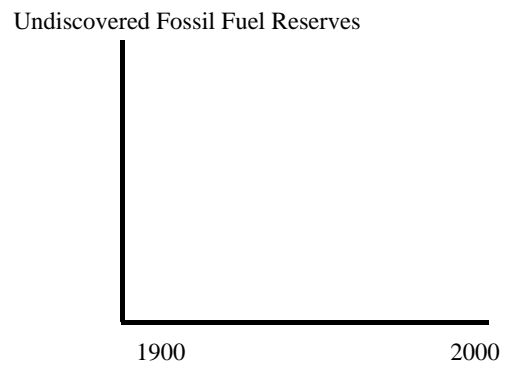


Stasis



Recognizing elemental patterns: *Exercises*

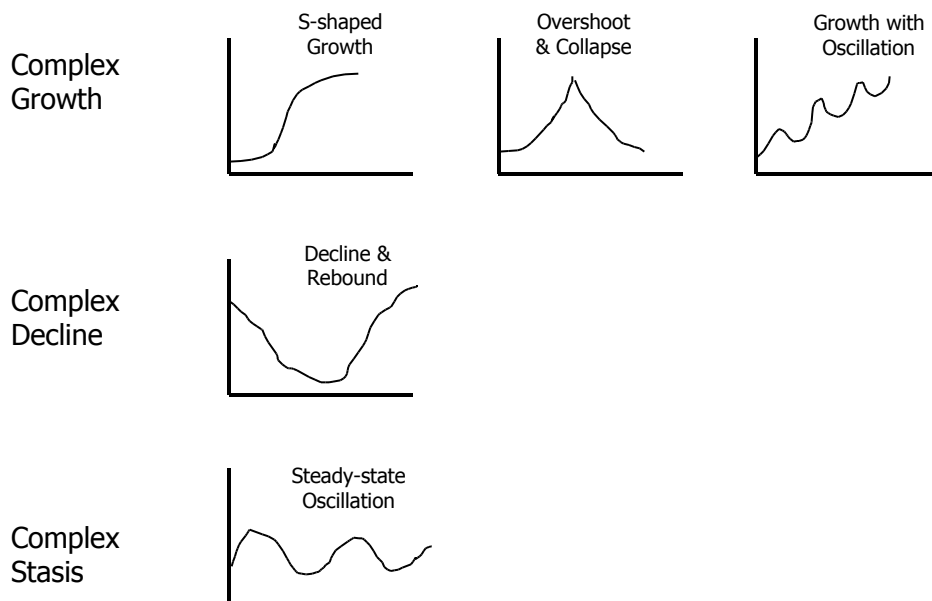
Trace the pattern of *actual* fossil fuel reserves that have not yet been discovered over the last 100 years.



3. Building Dynamic Thinking Skills

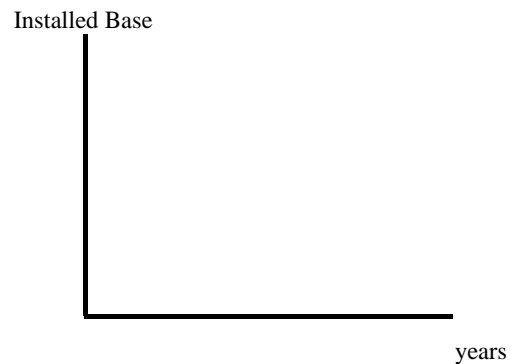
Recognizing complex patterns

Complex behavior-over-time patterns are built up from various combinations of the three *elemental* patterns...

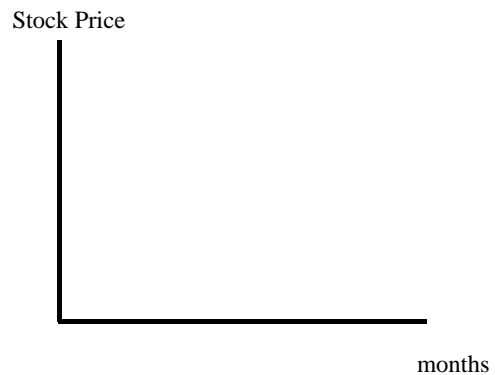


Recognizing complex patterns: *Exercises*

1. Sketch a common pattern traced by bacteria growing in a Petrie dish, or on a Hostess Twinkie.



2. Chart a pattern that might be traced by a “.com” startup’s stock price from IPO to one year out.



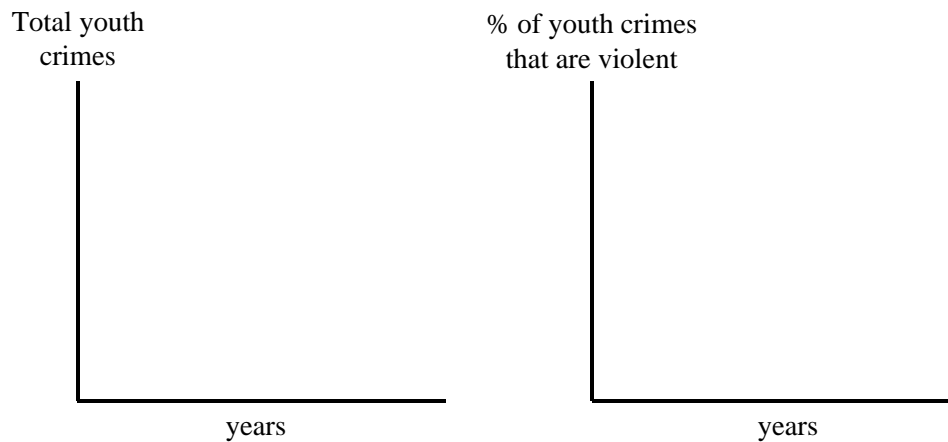
3. Building Dynamic Thinking Skills

Developing a Reference Behavior Pattern

An RBP is a graph *over time* of a performance barometer that captures the essence of the problem /issue of interest. RBP's usually include an "As Is" (historical) and a "To Be" (future) segment.

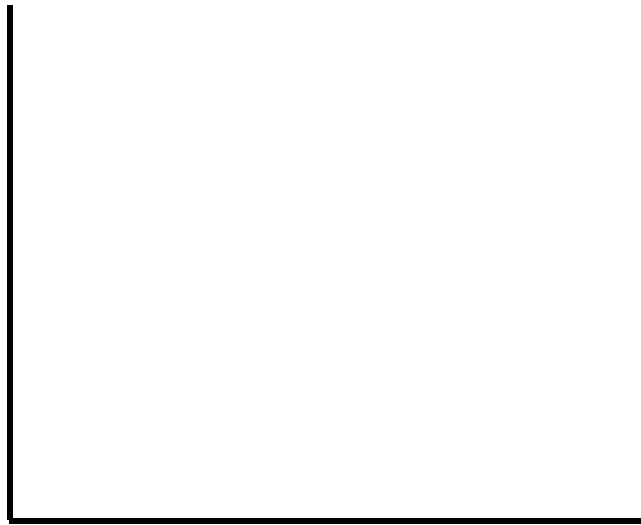
If possible, use or develop a "normalized" performance barometer (e.g., % violent youth crimes vs. total youth crimes).

Label the time axis (e.g., weeks, months, quarters, years). This will help to set a *temporal boundary* for your model (include only dynamics within one time unit on either side of your chosen time unit)..



Reference Behavior Pattern: *Exercises*

Construct a Reference Behavior Pattern that's relevant for the arena in which you teach. Be sure to label both axes...



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Language:
Nouns and Verbs
Operational Thinking

Overview

1. Nouns & Verbs

2. Defining *Operational Thinking*

3. Operational Thinking Skills*

- *Distinguishing between stocks and flows*

* Mental simulation and itthink software skills will be developed in the process of developing your Operational Thinking Skills.

1. Nouns & Verbs

- A fundamental distinction recognized in most languages is that between *nouns* and *verbs*.
- Stocks and flows are the nouns and verbs of the systems thinking language.
- Distinguishing between them is the first **operational thinking** skill to master.

2. Defining *Operational Thinking*

- Capturing the way something *really* works, as opposed to putting forth lists of factors, influences, or drivers.
- Contrasts with: *Factors/Laundry List/Correlational Thinking*. The 9 Drivers of Sustainable Business Success, The 7 Habits of Highly Effective People, The 3 Critical Success Factors in this business, The 6 Pillars of Self-Esteem.
- The “so what:” *Facilitates identification of actual levers for improving performance.*

2. Defining *Operational Thinking*

An example: *Milk Production*

Milk Production = $f(\text{GNP, feed prices, i rates, ...})$

versus...

3. Operational Thinking Skills

Distinguishing between stocks and flows

Stocks: Nouns. Represent current state, magnitude, or condition. They tell how things are. Freeze the action, and the current condition *persists*. Stocks *accumulate*. You can think of stocks generically as “Resources.” **Reservoirs** are the most common form of stock. Think of them as like bathtubs.

Reservoir



Population, Water Reserves, Debt, Pollution, Biomass
Trust, Commitment, Anger, Confidence, Frustration, Self Esteem.

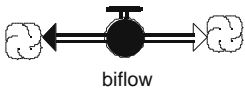
Conveyor



Conveyors are like “moving sidewalks.” They can be used to create the highest level representation of a process, or a pipeline delay.



Flows: Verbs. Represent *actions*. They tell how things are going. Freeze the action and flow volumes go to zero. Use “ing” ending whenever possible.



Being born, dying, scolding, lecturing, learning, communicating

Distinguishing between stocks and flows: *Exercises*

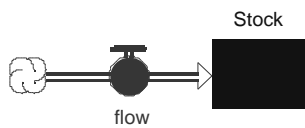
1. Stocks & flows in your School

Think of a stock that has generated a “buzz” in your school. Map it. Identify one inflow and one outflow associated with the stock. What actions has the “buzz” given rise to?

2. Stocks & flows in your Life

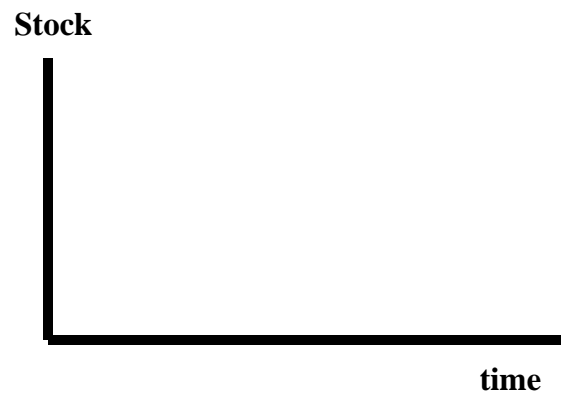
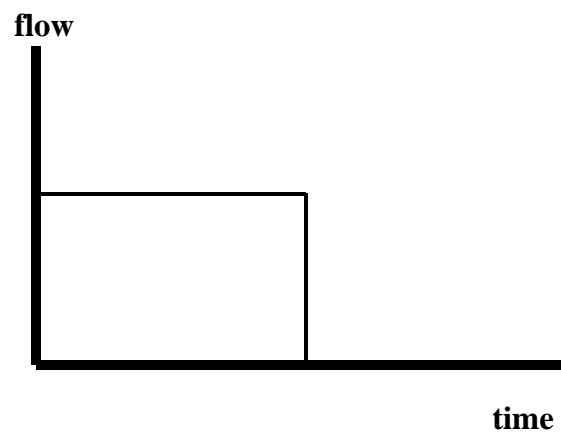
Think of a stock that is generating a “buzz” in your life. Map it. Identify one inflow and one outflow associated with the stock. What actions has the “buzz” given rise to?

Distinguishing between stocks and flows: *Exercises*

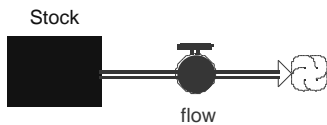


3. Mental Simulation

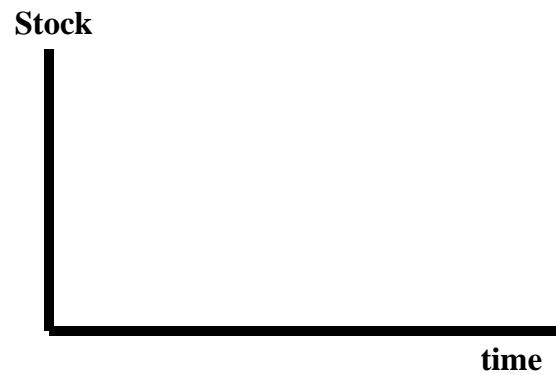
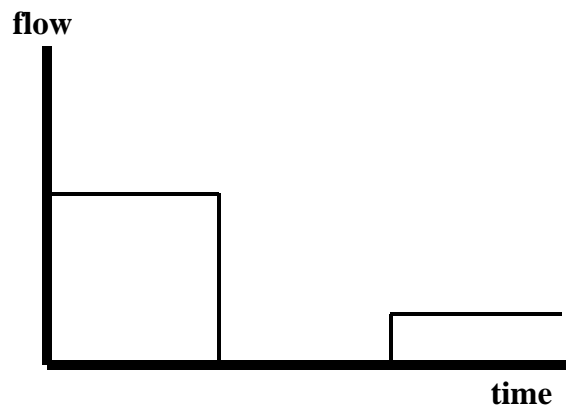
- a. Mentally simulate what will happen to the stock over time given the flow pattern shown at right. Sketch your guess on the axis provided. Then, open "levell.itm" and check your answer using computer simulation.



Distinguishing between stocks and flows: *Exercises*



- 3b. Mentally simulate what will happen to the stock over time given the flow pattern shown at right. Sketch your guess on the axis provided. Then, open “level2.itm” and check your answer using computer simulation.

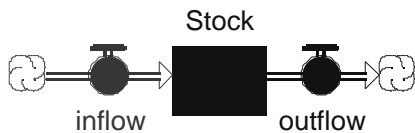


Distinguishing between stocks and flows: *Exercises*

4. The Body Weight Puzzle

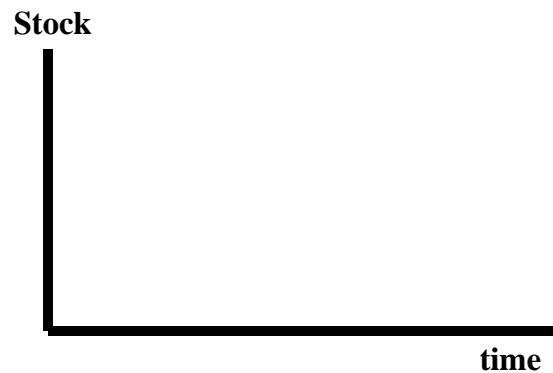
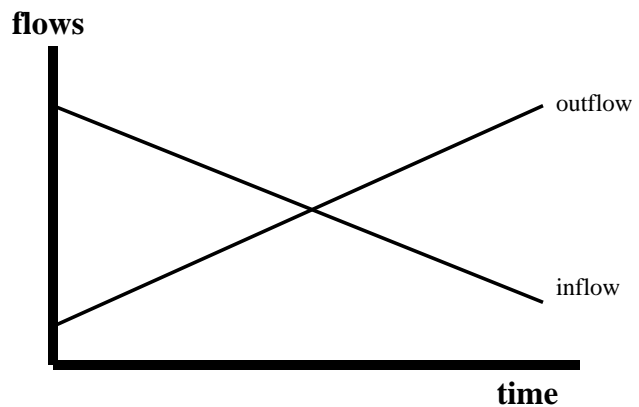
John found himself gaining weight. He successfully implemented an aerobic exercise program, and also succeeded in eliminating his daily trips to the pastry cart. In addition, he did not compensate by eating more at regular meals. Yet one month after implementing both initiatives, he discovered that he had continued to gain weight! Use the stock/flow language to help you think through how this could happen. (Hint: There are no “tricks,” nor does the solution depend on any advanced knowledge of physiology—for example, it’s not that his exercise program built muscle, and muscle weighs more than fat.)

Distinguishing between stocks and flows: *Exercises*



5. Complex Mental Simulation

Mentally simulate what will happen to the stock over time given the flow patterns shown at right. Sketch your guess on the axis provided. Then, open "level3.itm" and check your answer using computer simulation.



Distinguishing between a stock and a flow: *Exercises*

6. Checkbook Dynamics

Explain how it could be that your monthly deposits are increasing, your monthly withdrawals are decreasing, and your checking account balance is falling.

Distinguishing between stocks and flows: *Exercises*

7. Deficit/Debt

How would it be possible for the US Federal government to be running at a deficit without doing any borrowing (i.e., adding to its level of debt)?

Distinguishing between stocks and flows: *Exercises*

8. Bernie Sanders versus Phil Knight

Bernie Sanders, the socialist congressperson from Vermont and Phil Knight, the President of Nike, were engaged in an acrimonious exchange. Bernie was screaming about how deplorable conditions were in many of Nike's offshore manufacturing facilities. Phil was shouting at Bernie that Nike was spending millions to improve conditions in these plants! Is it possible that *both* men have a point?

9. FAA versus America West

On January 25, 2000, the FAA tells America West that it is giving serious consideration to preventing the Airline from flying more planes than it operates now because of a lack of control over maintenance contractors. On January 31, America West replies that the FAA's statements "...reflect a disregard to the substantial efforts we have made on maintenance matters."

USA Today, 2/2/2000, p B1

Distinguishing between stocks and flows: *Exercises*

10. Pricing internet services

You are going to offer a service that allows people to equip their computer simulation models with a gaming interface and to install them on your website so that others can exercise them. As it turns out, by allowing users to make use of a configuration/ installation wizard you've created, the cost of getting models up and running on your server is virtually zero! The issue being debated within your Company is: *How should you price this service?*

There is consensus that a "hosting fee," based on space consumed per month, should be charged. However, one camp wants to add a small charge for installation/configuration. The other camp wants to charge nothing for installation, and instead jack up (by a considerable amount) the monthly fee.

What position in the pricing debate would you take and how would you argue it?

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Language:
Constructing Sentences
Operational Thinking

Overview

1. Constructing Sentences

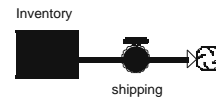
2. Operational Thinking Skills*

- Grammar: *Respecting Unit Consistency*
- Grammar: *Respecting Conservation Laws*

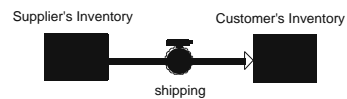
* Mental simulation and basic itthink software skills will be developed in the process of developing your Operational Thinking Skills.

1. Constructing Sentences

- A simple “sentence” consists of one noun and one verb (i.e., one stock and one flow).



- A “compound sentence” (called a “main chain” or “spinal cord”) consists of more than one stock linked together by one or more flows.

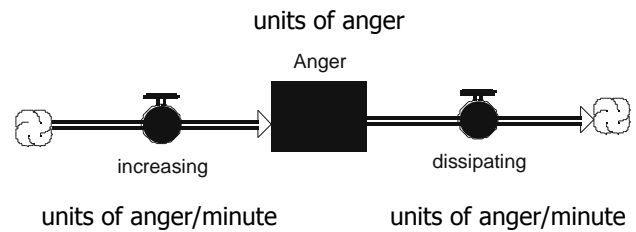
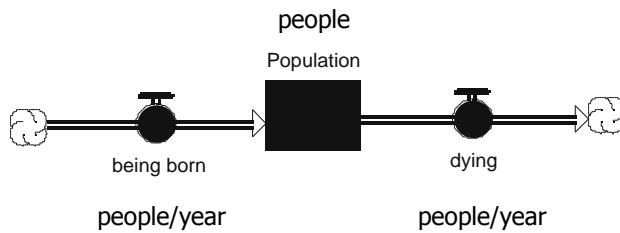


- There are rules, or grammar,” for how nouns and verbs may be “put together.”
- There are *two* rules in the grammar of stocks & flows.

2. Operational Thinking Skills

Rule 1: *Respect Unit Consistency*

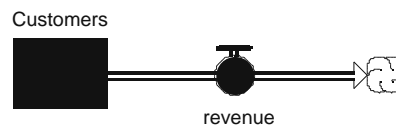
All flows into and out of a stock must bear the *same* units-of-measure as the stock itself, except for “/time.”



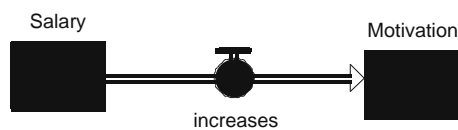
Respecting Unit Consistency: *Exercises*

Use mental simulation to identify what's wrong with these stock/flow representations.
Do not concern yourself with "fixing" them at this point.

1. "Customers generate revenue..."

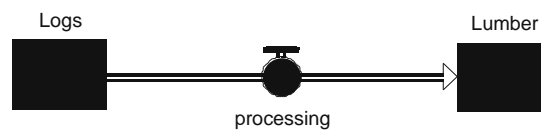


2. "Salary increases motivation..."



Respecting Unit Consistency: *Exercises*

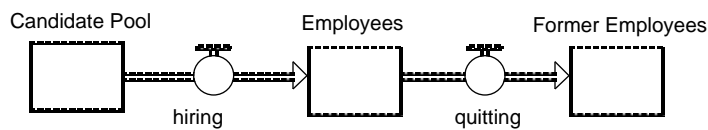
3. “Logs are processed into lumber...”



2. Operational Thinking Skills

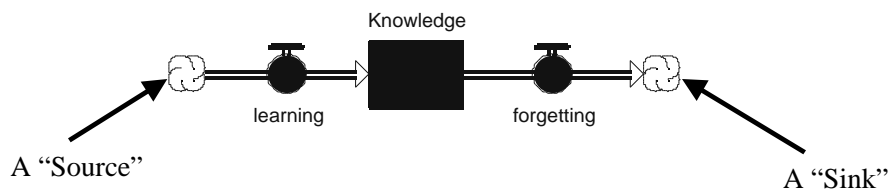
Rule 2: *Respect Conservation Laws*

All *physical* flows come from somewhere (i.e., *deplete* some feedstock), and go to somewhere (i.e., *fill* some repository).



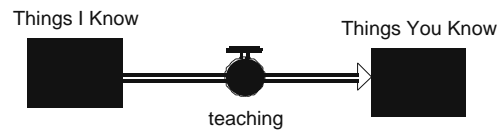
In building a model, you must make a conscious choice as to whether you wish to conserve a physical flow—it's a model-boundary-setting decision.

Virtually all *non-physical* flows come out of thin air, and vanish into same.



Respecting Conservation Laws: *Exercises*

1. A knowledge transfer process is mapped below. Run a mental simulation of this process as depicted. Does it make sense? Check your mental simulation against that generated by “tiktyk1.itm.”



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Language:
Creating Multiple-Sentences
Operational Thinking

Overview

1. Creating Multiple-Sentences

2. Introducing the Connector

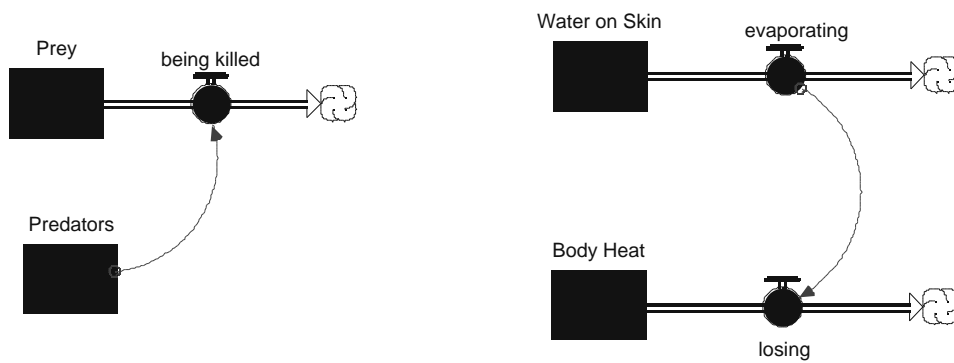
3. Operational Thinking Skills*

- Stock-generated flows
- Flow-generated flows

* Mental simulation and basic itthink software skills will be developed in the process of developing your Operational Thinking Skills.

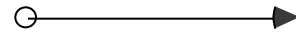
1. Creating Multiple-Sentences

A multiple-sentence is formed when either the noun or verb within a given sentence links to the verb in another sentence...



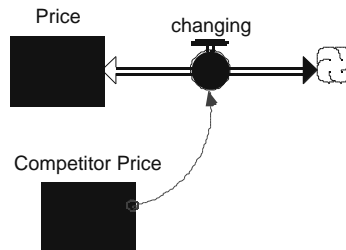
To make these links, we need a *new* language element...

2. Introducing the Connector



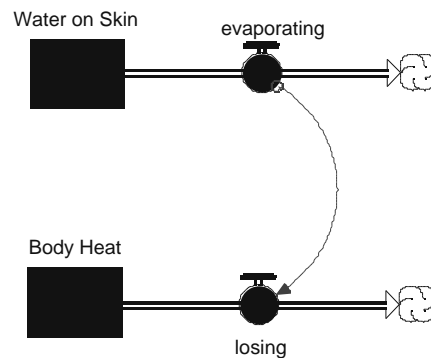
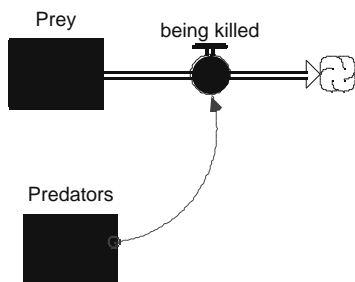
Connectors *transmit* (as opposed to *transport*)...

- **Information** that serves as input to flow regulators.



Connectors serve as inputs, *not* inflows. Therefore, connectors *cannot* connect into stocks.

- **Actions** from resources that serve as *catalysts* (i.e., are not consumed), or from coincident actions...

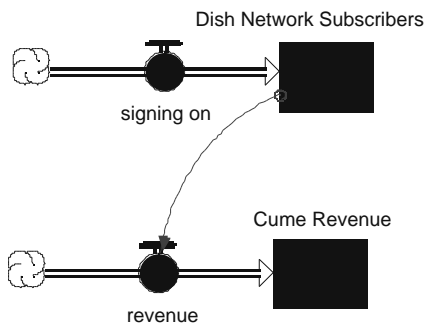


3. Operational Thinking Skills

Distinguishing two types of links

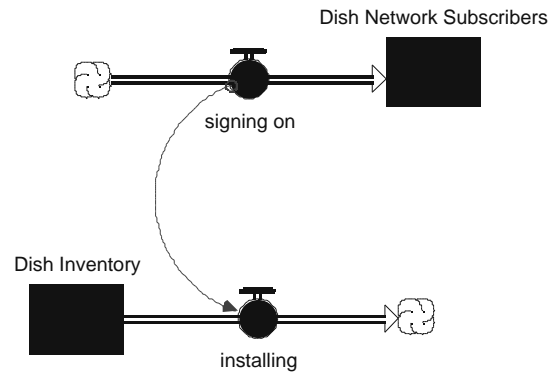
Stock-generated flow

Monthly Subscriber Revenue



Flow-generated flow

Depleting Dish Inventory



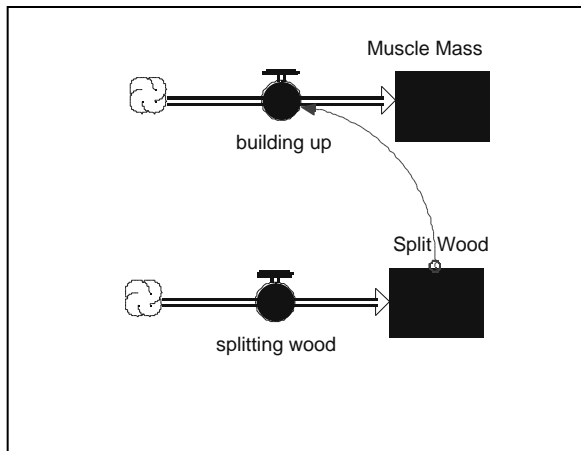
Distinguishing two types of links: *Exercises*

1. Split the Difference

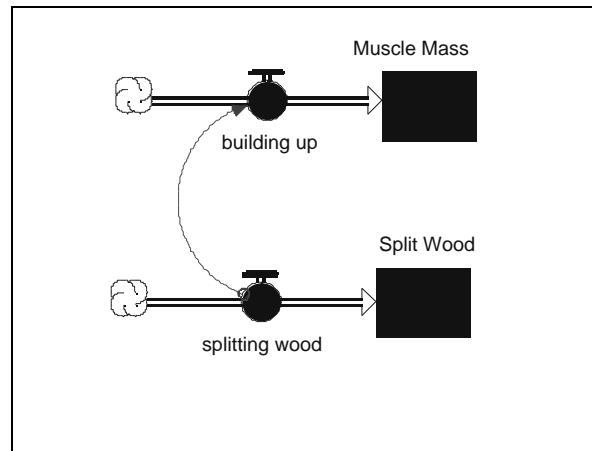
Below are two representations of the build-up of muscle mass associated with the action of splitting wood.

Run a mental simulation of each. Which is the better representation, and why?

A.

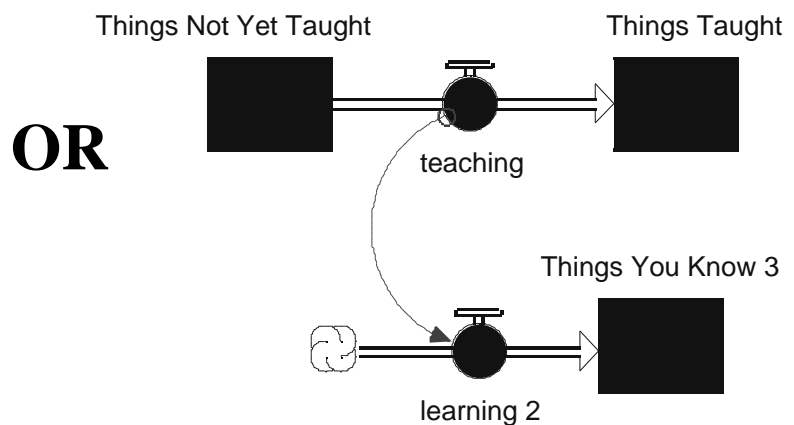
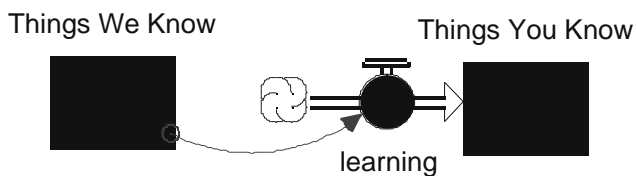


B.



Distinguishing two types of links: *Exercises*

2. Which representation more accurately describes what's going on during this workshop? Why? Mentally simulate both, then check your intuition by opening "tiktyk2.itm" and running a computer simulation.



Distinguishing two types of links: *Exercises*

3. The Industrial Age

The industrial age has been described as an era during which social and natural capital were harvested for purposes of creating industrial capital. Diagram this description, and determine if you agree with the direction of causality implied by the connectors.

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Language:
Constructing Paragraphs
Closed-loop Thinking

Overview

1. Constructing Paragraphs

2. Defining *Closed-loop Thinking*

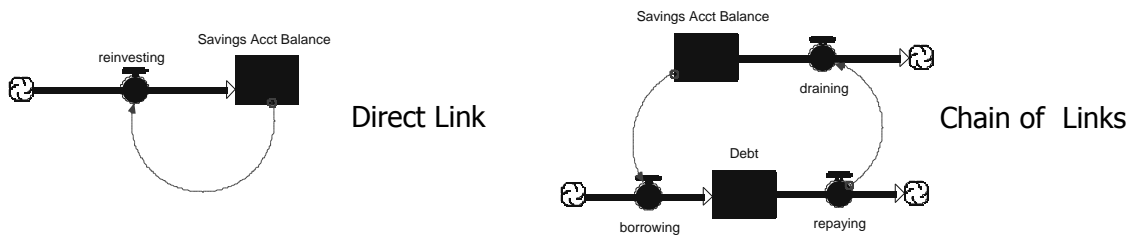
3. Closed-loop Thinking Skills*

- Recognizing two types of loops
- Anticipating unintended consequences

* Mental simulation and basic itthink software skills will be developed in the process of developing your Closed-Loop Thinking Skills.

1. Constructing Paragraphs

- A “paragraph,” or *feedback loop* in the language of systems thinking, occurs whenever you link a noun in a sentence to a verb in the *same* sentence. The link may be direct, or may be part of a chain of links passing through other sentences first.



- Paragraphs “tell stories;” i.e., they *self-generate* dynamics!

2. Defining *Closed-loop Thinking*

- Seeing causality as *circular*, rather than *straight-line*, in nature.
- Contrasts with: *Straight-line Thinking*.

These “n” things cause that...

The “so what”: *Shifts perspective from a static to a dynamic/ongoing-process view.*

An example: *What causes an student to achieve at a high level?*

3. Closed-loop Thinking Skills

Recognizing two types of loops

There are two types of feedback loops:

Counteracting Loops

These loops *counteract* change;
they seek to maintain the status quo.
Also called “Balancing” Loops.

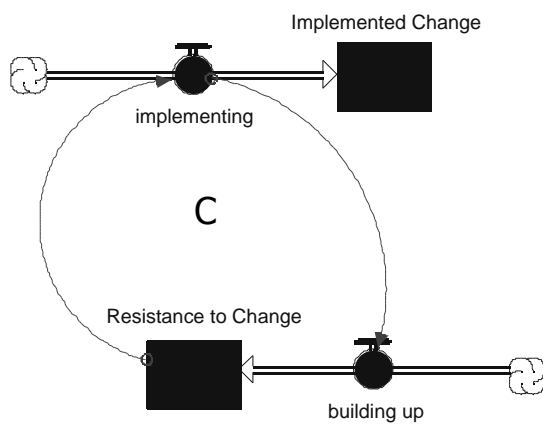
Reinforcing Loops

These loops *reinforce* change;
they seek to “run away” from status quo.
Also called vicious/virtuous cycles.

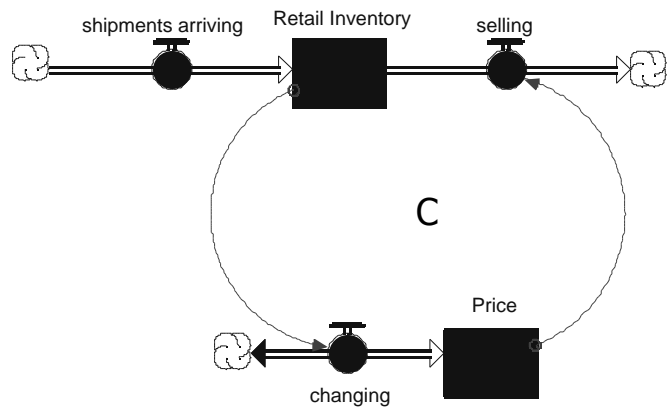
3. Closed-loop Thinking Skills

Recognizing Counteracting Loops

Implementing change often breeds resistance which then slows implementing...



Inventory levels drive price changes which then impact the rate at which selling drains inventory...



Recognizing Counteracting Loops: *Exercises*

1. Map the following...As average speeds on a freeway increase, the State police set up more speed traps, which bring the average speed levels back down...

2. Map the following...When work backlogs swell beyond normal levels, workers are asked to put in overtime to address the situation (and vice versa)...

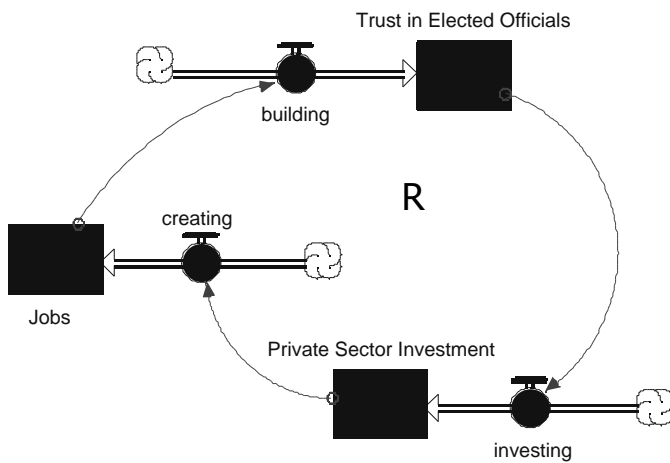
Recognizing Counteracting Loops: *Exercises*

3. Map the following... When an area becomes recognized as “attractive,” housing prices tend to be driven up and this drives down attractiveness (and vice versa).

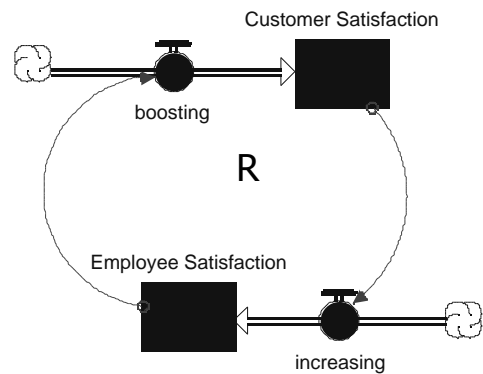
3. Closed-loop Thinking Skills

Recognizing Reinforcing Loops

Trust in elected officials stimulates private sector investment, which leads to jobs...which further boosts trust..



Satisfied customers boost employees' satisfaction with their jobs. Satisfied employees, in turn, boost customers' levels of satisfaction...



Recognizing Reinforcing Loops: *Exercises*

1. Map the following...As market awareness of a product increases, more people purchase it. As increasing numbers of people own the product, this stimulates still more market awareness.

2. Map the following...When someone performs at a high level, their self-confidence receives a boost. Higher levels of self-confidence then inspire further improvements in performance (and vice versa).

Recognizing Reinforcing Loops: *Exercises*

3. Map the following...The more frustrated you get, the more mistakes you make. The more mistakes you make, the more your frustration increases.

4. Map the following...The larger the purchase volume, the bigger the discount a purchaser can command. The bigger the discount, the lower the price they can offer customers. The lower the price they offer, the larger the volume of sales, and hence the volume of purchases.

Recognizing Reinforcing Loops: *Exercises*

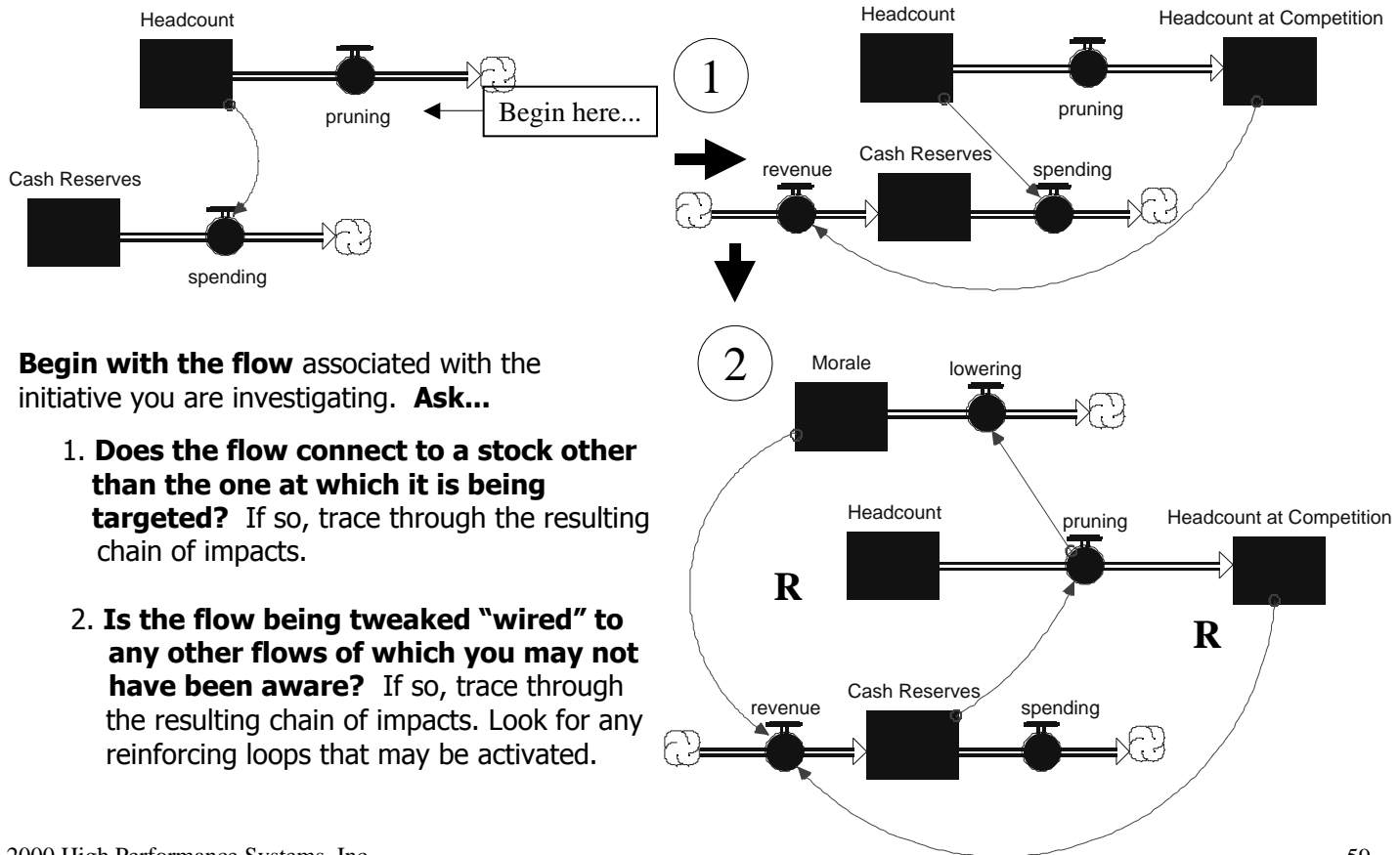
5. Rage Dynamics

Map the following... “Of all the moods that people want to escape, rage seems to be the most intransigent; Tice found that anger is the mood people are worst at controlling...The longer we ruminate about what has made us angry, the more ‘good reasons’ for being angry we can find. Brooding fuels anger’s flames. But seeing things differently douses those flames. Tice found that reframing a situation more positively was one of the most potent ways to put anger to rest...One way of defusing anger is to seize on and challenge the thoughts that trigger the surges of anger, since it is the original appraisal of an interaction that confirms and encourages the first burst of anger, and the subsequent reappraisals that fan the flames. Timing matters; the earlier in the anger cycle, the more effective. Indeed, anger can be completely short-circuited if the mitigating information comes before the anger is acted upon. But, once rage takes hold, people experience ‘cognitive incapacitation,’—in other words people can’t think straight.”

Emotional Intelligence, D. Goleman, p.59-62.

3. Closed-loop Thinking Skills

Anticipating unintended consequences



Begin with the flow associated with the initiative you are investigating. **Ask...**

- 1. Does the flow connect to a stock other than the one at which it is being targeted?** If so, trace through the resulting chain of impacts.
- 2. Is the flow being tweaked "wired" to any other flows of which you may not have been aware?** If so, trace through the resulting chain of impacts. Look for any reinforcing loops that may be activated.

Anticipating unintended consequences: *Exercises*

1. Dueling Daughters

In an effort to reduce one daughter's fear of failure, a father encouraged her efforts with gentle praising. In the process, a second daughter became jealous of the praise her sister was receiving. When Dad finished interacting with his first daughter, his second daughter would show up and tease her sister about failing. Back to square one.

Begin with Dad's initiative, showing how it was intended to work. Then use the framework presented on the previous page to trace through any *unintended* consequences that were created. Does the map suggest a better approach?

Celebrating the Writing Metaphor
Accelerating Learning of Systems Thinking
by De-coupling the Learning Curves

Constructing
More Interesting
Paragraphs, Part 1
Operational Thinking

Overview

1. Constructing More Interesting Paragraphs, Part 1

2. Introducing the Converter

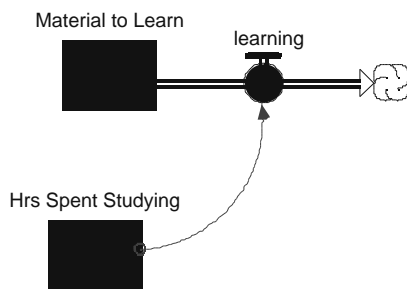
3. Operational Thinking Skills*

- Recognizing the five *generic flow templates*

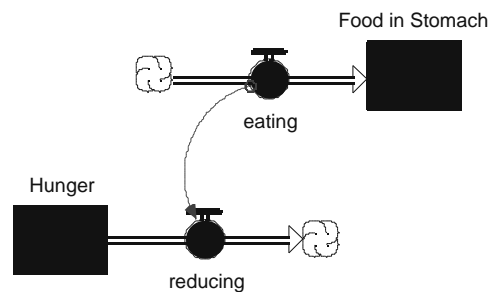
* Mental simulation and basic itthink software skills will be developed in the process of developing your Operational Thinking Skills.

1. Constructing Better Paragraphs, Part 1

If, in constructing multiple-sentences, the building blocks of paragraphs, *only* stocks or flows “drove” flows, we’d have a “units” issue...



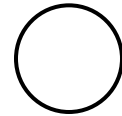
Hrs Spent Studying is "hrs/week."
learning is "material/week."
Hrs Spent Studying learning.



eating is food/hr
reducing is Hunger/hr
eating reducing

That's why we need need *Converters*.

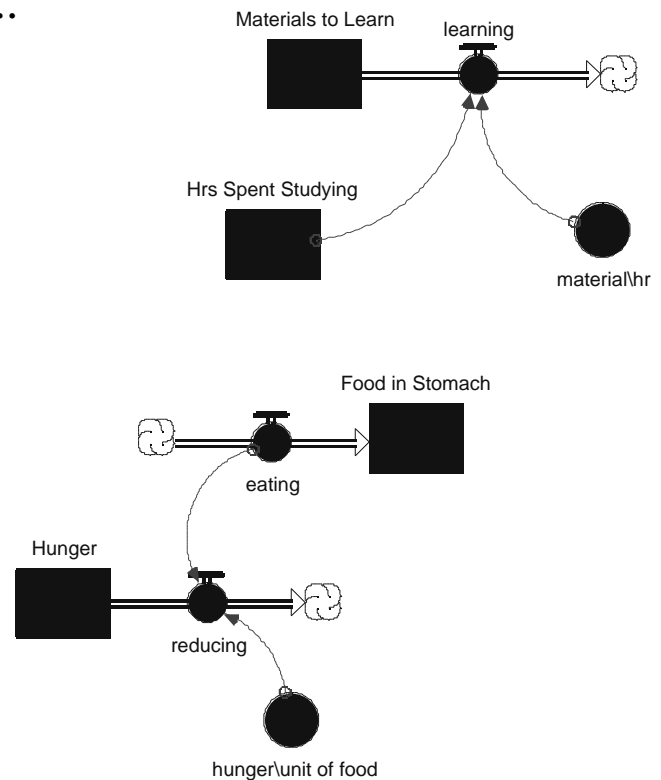
2. Introducing the Converter



Converters operate mainly as “adverbs”
(i.e., they *modify* verbs/flows)...

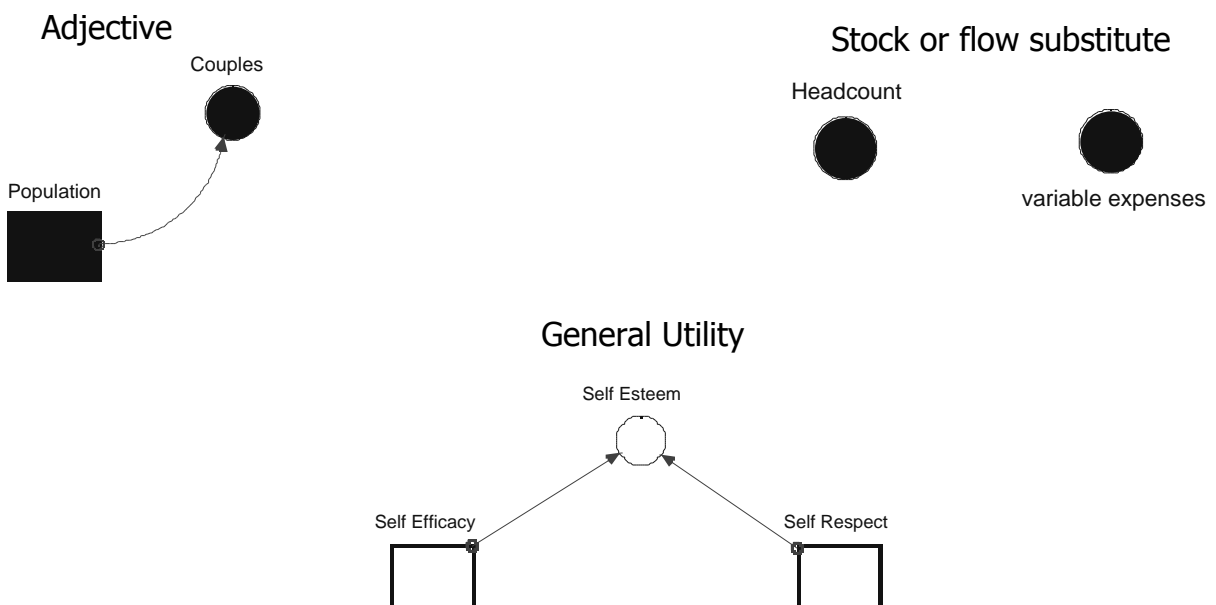
When used as adverbs,
Converters appear
as “productivity terms.”

They enable flows not to
be *equal* to the stocks/
flows that drive them.



2. Introducing the Converter (cont'd)

Converters also can serve as “adjectives,” stock or flow substitutes, and/or “general utilities”...



3. Operational Thinking Skills

- There is some “science” to constructing good paragraphs.
- The science focuses on construction of good *flow* equations. That’s because flows generate actions, and actions constitute the “story line.”
- The science lies in recognizing that there are relatively few generic forms that can accurately describe the *nature* of most actions.
- In fact, there are five *generic flow templates* that reappear with very high frequency in good models.

3. Operational Thinking Skills

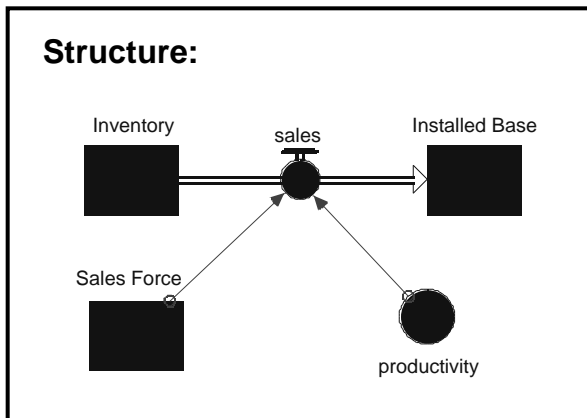
Recognizing Five Generic Flow Templates

- In most of the models we build, 80% - 100% of the flows are specified using one of these templates.
- Do yourself a BIG favor: *Before you set out to specify a flow by devising an ad hoc formulation, see if one of the templates you are about to see will do the trick.*
- Four of the generic templates are *stock*-generated, and one is *flow*-generated.

Five Generic Flow Templates

1. Producing

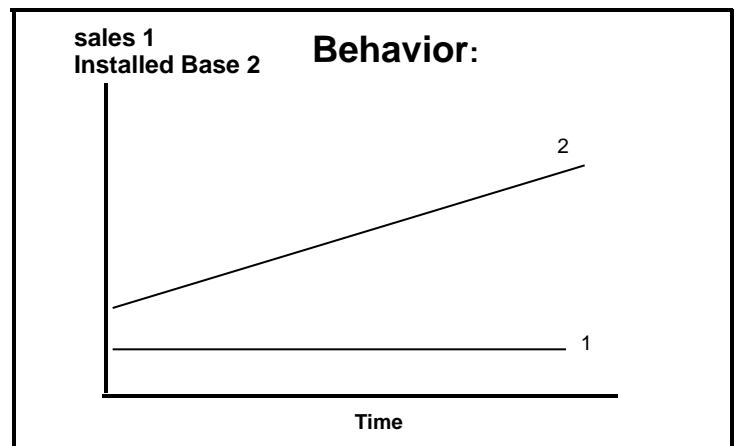
“This activity is driven by an external resource.”



$$\text{sales} = \text{Sales Force} * \text{productivity}$$

[units/t] [persons] [units/person/t]

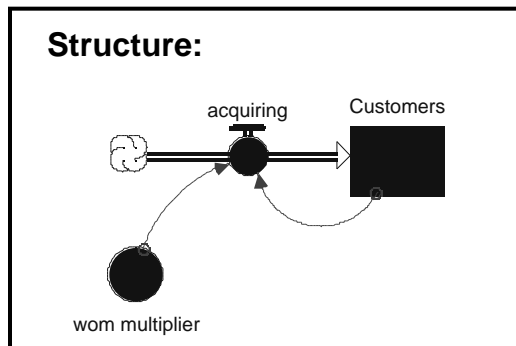
$$\text{producing} = \text{Stock} * \text{productivity}$$



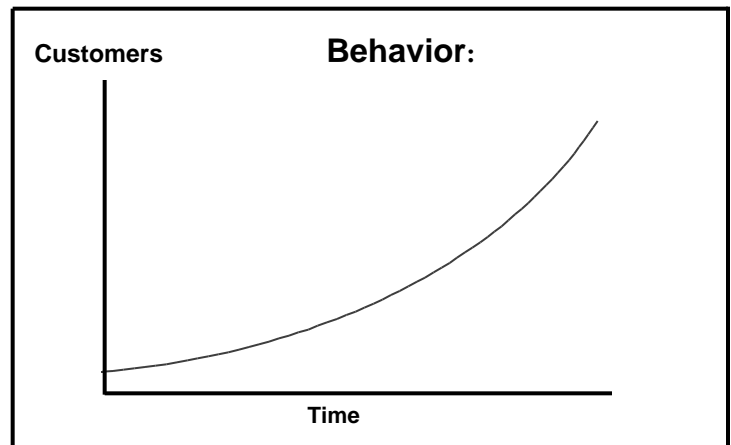
Five Generic Flow Templates

2. Compounding

“This activity is driven by a ‘feeds upon itself’ process.”



This is the simplest possible reinforcing feedback loop!



$$\text{acquiring} = \text{Customers} * \text{wom multiplier}$$

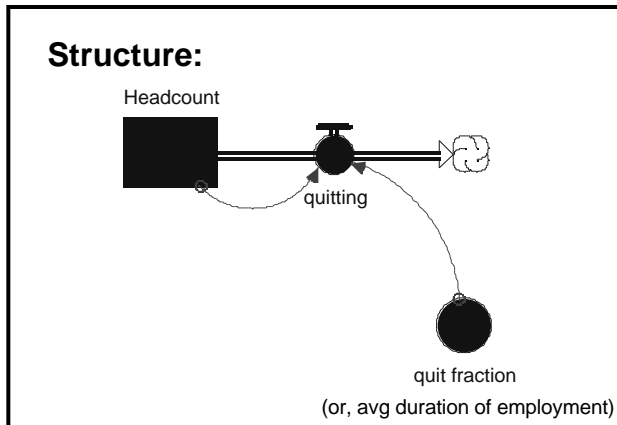
[customers/t] [customers] [(c/c)/t]

$$\text{inflowing} = \text{Stock} * \text{compounding fraction}$$

Five Generic Flow Templates

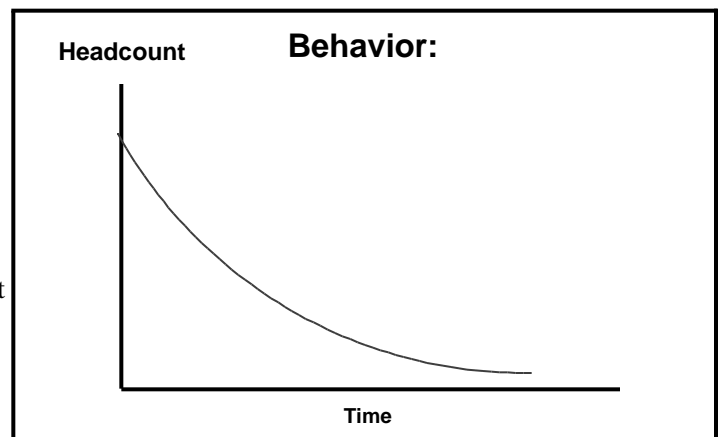
3. Draining

“Pressure to relieve the condition rises as the magnitude of the condition rises.”



This is the simplest possible counteracting feedback loop!

“Half the distance to the wall.”



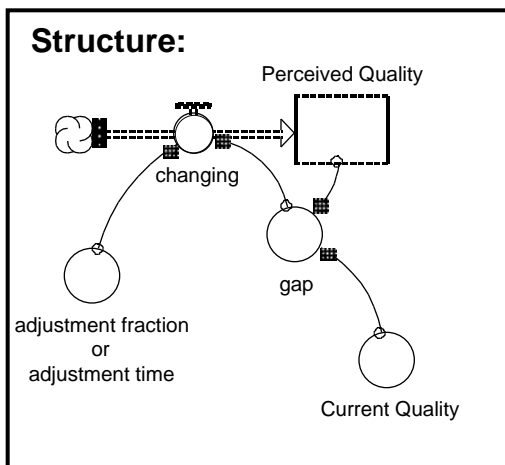
$$\begin{aligned} \text{quitting} &= \text{Headcount} * \text{quit fraction} \\ [\text{people}/t] & \quad [\text{people}] \quad [\text{frac}/t] \\ &= \text{Headcount} / \text{avg duration of employment} \\ & \quad [\text{people}] \quad [t] \end{aligned}$$

$$\text{outflowing} = \text{Stock} * \text{loss fraction} / \text{time constant}$$

Five Generic Flow Templates

4. Stock-adjusting

“The stock gradually adjusts to a target or indicated value.”



$$\text{gap} = \text{Current Quality} - \text{Perceived Quality}$$

$$\text{changing} = \text{gap} * \text{adjustment fraction}$$

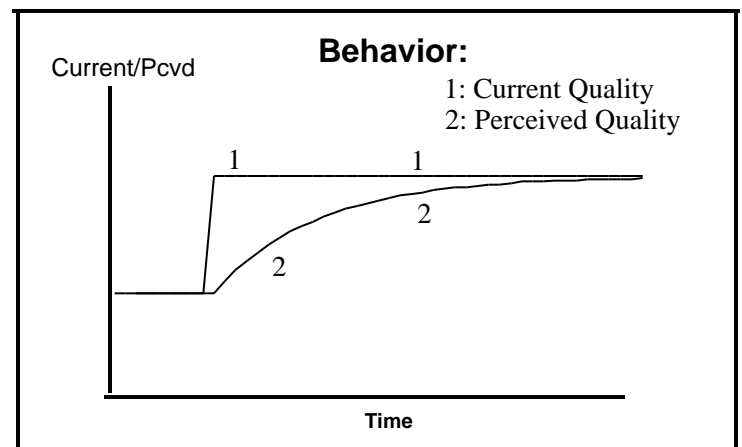
[quality/t] [quality] [frac/t]

$$= \text{gap} / \text{adjustment time}$$

[quality] [t]

$$\text{stock adjusting} = \text{gap} * \text{adjustment fraction}$$

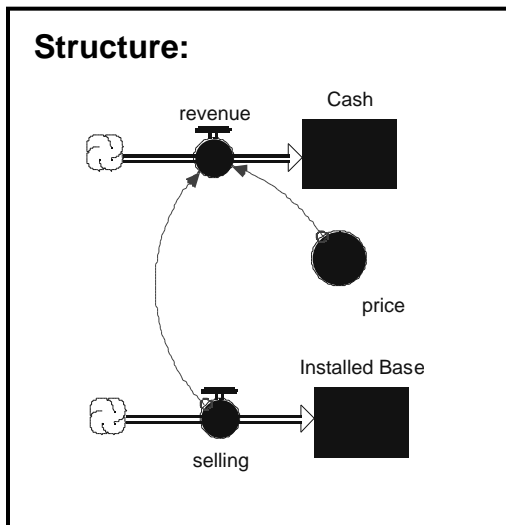
$$= \text{gap} / \text{adjustment time}$$



Five Generic Flow Templates

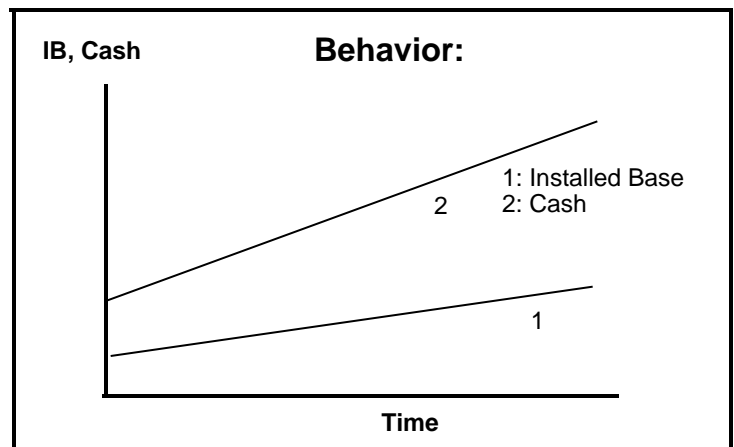
5. Co-flowing

“This action is driven by a coincident action.”



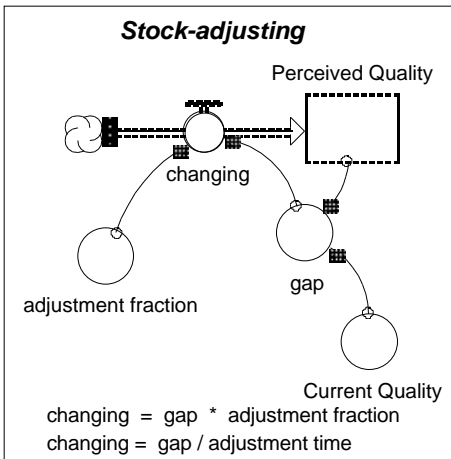
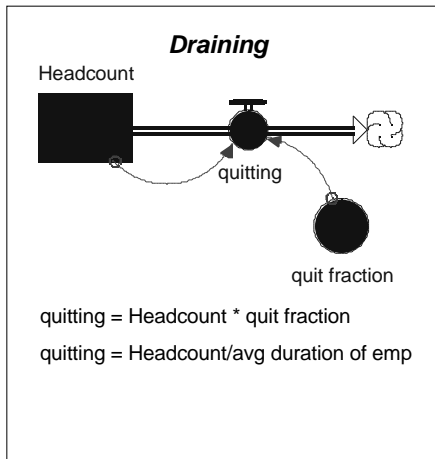
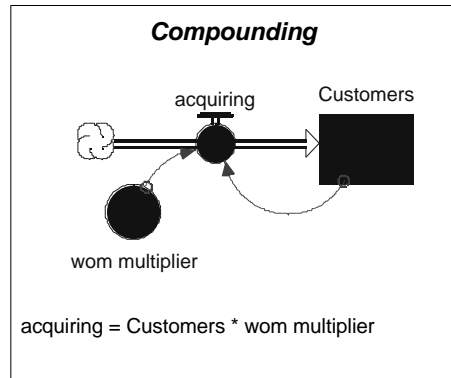
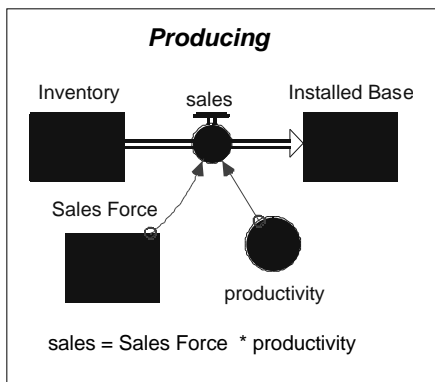
$$\text{revenue} \left[\frac{\$}{t} \right] = \text{selling} \left[\frac{\text{units}}{t} \right] * \text{price} \left[\frac{\$}{\text{unit}} \right]$$

$$\text{co-flowing} = \text{driving flow} * \text{conversion coefficient}$$

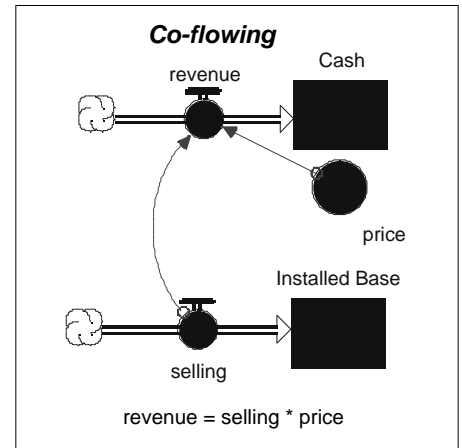


Summary of Generic Flow Templates

Stock-Generated



Flow-Generated



3. Operational Thinking Skills

Summary

- Paragraphs “tell stories” (feedback loops *self-generate* dynamics).
- Writing a good paragraph requires focusing on how the associated flows are generated.
- There is some science to flow generation.
- The science consists primarily of using five generic flow templates.
- Use the science...*Trust The Force.*

Generic Flow Templates: *Exercises*

For each of the following, see if you can use one of the generic flow templates to characterize the flow being described.

1. Epidemic

An infectious disease epidemic is predicted this winter. Specify the *becoming infected* flow.

2. “Bugs”

The programmers at Harden Software have found that in the process of writing code they also inadvertently create bugs. Specify the *bug-creating* flow.

Generic Flow Templates: *Exercises*

3. Fliers

Wright Brothers' Sporting Goods uses high school kids to distribute promotional fliers. Specify the *distributing* flow.

4. Hiring

The rate of hiring slows down as the staff level approaches its target. Formulate the *hiring* flow.

Generic Flow Templates: *Exercises*

5. Hunter Thompson's

"First Law of Relationships"

"Ya gotta show up." If you don't, the strength of a relationship decays over time. Specify the *decaying* process.

6. The best argument yet for internet marketing

3.5 million tons of paper were used to create the 17.6 billion catalogs that were distributed in the US in 1999 (USA Today, 11/29/99, p 3A). That's 64 catalogs for every man, woman and child! The processes of creating and disposing of the catalogs consumed 105 billion BTUs of energy. They also generated 30,000 tons of nitrous oxide (a precursor to smog), 51 billion gallons of wastewater, and 3.7 million tons of solid waste. Represent the nitrous oxide, wastewater and solid waste *generating* flows.

Generic Flow Templates: *Exercises*

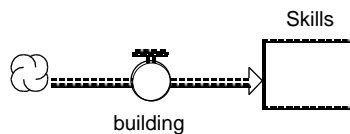
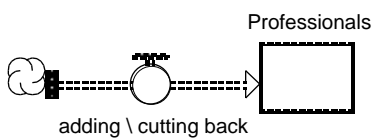
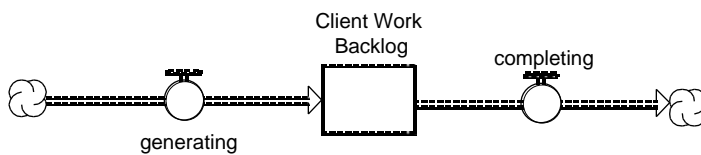
7. How do you learn?

Specify the process by which you learn. Do not list all the “factors” that “influence” learning, but rather specify the *nature* of the learning activity.

Generic Flow Templates: *Exercises*

8. Consulting Company Dynamics

Specify each flow, using the descriptions at right to help...



The firm gains new clients through word-of-mouth.

The firm loses a certain fraction of its clients each year.

Clients generate work; professionals complete it.

Professional headcount is adjusted to a target headcount set by the balance of Work Backlog and headcount.

Professionals build skills by completing client work; their productivity in doing this work is primarily determined by their skill level.

Generic Flow Templates: *Exercises*

9. Subscriber.com

You now have 50 subscribers. Through word-of-mouth, they are currently attracting 10 new subscribers per month. Each subscriber pays \$150 per month for your service. Your fixed expenses are \$5000 per month, and it costs you \$100 per month to service each subscriber. You now have \$10,000 in the bank. Map, model, then simulate this business to see what happens to your bank balance over time.

Extension exercises

Extend the model to reflect the following:

- Market research shows you can charge a \$25 initiation fee for starting up new subscribers.
- You discover you are losing subscribers at a rate of about 10% per year.
- You are concerned about the accuracy of your fixed expenses estimate. Use *sensitivity analysis* to examine the impact of fixed expenses ranging from \$5000 to \$9000 per month.
- Put an interface on your model to convert it into a “game.” Include “messaging” that reports on the status of the business’s cash balance.

Celebrating the Writing Metaphor
Accelerating Learning of Systems Thinking
by De-coupling the Learning Curves

Constructing
More Interesting
Paragraphs, Part 2
Quantitative Thinking

Overview

1. Defining *Quantitative Thinking*

2. Constructing More Interesting Paragraphs, Part 2

3. Quantitative Thinking Skills*

- Quantifying Relationships

* Mental simulation and basic itthink software skills will be developed in the process of developing your Quantitative Thinking Skills.

1. Defining *Quantitative Thinking*

- An important distinction...

Quantifying things vs quantifying relationships

You can see, touch, and often even measure, physical things. This usually makes quantifying them pretty straight-forward. *Relationships* usually are invisible. Quantifying them often involves collecting empirical data over a period of time, and then analyzing it to draw inferences about what the relationship “must be” that generated the data.

- Contrasts with: *Measurement Thinking*

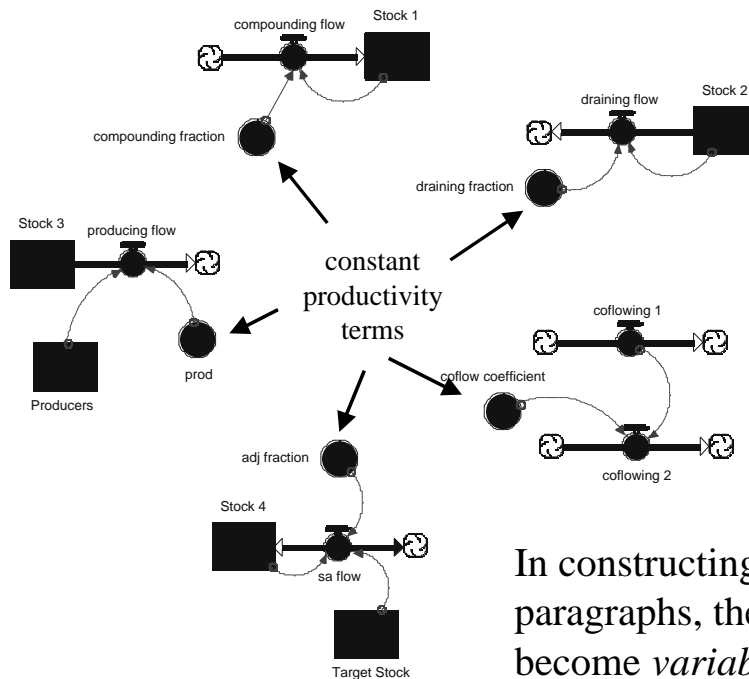
“To *know*, you must *measure* precisely.” *Knowledge* involves *things*.

vs

“To *understand*, you must *think* precisely.” *Understanding* involves *relationships*.

2. Constructing More Interesting Paragraphs, Part 2

Each of the 5 generic flow templates has a *constant* “productivity” term...



In constructing “more interesting” paragraphs, these terms often become *variable*!

2. Constructing More Interesting Paragraphs, Part 2 (cont'd)

The BIG question is:

How do we make a variable (like a “productivity term”) depend on one or more other variables?

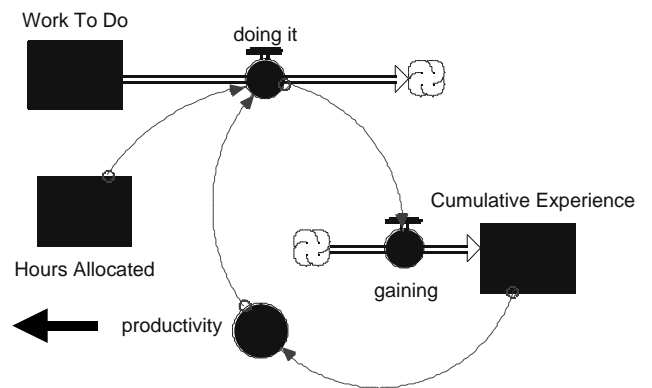
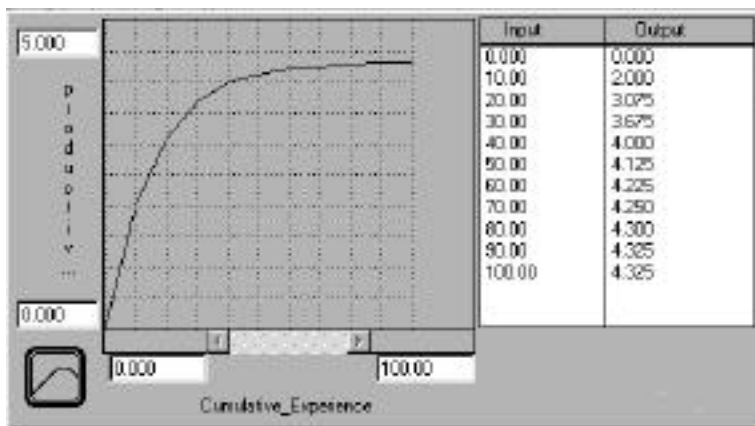
One option: *Mathematics.* $Y=f(X_i)$
(Lotsa people have lotsa problems with this option)

So, we'll offer an alternative (the graphical function).
(*You'll sketch a curve to represent the relationship*)

3. Quantitative Thinking Skills

Quantifying Relationships

An illustrative graphical function...



productivity (widgets/worker/hour)

depends on

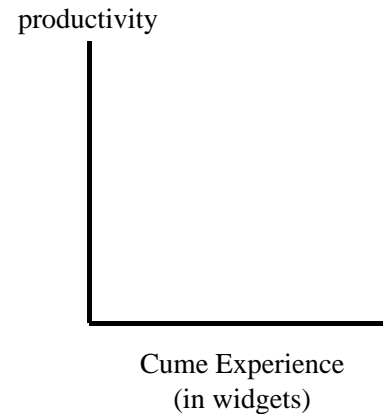
Cumulative Experience (widgets)

3. Quantitative Thinking Skills

Quantifying Relationships

In defining a graphical function, you should follow these steps...

1. Think only of the relationship between the input variable and the output variable, holding all other variables impacting the output variable constant.
2. “Normalize” the input variable, if need be (often dividing it by something does the trick; e.g., revenues per employee). Index variables (e.g., 0-100) need not be normalized.
3. Define ranges for the input and output variables. Be sure to define a range that incorporates the full possible movement, not just a range over which the variable has moved in the past.
4. Determine the direction of slope; the slope should, in almost all cases, be either positive or negative (or zero) over the *whole* range. If the sign of the slope changes, be certain you are not inadvertently including another influence in your thinking.
5. Identify the extreme points on either end of the range (*remember that the first and last values are held forever; graphical functions do not extrapolate!*). In some cases, you’ll also be able to identify a so-called “normal” point.
6. Sketch a smooth curve through the points.



Quantifying Relationships: *Exercises*

1. What bothers you about the following inference?

"Adolescents in the state of Texas are the most athletic teens in the nation, with more high school sports participants in the 1998-99 school year than any other state." The states with the most teen athletic participants:

Texas	783,751
California	584,590
New York	328,854
Ohio	290,226
Illinois	288,212

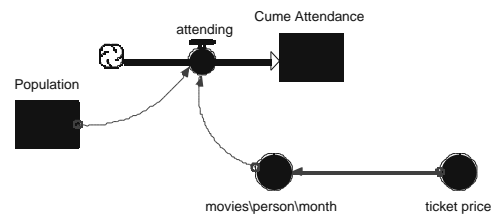
USA Today, 9/27/99, p 1A

Quantifying Relationships: *Exercises*

Use a graphical function to represent the following relationships...

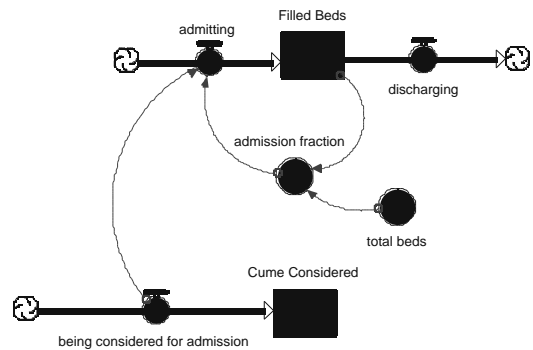
2. Movie Madness

“A local cinema company is trying to represent the relationship between the prices it charges and the average frequency of attendance. Assuming your price sensitivities are representative of the local populace, fill in the graphical function in “Movies.itm.”



3. Admission Admission

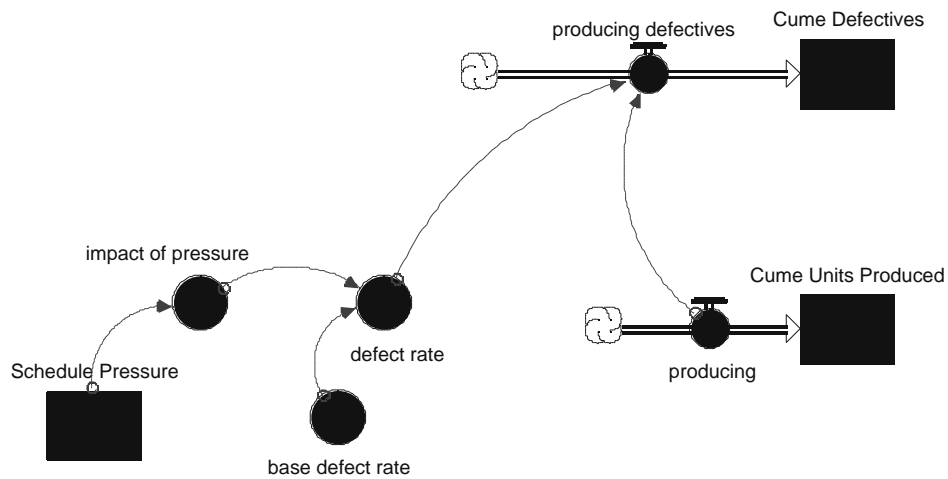
Jack Wennberg, Director of the Center for Evaluative Science at Dartmouth Hitchcock Medical Center, is convinced that, under most circumstances, the # 1 factor in determining whether someone is admitted to the hospital is not their medical condition, but rather how full the hospital is at the time. Represent Wennberg’s view by opening “Beds.itm” and sketching in the *admission fraction*.



Quantifying Relationships: *Exercises*

4. The impact of schedule pressure

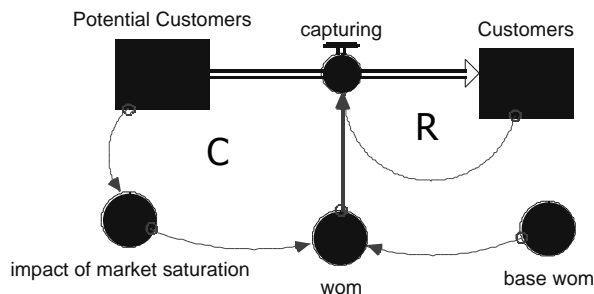
In the model called “Pressure.itm,” specify the *impact of pressure* to reflect the fact that as schedule pressure rises, the defect rate follows suit. Note the use of a “base and impact” formulation. It is often a good idea to break out the base rate, rather than “bury” it in the graphical function. Doing so facilitates sensitivity analysis and makes the associated graphical functions model-independent.



Quantifying Relationships: *Exercises*

5. Market Penetration Dynamics

- A. Examine the structure shown below. Assume the *Potential Customers* pool is untapped and the *Customers* base is nearly empty. Which loop will dominate behavior under this condition? Sketch the pattern of behavior you think the system will exhibit? Run “WOM.itm” to check your intuition for the dynamics.



- B. Now change the initial value in *Customers* to 800. What pattern of behavior will the system exhibit now? Why? Check your intuition by running the model.

Customers



time

Nonlinear relationships can cause shifts in Feedback Loop Dominance

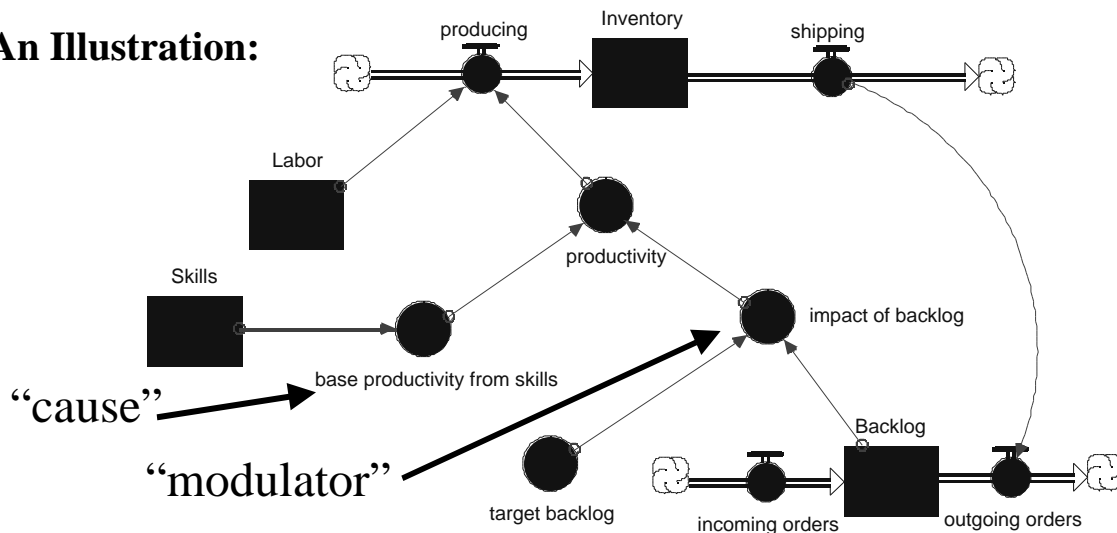
3. Quantitative Thinking Skills

Quantifying Relationships

Multivariate Relationships

- Thus far, we have considered “productivity terms” that depend on only a *single* input. How do you capture situations in which there are *multiple* inputs?
- A useful technique is distinguish “causes” from “modulators”...

An Illustration:



$$\text{productivity} = \text{base productivity from skills} * \text{impact of backlog}$$

Multivariate Relationships: *Exercises*

1. A Production function

production = $f(\text{Labor}, \text{Labor Skills}, \text{Raw Materials}, \text{Capital Equipment})$

Use *operational* thinking to convert this “factors thinking” expression into an itthink model.

See Prodn.itm
for help.

Multivariate Relationships: *Exercises*

2. Soil Loss

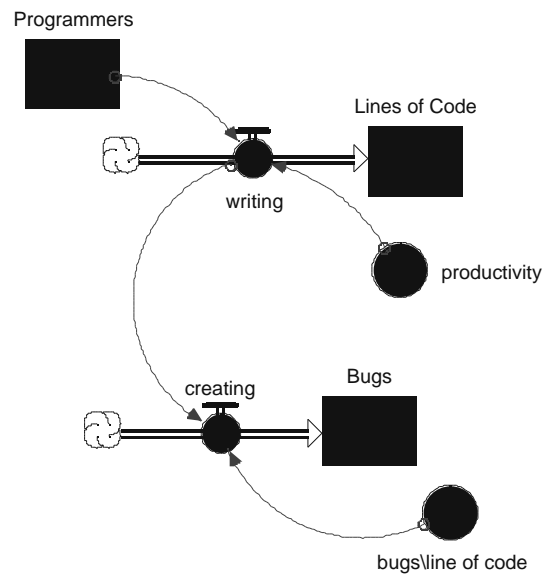
Rate of erosion = f (particle size, runoff volume, vegetative cover)

Convert the “factors thinking”-generated formula above into an itthink model by using *operational* thinking.

Multivariate Relationships: *Exercises*

3. “Bugs” Revisited

Remember the programmers at Harden software who inadvertently created bugs when they wrote lines of code? Close a feedback loop or two to enrich the picture (open “Bugs.itm”)...



Celebrating the Writing Metaphor
Accelerating Learning of Systems Thinking
by De-coupling the Learning Curves

Adding Texture:
Quantifying
Non-Physical Things
Quantitative Thinking

Overview

1. Quantifying Non-Physical Things
2. Quantitative Thinking Skills*

* Mental simulation and basic itthink software skills will be developed in the process of developing your Quantitative Thinking Skills.

1. Quantifying Non-Physical Things

- **An important distinction re-visited: *Measurement vs Quantification***

Many important things cannot be *measured* (e.g., morale, trust, self-esteem).

All of them can be *quantified*.

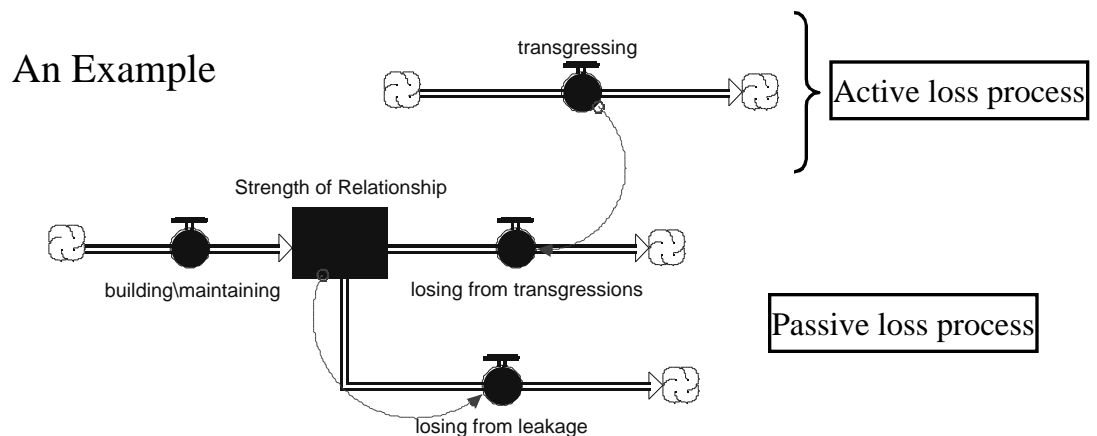
- **The “so what:”** *Enables you to derive insights without having to spend a lot of time collecting measured numerical data, and enables you to bring non-physical variables within the framework of rigorous thinking.*

An example: *Self-esteem in alcoholics*

2. Quantitative Thinking Skills

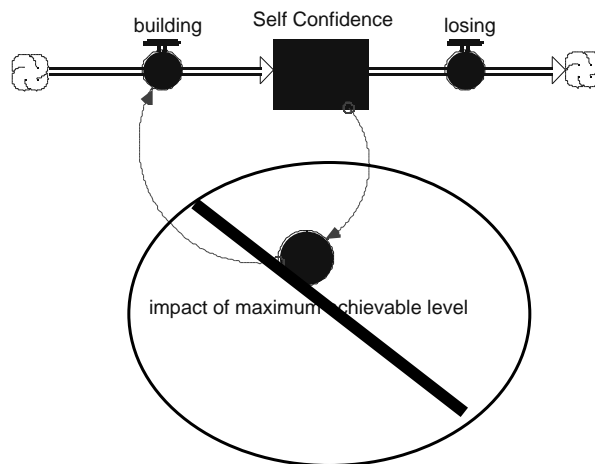
Quantifying Non-Physical Things

- Quantify non-physical stocks using a *consistent* scale; we suggest 0-100. *0 means a complete absence; 100 means as much as it's possible to have.*
- Often you can use either simulation results or known quantities (e.g., known values of physical variables) to estimate the values of non-physical variables.
- Many non-physical variables obey the “Use it or lose it” Law. That is, their magnitude should “automatically” leak or drain away, just as a muscle “automatically” atrophies if it isn’t exercised. These stocks may also have an *active* loss process as well.



2. Quantitative Thinking Skills

Don't just "clip" an inflow to prevent a stock from exceeding the value you have arbitrarily, *but definitionally*, established as a maximum achievable level. Instead, think about the real counter-pressures that will arise as the stock approaches its maximum.



Quantifying Non-Physical Things: *Exercises*

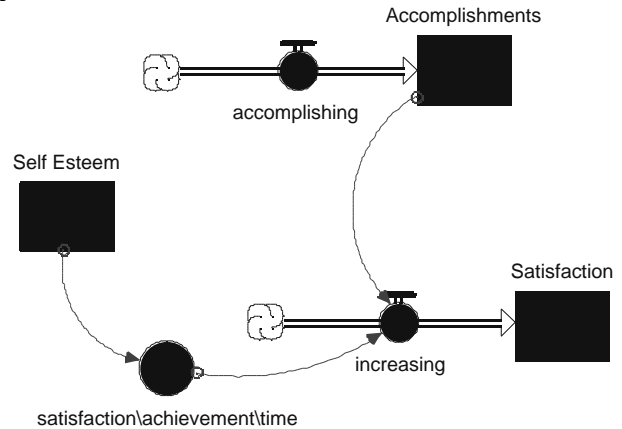
1. Self-Esteem/Satisfaction Dynamics I

Use the following description to help in filling in the graphical function in “Esteem.itm”...

”While poor self-esteem sometimes undercuts the capacity for accomplishment, *what is far more certain is that it undercuts the capacity for achieving satisfaction from accomplishments*. This is a painful reality well known to many high achievers”

The Six Pillars of Self-Esteem, N. Branden, p.20.

Can you offer a critique of Branden’s theory based on your simulation results?



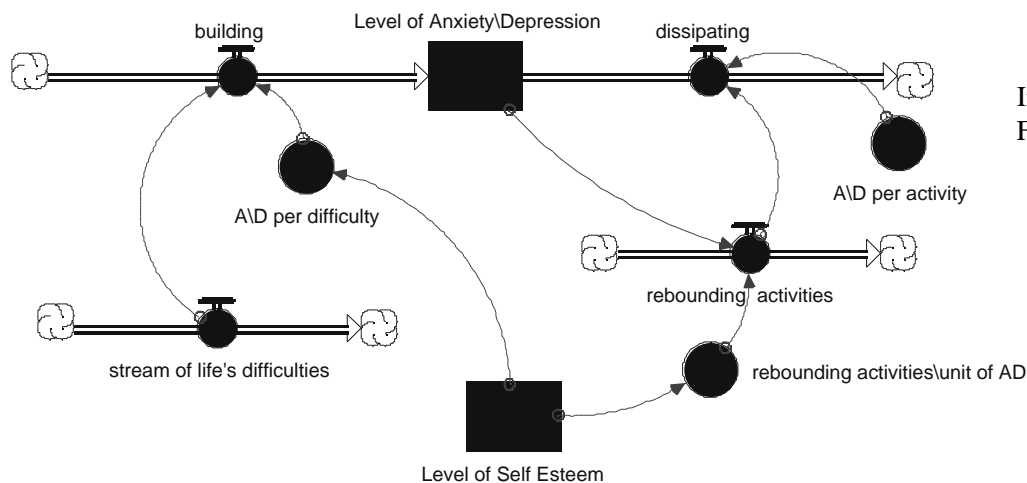
Quantifying Non-Physical Things: *Exercises*

2. Self-Esteem/Satisfaction Dynamics II

Use simulation and your experience to numerate the model below which is based on the following passage...

“Just as a healthy immune system does not guarantee that one will never become ill, but makes one less vulnerable to disease and better equipped to overcome it, so a healthy self-esteem does not guarantee that one will never suffer anxiety or depression in the face of life’s difficulties, but makes one less susceptible, and better equipped to rebound quickly.”

The Six Pillars of Self-Esteem, N. Branden, p. 18.



In your Exercises Folder as “AD.itm”

Quantifying Non-Physical Relationships: *Exercises*

3. Trust Dynamics

Construct a simple *ithink* model of the following... “Trust plays a central role in the size of tolerance zones for customers, employees and partners. The bond of trust increases tolerance for a misstep. A mistake or failure on the part of a trusted other is more likely to be viewed as an aberration. Trust creates a reservoir of goodwill that in bad times allows an opportunity to rebuild, restore, redo.” *Discovering the Soul of Service*, L. Berry, p.133.

Improving Business Performance
A Systems Thinking Approach

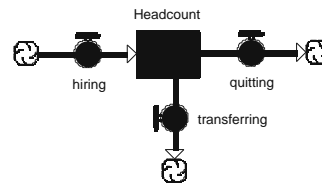
Numerating:
The Big Picture
Quantitative Thinking

The first numeration of your model should be to support “robustness testing.” These tests are designed to reveal weaknesses in model formulations, highlight conditions/situations under which your model is not well-suited to contribute, and identify possible high/low leverage points...

- Initialize your model in *steady-state* (sum of inflows = sum of outflows for each stock).
- Enter numbers for those variables whose magnitudes are well-known, first.
- Use the well-known values you’ve included—in addition to the requirements of *steady-state*, and also feedback from simulation results—to “drive you” to values for those variables for which numerical values are unknown.

Once the model is initialized in steady-state, use an “idealized” test-input (such as a *pulse* or *step* function) to knock it out of balance...enabling you to observe the “pure” internally-generated dynamics of your model.

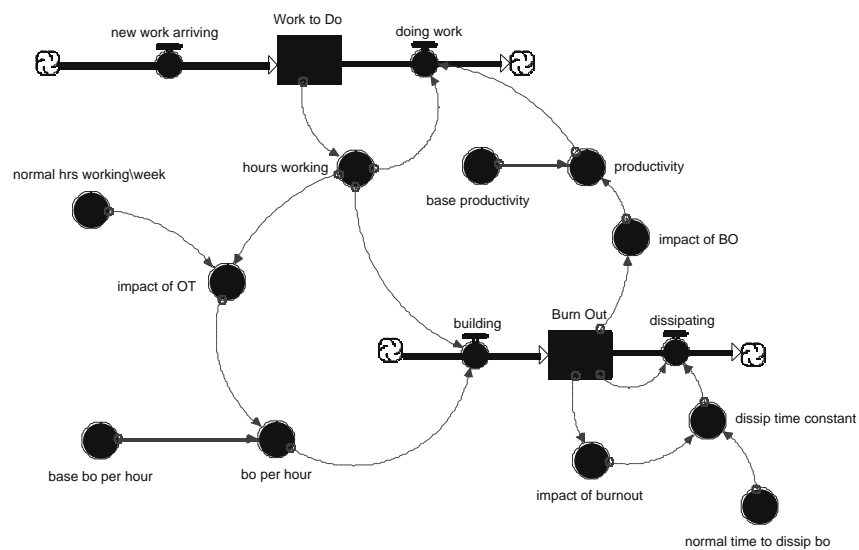
In steady-state...
 $\text{hiring} = (\text{quitting} + \text{transferring})$



In the model shown above, a pulse-increase in *transferring* would be one way to knock the model out of steady-state.

Steady-State Initialization Exercise

Initialize the model shown below in steady-state. Then, “hit it” with a pulse-increase in “new work arriving.” Explain the resulting dynamics. Next run a sensitivity analysis on the parameter in which you have least confidence. Explain your results.



Model is “SSinit”
in Exercises Folder.